

Historical-ecological evaluation of the long-term distribution of woodland caribou and moose in central British Columbia

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Abstract. Throughout the 1800s and the 1900s, woodland caribou disappeared from much of the central and southern portions of British Columbia, Canada. Conversely, moose populations expanded during the 1900s and rapidly colonized forested areas formerly occupied by caribou. Although the general trend in range recession and expansion is documented, the processes, timing, and spatial extent of overlap between these two ungulates are uncertain. Such details have implications for our understanding of the ecology of these species and the conservation of woodland caribou. Using historical-ecological methods, we documented the distribution and abundance of caribou and moose over a 150-year period. Also, we evaluated three general sources of evidence for documenting long-term changes in the distribution of hunted or trapped fauna: (1) semi-structured interviews with Aboriginal and non-aboriginal residents; (2) journals of the Hudson's Bay Company (HBC); and (3) primary written sources. The findings of this study suggested that caribou were relatively wide-spread throughout the study area until the late 1800s when their distribution began to decline. The first recorded sighting of moose in the study area was 1832, although consensus among sources suggested that moose expanded into the area at the end of the 1800s becoming abundant in the 1920s and 1930s. Proposed causes of decline of caribou included climatic change during the 1800s and habitat loss, hunting, and altered predator-prey dynamics through the early 1900s. Our analysis of three sources of historical information and knowledge confirmed the value of Local and Traditional Ecological Knowledge in documenting and explaining long-term historical distribution of hunted species. Alternatively, HBC journals and other written sources provided good temporal specificity, but few recorded locations of caribou or moose. Documenting changes in the long-term distribution of both species can enlighten conservation planning for woodland caribou.

Key words: ecological change; historical ecology; Hudson's Bay Company; moose; species distribution; traditional ecological knowledge; woodland caribou.

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INTRODUCTION

Woodland caribou (*Rangifer tarandus caribou*) has demonstrated dramatic declines in distribution and abundance across most of its continental

range (Festa-Bianchet et al. 2011). In British Columbia (BC), Canada, the decline of caribou during the last two centuries has been most noticeable in the southern and central portions of the province, where landscape change resulting

from increased use of natural resources, settlements, and recreational activities have altered caribou habitat and the distribution of predators (Seip et al. 2007, Wittmer et al. 2007). Similar patterns were noted for other populations found across the boreal forest of Canada (Schaefer 2003, McLoughlin et al. 2003, Vors and Boyce 2009).

Historically, caribou were present across most of north-central BC (Spalding 2000). During the 1900s, these populations contracted into the surrounding mountain regions or disappeared altogether (Poole et al. 2000). The historical dynamics that triggered this decline are unknown, although increased human presence and development related to forestry and mining correlate with the contraction in caribou distribution. Concurrent with the decline of caribou in the 1900s, moose (*Alces alces*) increased in both distribution and abundance (Hatter 1950, Bergerud and Elliot 1986, Spalding 1990, Kay 1997). The increase in moose, providing a more abundant prey species for wolves (*Canis lupus*), is thought to have changed the predator-prey dynamic across these sub-boreal landscapes. This is now one of the primary hypotheses explaining the contemporary decrease in populations of caribou (Poole et al. 2000, Serrouya et al. 2011).

Although broad changes in the distribution of moose and caribou over the past 150–200 years are documented, there is still considerable uncertainty about the timing and mechanisms of change. Currently, caribou are threatened by a combination of interacting factors, but debate continues about the role of long-term sources of mortality and habitat loss as well as the historical rate of decline. Such information is important for determining the level of intervention when developing recovery actions for woodland caribou, a federally and provincially recognized species, and predicting the persistence of individual populations. A more comprehensive understanding of caribou decline requires the consideration of the historical role of natural and human-caused factors.

The use of historical evidence and associated methods is beginning to play a larger role in the applied ecological sciences (Rhemtulla et al. 2009, Bjorkman and Vellend 2010). These approaches, termed historical ecology, examine the long-term interactions between humans and the environment and the resulting changes to landscapes

(Crumley 1994). Most authors promote historical ecology as a holistic approach to the study of natural and anthropogenic phenomena over long time periods where humans are mechanisms of change (Crumley 1994, Rival 2002, 2006; Balée 2006).

In this study, we used historical-ecological methods to investigate the spatio-temporal patterns of caribou decline and the expansion of moose populations in central BC. We investigated the period of 1800 to 1950, a time when European explorers entered the study area (1806), followed by settlers throughout the 1800s and industrial activities in the 1900s. We employed two sources of written evidence (Hudson's Bay Company records and written accounts of the region) as well as interviews with First Nations and non-aboriginal residents to study the changes in the distribution of caribou and moose.

The use of written historical evidence, local knowledge, and Traditional Ecological Knowledge involves integrating non-scientific information into a scientific research framework. Historical information may not be available for all areas and/or time spans, or the sources may be too fragmented to be useful (Swetnam et al. 1999). Therefore, the second objective of this study was an evaluation of the sources of historical information that we reviewed. We developed a set of criteria that allowed a relative comparison of the spatial and temporal precision, richness of content, and barriers to application of Hudson's Bay Company (HBC) journals, written historical evidence, and interviews with knowledge holders.

METHODS

Study area

We focused this study on an area of approximately 32,000 km² within the upper Nechako Plateau, located in the north-central interior of BC. The specific boundaries were related to the extent of the traditional territories and occupancy range of the First Nations on which this research is based, and the perceived sphere of influence of the HBC post of Fort St. James, BC (Fig. 1). Several mountain ranges surround the edges of the plateau. Dominant forest vegetation consists of white and black spruce (*Picea glauca*; *Picea*

