Assessment of Human Population Carrying Capacity Prior to European Influence and Trade of the Brittany Triangle and Xeni Gwet'in Trapline Areas in the Nemiah Valley, British Columbia (the "Claim Area")

Assessment by:

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Purpose of this Report

This report summarizes the findings of a study undertaken by Dr. Mathis Wackernagel to assess the human carrying capacity of the Brittany Triangle and Xeni Gwet'in Trapline Areas in the Nemiah Valley, British Columbia (otherwise known as the "Claim Area") for a human population around 1800, prior to European influence and trade.

Key Conclusions

By taking six different approaches of assessing the carrying capacity of the Claim Area prior to European influence and trade, I conclude that the Claim Area supported a human population most likely on the order of 100-1000 people. The carrying capacity of the Claim Area was less likely to be in the range of 1,000-10,000 people, and also less likely to be in the range of 10-100 people.

Structure of the Report

The report is divided into the following sections:

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1. Statement of Qualifications

Expertise of Mathis Wackernagel, Ph.D.

Trained as an energy systems engineer and regional planner, my professional work has centered on assessing the resource metabolism of societies. I co-developed a scientific approach for assessing human carrying capacity. This approach, called “Ecological

Footprint" essentially consists of a resource accounting tool that allows researchers to compare human demand on nature with nature's ability to regenerate these resources. The purpose of this tool, which is now in use worldwide, is to measure how much productive land area is necessary to maintain a given human population's resource consumption. Most of my work has focused on industrial societies, primarily since the requisite data are readily available; however, the Ecological Footprint method is applicable to any human society. The study of energy balances – that is, examining the supply of and demand on the regenerative capacity of ecosystems – is equally applicable to any time period, provided that the data are available.

I currently serve as Executive Director of Global Footprint Network, an international non-profit that seeks to continually improve the scientific methodology of the Ecological Footprint and to standardize the way it is applied (see C.V. for details).

2. The Geographic Area Considered

The total Claim Area is approximately 4,300 square kilometers. It is composed of two overlapping areas: the Brittany Triangle, an area between the Chilko and Taseko Rivers, which covers approximately 155,000 hectares (1,550 square kilometers); and the Traplines area, which covers some 332,000 hectares (3,320 square kilometers).

3. Background for this Analysis: 'Answerability' of the Research Question and Key Concepts

Woodward and Company asked me on behalf of Chief Roger William to provide