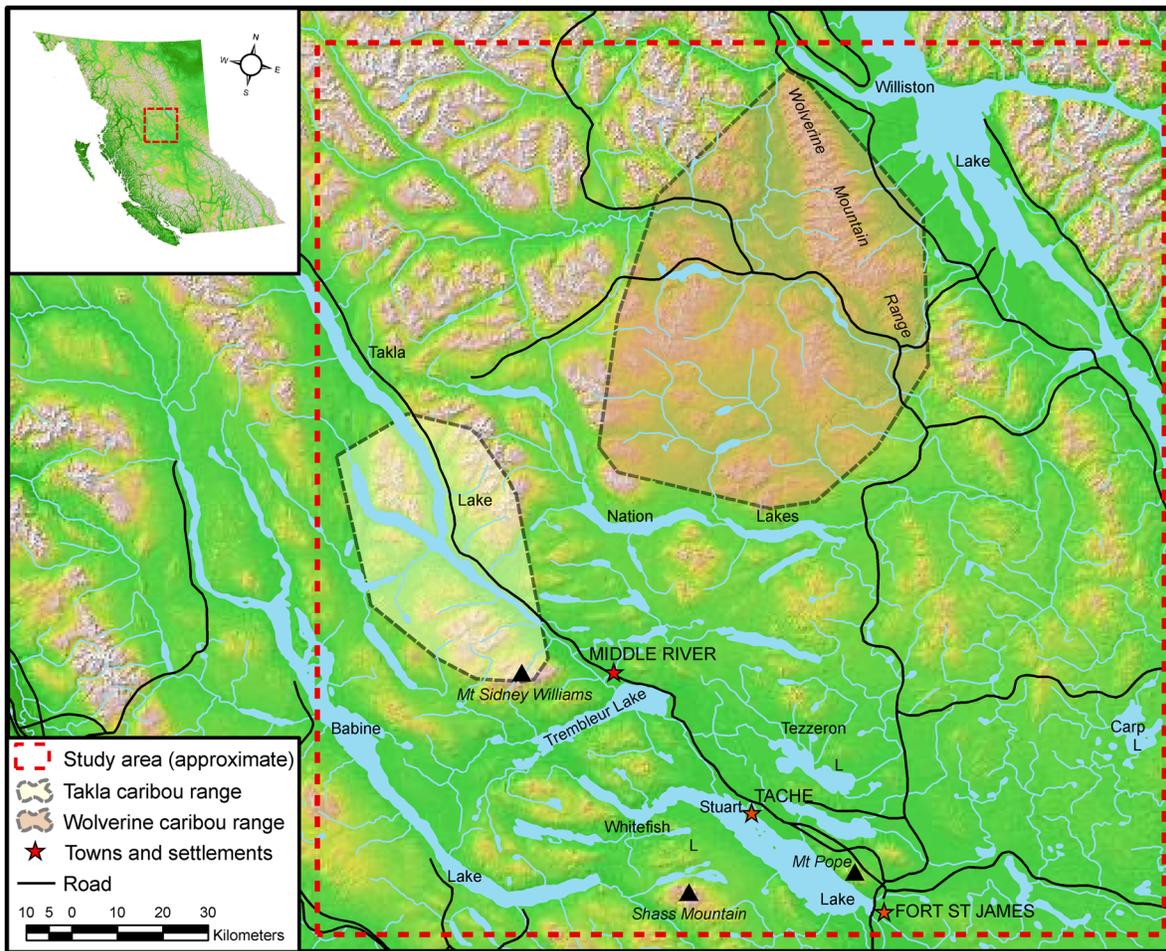


Fig. 1. Approximate boundary of the study area across the Nechako Plateau, BC, and current distribution of remnant caribou populations.

mariana), subalpine-fir (*Abies lasiocarpa*), lodgepole pine (*Pinus contorta*), trembling aspen (*Populus tremuloides*) and western white birch (*Betula papyrifera*).

The Nak'azdli Band and the Tl'azt'en Nation are the Aboriginal communities at the centre of the study area. Both groups are part of the central Dakelh (Carrier) linguistic group of the Athabaskan language family. Historically, the primary source of subsistence for the Carrier Dakelh people was fish. Salmon (primarily *Oncorhynchus nerka*) was collected in large quantities, usually in late August and used throughout the winter, while other freshwater species were taken in the fall and in the winter (Morton 1988). After fish, small game was most important. Beaver (*Castor*

canadensis), marmot (*Marmota caligata*), muskrats (*Ondatra zibethicus*) and other furbearers were gathered using traps and snares. Larger animals such as black bears (*Ursus americanus*) and lynx (*Felis lynx*) were taken using pits and deadfalls (Hudson 1983). Large herbivores used prior to contact with Europeans and during the early contact phase included mountain goats (*Oreamnos americanus*), deer (*Odocoileus* species), caribou, and possibly elk (*Cervus elaphus*) (Hall 1992).

Information sources and collection

We used a combination of qualitative and quantitative techniques founded on grounded theory to generate a historical chronology of the

distribution of caribou and moose across the study area (Strauss and Corbin 1998). Grounded theory does not follow the traditional scientific flow of research starting with the formulation of hypotheses, testing, and development of subsequent theories. When adopting a grounded theory methodology, the researcher starts with a general question. Data are then sampled from designated sources. The collected information is analyzed to generate patterns and themes, often referred to as 'concepts'. The examination of concepts may in turn underline the need for further sampling (Bryman 2004). In this context, we employed three sources of information: interviews with Aboriginal and non-aboriginal residents of the study area with significant local or traditional ecological knowledge, systematic review of archived reports from the Hudson's Bay Company, and a review of written evidence documenting environmental conditions or use of game by local peoples. When reviewing and assessing these sources, we focused on addressing one question: how did the distribution of caribou and moose change in the study area between the years 1800–1950?

Interviews.—We developed a number of criteria to identify and categorize potential participants for interview. Elders were defined as people whose parents and/or themselves resided in the study area at the time of the research, and who were respected by their peers or communities as exceptionally knowledgeable about wildlife and associated environments. The information from Aboriginal and non-aboriginal elders is equally weighted in the results.

We adopted a reputational case selection strategy to identify participants (Schensul et al. 1999). Potential interview candidates were nominated through the advice of 11 community experts with whom we had established relations through earlier research projects and who had been identified by community members themselves as experts. We asked the experts to nominate elders with knowledge of the historical distribution and abundance of caribou and moose in the region before 1950. We received 72 nominations and 36 names of individuals of Aboriginal ancestry and 4 non-aboriginal candidates. We chose to interview only those elders who received more than one nomination. This reputational selection technique resulted in the

identification of 12 Tl'azt'enne, three Nak'azdli and four non-aboriginal nominees.

We worked with a community researcher to pre-test the interview questions and process. The equipment for the interviews consisted of a digital voice recorder, a video camera, and topographic maps. We employed a semi-structured approach. This format allowed the interviewer to pursue sideline topics through additional questions, often leading to insights (Bryman 2004). During the interview, we used a guide, in the form of a checklist, to ensure that all of the focal topics for the research were discussed with the interviewee. We transcribed the interview files, applying minimal editing to improve grammar and fluidity.

Hudson's Bay Company journals.—The HBC journals represent a significant source of primary evidence of Canadian history (Moodie 1977, Catchpole and Moodie 1978). The type of HBC written records available for Fort St. James include post journals, correspondence books, correspondence inward, account books, reports on districts, list of servants, and other miscellaneous items. We examined approximately 3,000 pages and four reels of the Fort St. James post, unevenly covering 42 years of history from 1820–1825 (1M128), 1824–1830 (1M129), 1827–1856 (1M130), and 1892–1898 (1M1022). The remaining years of records, destroyed by fire, were unavailable.

Written sources.—We analyzed three other broad categories of written information describing the environment and fauna of the study area. This included written accounts of non-aboriginal explorers, travelers and early traders of Fort St. James who initially settled the study area (1806–1850); the written accounts of fur-traders, settlers and missionaries from 1850 onward; and recorded, transcribed, and sometimes published interviews of Native accounts of life and recollections of the past. This last source included the interviews published by the Nak'azdli Elders Society (2001) and archived projects conducted by Tl'azt'en Nation, as well as the published account of Lizette Hall on Dakelh life (1992). Additional information included a collection of interviews presented by McKay (*unpublished manuscript*) on caribou distribution in a portion of the study area.

Content analysis and summary of results

We used a structured analytical technique, content analysis, to identify key themes and ideas within the interview transcripts and the written sources (Berg 1998, Patton 2002, Bryman 2004). The main function of this method was to reduce large volumes of information into thematic units specific to the objectives of the research. Using key words as relevant thematic items, we identified material that suggested changes in the distribution or abundance of caribou and moose as well as causal reasons for that change. Key words included *caribou*, *moose*, *deer* and their semantic variations (e.g., *carribeaux*). Key words were often associated with indicator words. The latter provided no direct information on caribou and moose, though they often offered clues to the nearby presence of key words and/or pointed to relevant collateral information. Indicator words included *hunt*, *fur*, *skin(s)*, *return*, *mountains*, *antlers*, *moccasins*, *clothes*, *fires* and their semantic variations.

This process of data categorization occurred in three steps. First, each statement containing a key word was assigned a code, used to mark the statement in the transcript. Second, we analyzed each of the statements to determine whether it provided temporal and spatial references to historical observations of caribou and moose. Third, we placed the statement within an appropriate thematic category, such as *caribou distribution*. When statements lacked spatial or temporal references, we attempted to infer the information from the context of the statement or using collateral information.

Coded statements were linked to a geographic location. These locations provided the content for the spatial analysis and the mapping of the historical distribution of caribou and moose. In many cases, locations of caribou and moose were ascribed to specific topographic features referenced in the statement.

We summarized the temporal information as timelines of events of caribou and moose sightings. As several statements lacked temporal or spatial specificity, we used collateral information to estimate the part of the century to which it most probably belonged. Thus, expressions such as “my father’s time” meant that an observation may have occurred between 60 to 100 years ago. In the case of “my grandfather’s time”, the event

was pushed one generation into the past, hence in the second half of the 1800s or in the early 1900s.

Evaluation of sources

The sources of information had inherent strengths and weaknesses relative to their ability to document long-term changes in the distribution of caribou and moose. Few previous historical-ecological studies have performed a systematic evaluation of the spatial and temporal accuracy and precision or the information content of HBC journals, written primary sources, and interviews with long-term knowledge holders. A formal evaluation of each source provided a context within which to consider the biases and limitations of the findings and conclusions presented in this study.

Drawing from the methods and findings of others (Marshall and Rossman 1995, Creswell 2003, Bryman 2004), we developed four criteria for evaluating the three sources of historical information: output of data, temporal precision and accuracy, spatial precision and accuracy, and animal abundance. We defined precision as the measure of detail that a statement or source provided. For instance, a statement supplying a specific date of a historical observation was deemed precise. Accuracy was the degree to which the information reported was reliable, or error-free. We used triangulation to evaluate each source. This is an analytical process in which the information contained in one statement is compared against other sources. Collateral information from alternative sources can assist with the triangulation process, allowing the discovery of systematic or specific errors (Bryman 2004).

Output of data.—We evaluated the number of statements, or output, generated by each source. In a subsequent step, we explored the relationships between the total amount of information collected from each source, the overall quality of the information provided, and the effort required to collect and extract that information. We tabulated the quantity of statements by theme and assessed the efficiency of each source by comparing it with the others (Table 1).

Temporal precision and accuracy.—We used counts of the number of statements with a specific day, year, decade or some other form of temporal reference, such as parent or grandpar-

Table 1. Evaluation of interview-based Traditional and Local Ecological Knowledge, Hudson's Bay Company Journals, and written sources of evidence for explaining the historical distribution of woodland caribou and moose across the Nechako plateau of central BC, 1810–1950.

Evaluation criteria	Information source		
	HBC journals	Interviews	Other written evidence
Output and efficiency of data collection	<i>Poor</i> output and efficiency; 3,000 pages of records scanned resulted in 10 statements: 8 caribou, 1 moose and 1 miscellaneous. Gaps in records and legibility of journals made for difficult analysis.	<i>Good</i> output and <i>poor</i> efficiency; 52 statements: 18 caribou, 8 moose, and 26 miscellaneous. Interviews were time consuming and delay-prone.	<i>Good</i> output and efficiency: 25 statements: 17 caribou, and 8 moose. Sources were easy to locate and analyse, but variation in format and output among sources.
Temporal precision and accuracy	<i>Very high</i> : all statements related to a day of observation; type of record keeping suggests high accuracy.	<i>Low</i> : 4 temporally specific statements and 24 generic statements related to events or general periods of time.	<i>Medium</i> : 9 temporally specific statements, 7 statements with less-precise dates (~25–50 years), and 9 generic statements.
Spatial precision and accuracy	<i>High</i> : 5 statements with a specific geographic location and 5 statements describing a subregional location for caribou or moose. Specific animal locations referenced to successful hunting.	<i>Medium</i> : 10 statements with specific locations, 16 describing a subregional location, and 2 locations describing the distribution of caribou or moose at a regional scale. Some participants had detailed recollection of animal locations.	<i>High</i> : 10 statements with specific locations, 15 locations for the distribution of caribou or moose at a regional scale. Spatial accuracy and precision was dependent on the type of written source.
Document animal abundance	<i>Medium</i> : 5 statements describing numbers of caribou or moose and 5 statements for broad patterns of abundance. Provided detailed descriptions of small groups of animals hunted or encountered, but not of population trends.	<i>High</i> : 5 statements of specific population numbers, 23 of broad patterns of abundance. Participants largely focussed on broad historical changes in animal abundance.	<i>Medium</i> : 4 statements of specific population numbers, 21 of broad patterns of abundance. Most titles provided information on wildlife abundance at the regional scale.

ents age, to assess the relative precision of each source in providing the date that caribou or moose were observed. If statements were not related to a specific point in time they were defined as generic and thus considered valid either for the entire time frame considered by our study or classified as part of the 18th or the 19th centuries.

Spatial precision and accuracy.—We analyzed the spatial accuracy and precision of the historical information extracted from each source. Statements were referenced to a specific, subregional, or regional location, and precision of those locations were evaluated among the sources. A statement was deemed *specific* when it could be associated on a map to features such as mountains or small lakes; *subregional* when it was linked to a geographic feature on a larger scale; and *regional* when it lacked reference to a feature,

but nonetheless was located in the study area. As with the temporal criterion, the assessment of accuracy and objectivity was performed using triangulation.

Animal abundance.—Spatial ecology, conservation biology, and wildlife management is concerned with not only population distribution, but also abundance (Nielsen et al. 2004). Thus, understanding the total number or density of caribou and moose can provide additional insight into how the presence of those two species has changed over time. When addressing this criterion, we counted the number of times that each source provided a statement describing the abundance of either species. Statements that incorporated exact numbers of animals were of higher value whereas qualitative or descriptive expressions of abundance were considered less informative.

RESULTS

Content analysis of historical sources

Semi-structured interviews, HBC journals of Fort St. James, and historical written evidence each offered different interpretations of the history of caribou and moose in the study area. Results from the interviews suggested much larger populations of caribou in pre-contact and early historic times than those observed today. Interviewees suggested that caribou were common in the lowlands east of present Fort St. James, around Fort St. James and in the immediate vicinity of a number of local mountains (Fig. 2). Most participants reported that moose entered the study area at the end of the 1800s and were scarce until 1920–1930, at which point populations increased dramatically (Fig. 3). The decline of caribou began in the late 1800s and in the early 1900s, and in the opinion of many participants never recovered to match their historic distribution or levels of abundance.

HBC journals suggested moderate densities of caribou around Fort St. James. One statement reported the presence of moose in the area as early as 1832. The other written sources provided conflicting evidence, which appeared to depend on the cultural origin of the author or interviewee. The documents of early settlers and explorers upheld the idea that caribou populations in the lowlands were scarce, or at least not abundant enough to play a significant role in their sustenance. Moose were noted by non-aboriginals as being either absent from the area or present in very low numbers throughout the second half of the 1800s, with a marked increase in the 1900s.

Interviews.—We interviewed 10 First Nation and one non-aboriginal elder. Interviewees were more informative about the dynamics of caribou and moose in the study area than other sources. As examples of place and time specific observations, Interviewee 2 stated that caribou were present in the Stuart Lake region during the 1800s, and remembers hearing from elders that one population was wiped out in a single hunt in 1890. Interviewee 5, a non-aboriginal long-time resident of the area, remembers never having seen caribou south of the Wolverine mountain range, an area in the northern portion of the study area (Fig. 1). While sharing information

with ‘old-timers’ of the area, Interviewee 7 remembered the latter speaking about caribou being more abundant than in present times; specifically, caribou were found on Shass Mountain, Mt. Sidney Williams, and at a place called ‘Caribou Flat’. Interviewee 9 has a trapline near Whitefish Lake, approximately 45 km west of Fort St. James. She remembered her father talking about a number of caribou crossing around Whitefish Lake and being permanently present on Shass Mountain (Fig. 1). She also stated, “caribou were not there when I was growing up”. Interviewee 10 remembered many stories of past caribou abundance, but he did not recall witnessing caribou in the valleys and lowlands during his life. Interviewee 11, however, remembered seeing his first caribou in 1932, and stated, “there were lots then”, and, “that’s what my grandfather’s fathers hunted, and they were all over.”

Interviewee 1, a Tl’azt’enne participant, recalled elders speaking about the first time hunters saw moose tracks: “They followed it for two days, catch it, and then invited all the people. After that, the moose came, little by little”. Her statements were corroborated by Interviewee 2. His grandfather and others “had followed it [a moose], and, after few days, had killed it.” Between that date and the 1920s–1930s this elder maintained that moose were not found in the area in any number. Interviewee 4 remembered that in 1898 his uncle killed the first moose. He also stated “there weren’t much [moose] at the time, that’s when they started.”

Interviewee 5, the non-aboriginal guide, recalled ‘old-timer natives’ talking about eating beaver, and that moose was “a new delicacy” when it finally moved into the area. Interviewee 6 mentioned again a ‘first time’ when a moose was killed. The recurrent theme of a ‘moose first kill’ implied that at the time such an event created a sensation in the community: “I was a child [...] they had heard that somebody had killed a moose thirty miles from Fort St. James”. Interviewee 7 described a similar event occurring in 1911. He recollected his uncle saying “they followed a moose that crossed Nation River for seven days, at which point they killed it”. Interviewee 8 recalled how her father saw a moose for the first time while freighting cargo for the HBC from Prince George to Fort St. James.

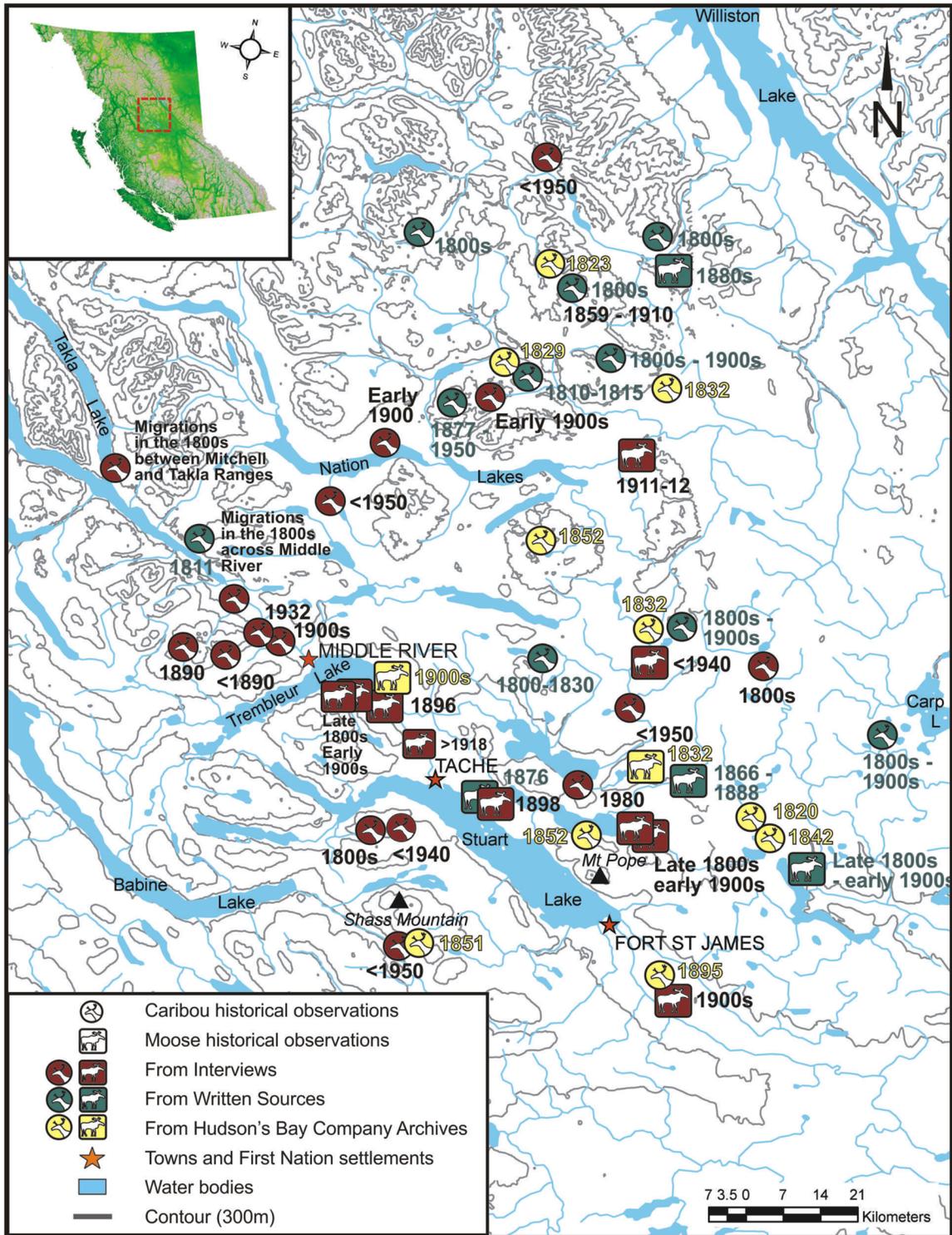


Fig. 2. Historical observations of the distribution of caribou and moose across the Nechako plateau, BC, 1810–1950. Locations were collected using Traditional Ecological Knowledge, Hudson’s Bay Company journals, and other written sources.

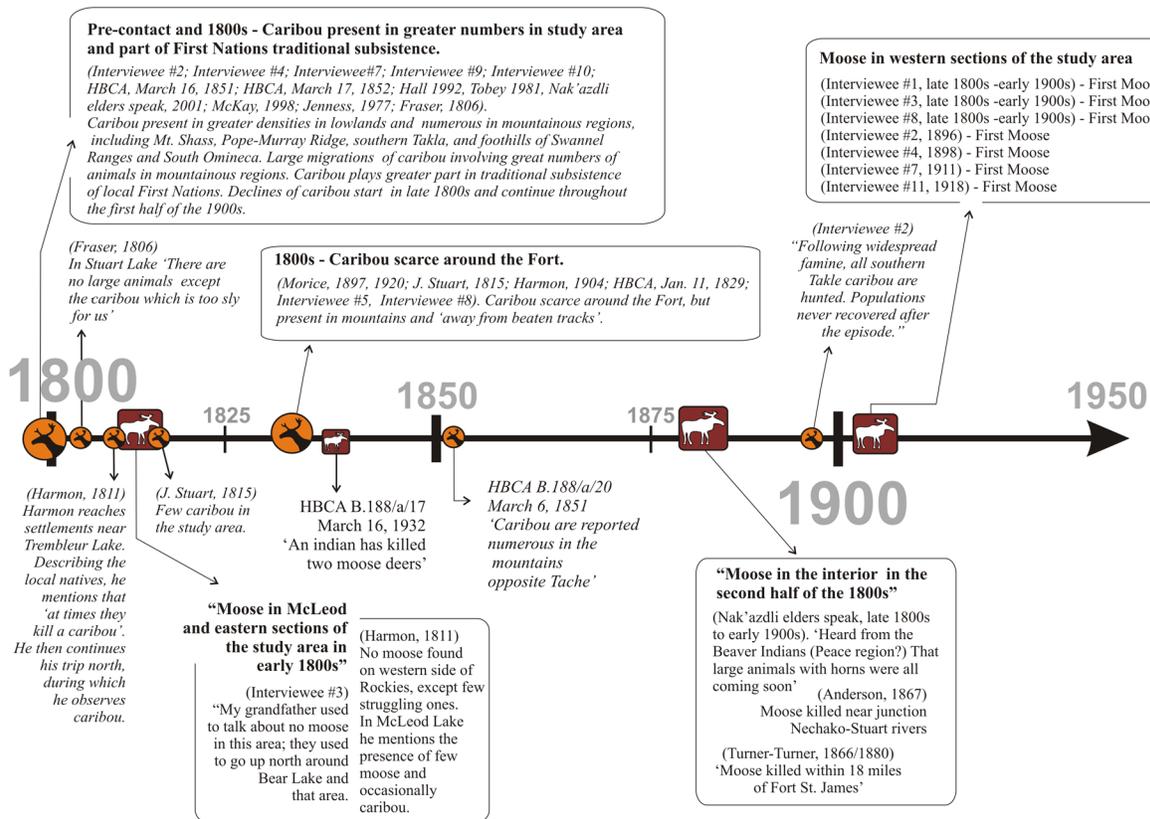


Fig. 3. Time line and corroborating statements representing the historical distribution of woodland caribou and moose across the Nechako plateau, BC, 1810–1950. Temporal information was collected using Traditional Ecological Knowledge, Hudson's Bay Company journals, and other written sources.

Shortly after that occasion, "moose started to come. No matter how far you'd go, you would kill a moose". In her opinion, however, the Dakelh knew about moose before that event, as Native traders from her community used to go to "Cree country" to trade foodstuff and goods for moose hide. Yet, Father Adrien Gabriel Morice, who lived in the area from 1885–1904, and learned the local language, noted that travel to 'Cree country' was rare: "owing to the natural barrier... they [the 'Carrier'] never had much contact with them [the Cree]" - and mostly dealt with Cree 'half-breeds' who were employed by the HBC (Morice 1892:111).

Hudson's Bay Company journals.—We reviewed approximately 3,000 pages of post journal covering a 50-year period, identifying only 10 relevant statements concerning caribou and moose. Eight of those statements were related to caribou and

one was attributed to "deer", though it may have referred to caribou. One statement referenced moose: "killed two moose deers" (Fort St. James HBC journals, B.188/a/17, March 16, 1832). However, the same statement was interpreted by Hudson (1983) as a caribou rather than a moose.

The HBC journals of Fort St. James suggested that caribou were scarce in the lowlands surrounding Fort St. James, and more abundant in surrounding regions. The statements "... caribou are reported to be numerous in the mountains opposite Tache" (Fort St. James HBC journals, B.188/a/20, March 6, 1851); and: "Prince and Brother [...] have made a good hunt of caribou and a few furs" (Fort St. James HBC journals, B.188/a/20 March 17, 1852; Prince is a common surname among First Nations in this area), suggested that caribou were occasionally found

in large numbers. In another statement, caribou were observed as close as Pinchi village on the shores of Stuart Lake: “Indians gave in a few bustards they also killed a caribou at the village along the Lake” (HBCA B.188/a/20, October 16, 1852). The ‘mountains opposite Tache’ and ‘village along the Lake’ offered clues to the presence of caribou on Shass Mountain and in the Mt. Pope-Murray Ridge area, respectively (Fig. 1). Caribou were also reported from less mountainous portions of the study area, such as Carrier Lake, about 25 km east of Fort St. James.

Written sources.—One of the earliest published sources of information concerning caribou and moose in the study area are the accounts of Harmon (1904 [1820]), who spent most of the second decade of the 19th century at Fort St. James. During his travels in the region, he wrote of caribou: “their principal food consists of salmon, white fish, and trout; and they, at times, kill a beaver, or a caribou” (Harmon 1904:179). The lack of supplies dictated by the cyclical nature of the salmon run was a recurring theme in the accounts of early explorers and traders (Harmon 1904, Lamb 1960). We must assume that in the first decades of colonization the traders of New Caledonia were faced with considerable hardships in finding sufficient provisions. Simon Fraser (in Lamb 1960) wrote in 1806 from the vicinity of Stuart Lake “we have nothing to expect but dry salmon [...] there are no large animals except the Carruban [caribou] which is to sly for us” (Lamb 1960:326). Such statements confirmed that caribou if not numerous, at least were known in the area. Some records, however, suggest a higher abundance.

The presence of moose in the area seems to be confirmed for the second half of the 1800s in a statement collected by Anderson (1872): “moose killed near the junction of Stuart and Nechako rivers” and by Turner-Turner (1888): “moose ... killed within 18 miles of Fort St. James”. Father Morice also mentioned both caribou and moose in his writings, noting that both were key subsistence species, having allegedly replaced elk, which the ‘Carrier’ avowed had previously inhabited the area, but had disappeared from the area long ago (1893:93). Furthermore, Morice (1910:139) observed how caribou and moose flesh could be “procured at a distance from

beaten tracks, or near the mountains”. Yet he also noted that “[m]oose are rare with the Carriers’ territory. . . . Therefore, with that tribe, mocassins, mittens and gloves, bags, etc., are almost exclusively of caribou skin” (1893:146). Morice’s accounts cover the Tsay Keh Nay, who live north of the region, and the Tsilhqot’in, who live to the south, and where he talks of moose providing skin or meat, it may be that he was referring more to these regions than that of the Fort St. James area. He noted tools and ornamentation made of caribou antler, but did not mention use of moose for such (1892:115; 1893:68, 69, 170). In his accounts of Dakelh (Carrier) myths, caribou were mentioned, but not moose (1892:125, 126; 1893:171; 1895:31–32). These details suggested that moose, while available, were relatively new to the area during Father Morice’s time.

Other sources deriving from Native accounts such as the set of interviews collected by McKay (*unpublished manuscript*) and the Nak’azdli Elders Society (2001) suggested that caribou numbers in the pre-contact period and early 1800s were much greater than they are today: “as I mentioned earlier there were no moose, but there were plenty of caribou, elk and some deer” (Hall 1992:18). “As I have been told, the caribou gathered in a herd of hundred or more. They fed in the lowlands. They were everywhere, and people killed these animals with bow and arrows” (Nak’azdli Elders Society 2001:54).

In the collection of ‘Elders Stories and Legends’, located in the Tl’azt’en Nation Archives, we found several references to both caribou and moose. In the traditional subsistence section of the records, one interviewee stated “moose came in 1913”. Another elder, speaking of times of starvation, commented on a hunting expedition for caribou in the mountains. On a tape dated 1987, also from the Tl’azt’en Archives, a Tl’azt’en elder recounted a legend named “Been Married to Caribou”.

The unpublished and confidential set of interviews of First Nation elders conducted by McKay (*unpublished manuscript*) provided valuable information on past distribution and abundance of caribou and moose in the central and western portions of the study area. Several elders suggested a remarkable theory for the historical distribution of caribou populations in the area. Named the ‘Grand Herd Theory’, the elders

explained how in the 1800s caribou migrated in great numbers across the north end of Takla Lake. The latter was deemed, in historic times, optimal caribou habitat, before settlers “burned and tilled the land” (B. McKay *unpublished manuscript*:4). The same elders also mentioned a herd composed of approximately 200 caribou, seasonally inhabiting Murray-Ridge and Mt. Pope, near present Fort St. James; an area where caribou are no longer found (Fig. 1).

McKay (*unpublished manuscript*), drawing from the comments of his interviewees and his own knowledge, concluded that caribou populations were much larger than today. Proof of larger herds, migrations, and an extended range across the whole Rocky Mountain trench were not only found in Traditional Ecological Knowledge gathered from elders, but also from old game trails, where hooves from ungulates resulted in paths cut ‘twelve inches deep’ in the forest floor. McKay (*unpublished manuscript*) hypothesized how such migration ceased because of anthropogenic obstacles to movement, overhunting, increased number of moose and wolves, industrial activities and changes in natural disturbance dynamics.

Evaluation of sources

Output of data.—Interviewees provided the largest number of references to the location or abundance of moose and caribou. We obtained 52 relevant statements, of which 18 related to the historical distribution of caribou, 10 to moose, and the remaining 24 contained collateral knowledge on caribou migration routes, traditional uses, and other relevant information (Table 1). The interview process was fraught with challenges and represented one of the most demanding components of this project. During summer months, elders were occupied with the salmon run, vacation, or resided on their trapline; thus, it was difficult to schedule interviews.

From the estimated 3,000 pages of written records contained in the HBC journals, we obtained eight statements related to caribou, one to moose and one to ‘deer’. While several references to the key word ‘moose’ are present in the journals, we recorded such mentions only when related to an actual observation, not when moose was mentioned as a trade good. The limited number of statements suggested that the

post journals were the least efficient in terms of the number of results relative to the volume of information analyzed. The process of gathering and scanning approximately 3,000 pages of HBC journals lasted one month. Content analysis was slowed by illegible handwriting, missing pages, and the discontinuity in the years of records available.

The written sources provided 25 statements, of which 17 related to caribou and eight related to moose. The descriptive works of missionaries and early explorers accounted for the largest amount of data. Overall, this was a very efficient source of information as written works were easily located, accessed, and reviewed. Also, these sources were often cross-referenced within other works.

Temporal accuracy and precision.—Considering the amount of information recalled and the length of time since the original observations, the memories of the Elders provided accurate depictions of the past. Of 28 statements, four were associated with a specific date, while 24 described events with terms such as ‘my father’s time’, or ‘long ago’. Using collateral information, we were able to assign generic dates to a further 18 statements. When compared to other written sources, however, the temporal accuracy and precision of the interviews were low (Table 1). Conversely, while the interviews possessed less temporal specificity than written sources, they provided a more continuous narrative of historical-ecological events.

The temporal precision of the HBC journals was the highest amongst the sources. The journals were written daily; therefore, all statements could be referenced to a specific date. However, most of the information concerning the location or number of caribou or moose was attributed to a third party observation, such as “Dechanyai killed a reindeer”. Consequently, there might be a gap between the time of actual observation and that reported in the journal, which would influence the temporal accuracy of the record.

Of 25 statements extracted from written documents, six statements for caribou were related to a year, seven offered less specific descriptions, and four had a generic time reference. For moose, three statements provided a year, two were less specific and three were

generic. Diaries and accounts of early explorers figured amongst the most precise and accurate sources of information, as they occurred in a structured document similar to that of the HBC journals. However, triangulation with other sources suggested that the statements contained in works by settlers and missionaries were redundant with other observations. Lastly, interview projects, notably McKay (*unpublished manuscript*), have the same temporal precision, accuracy, and objectivity as the project-specific interviews.

Spatial accuracy and precision.—The elders demonstrated excellent spatial memory of the events they described, due to their familiarity with the study area. Of the 18 caribou statements provided by the interviewees, eight were spatially specific, nine subregional, and one regional. Statements for moose were characterized by less spatial accuracy: two were specific, seven were subregional, and one was regional.

Statements taken from the HBC journals had precise spatial references: five out of 10 statements were specific, while the remaining statements were subregional. However, observations were mostly secondhand information such as: “All the Indians have now left here for their several hunting grounds—caribou are reported to be numerous in the mountains opposite Tache” (HBCA B.188/a/20, March 6, 1851). Thus, the precision of the information contained in the HBC journals was dependent on the source of the statement, rather than the author of the journal.

Five statements identified in written sources provided specific geographic references for caribou and 12 were subregional. The ratio was more favorable for moose; of eight statements, five provided specific information, and three were subregional. Overall, the written sources we consulted provided moderate spatial accuracy, although there was considerable variation among titles.

Animal abundance.—Of 18 statements for caribou identified in interviews, three provided abundance estimates, while the remaining 15 described population numbers in more general terms. For moose, two statements provided the number of individuals and eight had some qualitative description of abundance (Table 1). Moose ‘first sightings’ were generally described in more detail than were other observations.

Because of the commercial nature of the HBC, and perhaps because of the scarcity of provisions for the fort, the statements of the HBC journals provided detailed descriptions of animal abundance. Of 10 statements, five reported exact numbers, while the remaining five were more generic. As an example: “Indians shot 3 caribou beyond Carrier Lake” (HBCA B.188/a/19 February 12, 1842).

The overall precision of written sources in documenting the historical abundance of caribou and moose was poor. Of 17 caribou observations, 15 were generic and two provided specific numbers. The ratio is slightly higher for moose, though still below the average of other sources: two specific and six generic. The sources varied in their description of abundance. For instance, the diaries of Harmon (1904) offered accurate descriptions of single observations, but lacked the spatial and temporal breadth of observations reported by the interviewees.

DISCUSSION

Relative to present-day range occupancy (Poole et al. 2000, Johnson et al. 2002), the various sources we analyzed confirmed that caribou had widespread distribution across the upper Nechako Plateau, and were present in mountainous terrain as close as Shass Mountain and Mt. Pope, only a few kilometers from present Fort St. James (Fig. 1). Some sources suggested that caribou even demonstrated seasonal migration in large groups—behavior no longer observed in this portion of their range. Based on our understanding of the contemporary ecology of moose and caribou (Johnson et al. 2002, Nielsen et al. 2004), however, it is unlikely that the entire population of either species migrated beyond the boundaries of the study area. Thus, there were likely opportunities to observe caribou and later moose throughout the year.

Historical accounts by Aboriginal people revealed that caribou previously inhabited the study area in far greater abundance than today. Furthermore, our interpretation of the evidence suggested that caribou played an important role in the culture and traditional subsistence of First Nations of the study area, perhaps more so than what was previously assumed by other researchers (Hudson 1983, Morton 1988, Klippenstein

1992). Alternatively, Euro-Canadian historical records reported a lower density of caribou. Thus, what appeared abundant to Aboriginal peoples might have seemed scarce for non-Aboriginals. These differences in the knowledge of caribou distribution and abundance may be attributed to the Carrier people's superior knowledge of the land and associated fauna that they hunted for many generations before Euro-Canadians arrived.

Although the sources of information we investigated were informative, the exact causes and dating of range contraction for caribou remain mostly unknown. Our results suggest that sometime during the second half of the 1800s caribou disappeared from the vicinity of Stuart Lake, and became available to hunters only in the mountains and outside "the beaten tracks" (Morice 1910). Their rate of decline likely increased in the 1900s, until caribou range contracted to the present distribution across mostly mountainous habitats (Fig. 1).

The majority of the information suggested that moose were either absent or extremely rare in the study area until the 1900s, at which time they began to increase in numbers. Early sightings might be attributable to isolated animals wandering in the region from neighboring areas with established populations: "sicannies [Sekani] ...they remain on this side of the mountain where they find buffaloes, moose and deer. On the other side [i.e. the western], none of these animals except a few struggling ones are to be found" (Harmon 1904:156). Interviewee 9 described how 'before' moose arrived, "they used to go from Fort St. James to Cree country where they traded dried black bear and other goods for moose hides; they "never saw a moose but they did buy moose hides from them". 'Cree country' almost certainly referred to regions east of the Rockies. During the 1800s, moose were abundant in the Peace region, but only sporadically sighted on the ranges east of the Nechako plateau (Spalding 1990). In 1813, Harmon observed plentiful populations around present Fort St. John (Spalding 1990:3), where moose were hunted to supply dried meat and hides for the posts of the interior of BC.

No evidence from the sources we investigated supported the presence of moose in the western sections of the study area in the first half of the

1800s. The numerous and apparently significant reactions in the Native communities to the first sightings of moose cannot be dismissed easily. Whereas some Tl'azt'en and Nak'azdli might have recognized moose as being a trade item available from the east, the appearance of moose in the study area was not noted before the late 1800s or the early 1900s. Thus, we must conclude that, moose were practically absent from the study area during the 1800s.

Hypotheses of caribou decline

Caribou gradually abandoned the lowlands of the upper plateau of the interior of BC during the 1800s and the 1900s. During that period, caribou were reported as being available only in the mountains or, as Morice recollects, "at distance from beaten tracks" (1930:66–67). Across the three sources of historical ecological information, numerous authors and interviewees proposed causative mechanisms for the contraction of caribou in the study area. Although these reasons varied amongst the sources and were not supported by compelling evidence, they could serve to guide further investigation. We divided the various mechanisms of caribou decline into three broad hypotheses focused on (1) habitat change and loss, (2) excessive human harvest, and (3) increased predation.

A decrease in the availability of seasonal habitats for caribou might have occurred as a result of localized variation in climate and weather or as a result of anthropogenic disturbance such as logging and fire. Grayson and Delpech (2005) proposed that periods of warming corresponded to decreases in caribou range as a result of changing vegetation communities. Increasing snow depth or hardness is also known to influence the feeding habits of woodland caribou during winter (Johnson et al. 2002, Adams 2005). Hudson (1983:45, 65) noted that for our study area the 'little ice age' ended in 1850. In Hudson's opinion (1983), this climatic shift was directly linked to the decline of caribou in the region. Unfortunately, there is very scarce documentation of climate changes in this region during pre-contact times.

Laliberte and Ripple (2004) detailed how the richness of North American fauna declined following Euro-American settlement over the last two centuries. Industrial activities and land

clearing are recognized as primary causes of the contemporary declines in caribou (Oberge 2001, Dyer et al. 2002, Schaefer 2003, Vors et al. 2007). The importance of anthropogenic modifications of the environment in our study area was, nonetheless, difficult to correlate to a direct decline of caribou. Several gold rushes in BC (1858, 1862, 1866, and 1869–73) brought fortune seekers to the central and northern parts of BC. Although some of the miners passed through the study area, their numbers and the impact they might have had on local wildlife is unknown. The early 1900s were also characterized by an increase in settlements throughout the Nechako Plateau and Bulkley Valley to the west.

New legislation limiting Native's rights to resources, the decrease in profits from the fur trade, epidemics decimating the First Nations population, and failures in salmon runs, critical for subsistence, all contributed to the northern Dakelh shifting from subsistence hunter-gatherers and trappers towards laborers (Hudson 1983, Klippenstein 1992, Brown 2002). The effects on wildlife of such socio-economic dynamics were complex. In the case of our study area, the disruption of traditional Native systems of resource stewardship caused by these events (Brown 2002) may have increased unregulated hunting and provoked the adoption of a more competitive hunting ethic, with large numbers of First Nations people and fur traders alike concerned with immediate survival or profit rather than long-term stewardship. Similarly, increases in the population in Fort St. James during the 1900s added pressure on ecological systems already strained by almost a century of fur trade. Starting in the 1940s, the study area saw significant growth in logging and mining (Morris and Fondahl 2002). Other regional developments such as agricultural settlements in the Bulkley Valley, to the west of our study area, might have had negative repercussions for ecosystems as well.

The second hypothesis, over harvest, has been implicated in the decline of other caribou populations within and beyond BC (Bergerud 1974, 1978; Spalding 2000). Some of the statements from our research imply that over harvest during periods of food scarcity might have played a role in the eradication of local caribou. Interviewee 2 talked about a famine occurring in

1890, after which the entire herd of southern Takla was killed ("60–70 of it") to satisfy the needs of people in the region. Hudson (1983) documented how in 1888 the scarcity of furbearers and other food species, the failure of salmon fisheries, and unprecedented mildness of the winter of 1887–1888 underpinned profound socio-economic and cultural transformation for the Tl'azt'enne. Thus, hunting of caribou in times of severe game scarcity might have played an important role in the decline of certain populations. The notion of Aboriginal over-harvest has been extensively discussed by Kay (1994, 1997), Martin and Szuter (1999) and Laliberte and Ripple (2003). Kay (1997) suggested that the distribution of moose in the interior of BC had been controlled by Aboriginal hunters, who kept this species in check through systematic harvesting. In Kay's (1997) opinion, the observed increase in the abundance of moose through the 1900s was a result of the decline in First Nations populations following European-introduced diseases. We did not find significant evidence supporting Kay's (1997) hypothesis of Aboriginal over-harvesting of moose, though over-harvest may have played a part in the localized decline of caribou.

A change in the predator-prey dynamic is now a well supported explanation for recent declines in caribou populations (Wittmer et al. 2005). The theory of apparent competition suggests that although moose do not compete with caribou for forage, they do support widely distributed and abundant wolf populations (Wittmer et al. 2007, DeCesare et al. 2010). Wolves feed opportunistically on caribou, but there is no relationship between the density of caribou and wolf productivity. Thus, the availability of more abundant moose allows wolves to maintain high rates of predation on caribou even when caribou populations are at very low densities.

McKay's (*unpublished manuscript*) and several other interviewees provided evidence supporting the hypothesis that predator-prey relationships changed across the study area prior to contemporary scientific investigations (e.g., Poole et al. 2000). One interviewee suggested that caribou declined as a result of the arrival of moose, while others explained that the decline was a result of an increase in predation. A statement found in *Nak'azdli Elders Speak* (2001) highlights how

caribou were getting scarcer in the study area at the time moose arrived: “At this time the *Lht’at’en* people (Sekani) told the people here that it was heard from the Beaver Indians, that large animals with horns were all coming soon. Now at this time the caribou moved from the lowlands to the mountain country [...] caribou were getting scarce” (Nak’azdli Elders Society 2001:55). Given the limited amount of information available, however, the timing of the arrival of moose and their impact on caribou is unclear. Furthermore, there seemingly is a temporal gap of a decade or more between the years of an established moose presence in the region (the 1910s–1920s), and the decline of caribou in the areas surrounding Fort St. James in the late 1800s. This gap suggests that factors other than moose influenced the decrease of caribou, though the latter might still have played a secondary role during this transition period.

Evaluation of the sources

Among the sources of historical information and knowledge that we reviewed, interviews yielded the largest volume of data on the distribution of caribou and moose. While this source had inferior temporal precision relative to Hudson’s Bay Company journals, it provided high spatial accuracy and a broader perspective, including plausible causes of change. The disadvantage of the interview process was the time and financial costs of conducting interviews.

Considering the challenges involved in remembering decades-old events, the large number and the high quality of the statements provided by the elders confirmed the value of Traditional Ecological Knowledge in historical-ecological research. Nonetheless, because of the long period that this study considered, the elders’ memories were liable to be less precise in temporal terms than sources of written information. External influences such as conversations with other researchers, mass media and peers might also have exercised some degree of influence on the elders’ recollections. Such influences are a natural component of human societies and one of the reasons why Traditional Ecological Knowledge evolved as it is today. As Pierotti and Wildcat (2000) stated, although the Traditional Ecological Knowledge of First Nations is called ‘traditional’, it should not mean that it cannot change. Rather,

each generation makes observations that are incorporated with what they were taught, and make experiments with its reliability.

The HBC post journals of Fort St. James have been employed in almost all publications concerned with the history of the study area (Hudson 1983, Morton 1988, Klippenstein 1992, Spalding 1990, 2000). This source of information has served a prominent role in similar studies across Canada (see Catchpole and Moodie 1978, Catchpole et al. 1981). There are several reasons for the widespread use of the HBC journals in historical ecology. The journals provide information such as daily observations on weather and fur returns in a systematic manner that fits within most standards of scientific research. The commercial nature of the HBC limits the amount of personal statements and opinions in favor of ‘facts’. In addition, the journals are available for a variety of geographic locations and they are consistently reported in the same format.

Despite the apparent value of this source, we obtained only 10 statements after close to a month of review. Furthermore, there were potential biases including the limited knowledge held by the company employees of the surrounding environment, their prejudiced view of the local First Nations, and, at the same time, their reliance on the latter for subsistence, at least in the first decades of the Fort (Klippenstein 1992). Despite these issues, the temporal precision of the HBC journals was the highest amongst the sources we examined.

Written sources offered the second largest contribution in terms of quantity of information. The works of explorers and fur-traders operating in the early decades of the 1800s formed the bulk of this material, though the quality of the information made these sources less useful than interview projects such as that of McKay (*unpublished manuscript*). In terms of spatial and temporal precision and accuracy, these sources shared comparable attributes to the HBC records. The utility of these sources, however, varied greatly depending on the type of document and the corresponding geographic and cultural focus. For example, early colonialists and explorers often documented observations and ideas distinctive of the new frontier: minimal knowledge about the surrounding region, search for suitable places to settle and trade, biased curiosity about

local First Nations, and meticulous descriptions of the environment traversed during travels. Also, each source had a particular geographic focus which influenced its utility for this study. Fort St. James, as the former centre of the district of New Caledonia, often was the focus of discussion. Other parts of the study area, such as Takla Lake or the north were less explored by Euro-Canadians. The written documentation of First Nations Elders provided a broader geographic scope and from a different cultural perspective.

Implications for conservation

Understanding the long-term dynamics of ecosystems is essential for guiding restoration activities, including the recovery of species (Bjorkman and Vellend 2010). In the case of conservation planning for woodland caribou, one might argue that recent patterns of observed decline and extirpation are the result of long-term processes. Changes in the distribution of moose and wolves and ultimately predation on caribou may be the outcome of naturally occurring events. Although overharvest, industrial disturbance, and habitat change are co-occurring or, in the case of habitat change, a contributing factor to the predator landscape (Poole et al. 2000, Serrouya et al. 2011), there is very little consolidated evidence documenting the timing or rate of development of those processes. With few exceptions (e.g., Vors et al. 2007), we can describe the responses of caribou populations over the last 20–30 years only.

In contrast to scientific studies dependent on techniques such as radio-telemetry and population estimation, interviews, HBC journals and other written evidence provided a much longer chronology of the distribution of caribou and moose. These sources of historical information revealed environmental and socioeconomic changes through the 1800s and the early 1900s. Such complex dynamics acted concurrently and likely influenced the distribution of caribou and moose as observed today. During the last decades of the 1800s, woodland caribou abandoned the areas surrounding Fort St. James. Moose, previously absent or rare, became a common sight in the first half of the 1900s, occupying former caribou range at low elevations throughout the study area. The mechanisms

causing the decrease in caribou and concurrently the increases in moose during the last decades of the 1800s and the early 1900s are unclear.

Drawing on our current knowledge of predator-prey dynamics in these ecosystems, apparent competition involving caribou, moose, and wolves likely played a role in the decline of caribou (DeCesare et al. 2010). However, various statements suggested that humans were exercising an increasing influence on local environments from the onset of the 1800s. Trapping increased as new settlers populated the study area; caribou, one of the only big game species during the 1800s, was taken when encountered. Cultural and economic changes affecting First Nations societies during the same period might have contributed significantly to increased human predation on caribou. The disempowerment of traditional systems of governance for First Nations and the imposition of Indian Reserves and game laws changed long-standing patterns of human occupancy and resource use (Hudson 1983, Brown, 2002). Such changes may have manifested as an increase in unregulated hunting and habitat modification, with a subsequent decline in caribou.

Our interpretation of historical evidence suggests that humans played a role in determining the contemporary distribution of caribou and moose. This pattern is consistent with other observations of historical declines of large mammals across North America (Bergerud 1974, Ceballos and Ehrlich 2002, Laliberte and Ripple 2004, Mattson and Merrill 2002) including woodland caribou (Schaefer 2003). From a contemporary scientific perspective, these changes are long-term or 'historical'. The absence of purely evolutionary forces acting on caribou populations suggests that conservation action is warranted for caribou, greater than 100 years after the beginnings of change.

Our research demonstrates the efficacy of various sources of information that contribute to an understanding of historical-environmental change. Considering the expanding temporal scope of ecological research when documenting climate patterns, understanding declines in species abundance and distribution, and setting objectives for restoration these sources hold much promise for revealing long-term patterns (Rhemtulla et al. 2009, Bjorkman and Vellend

2010). And as we have demonstrated, these sources are not only useful for documenting the ecology of changing systems, but also the history and geography of human populations that influenced those systems.

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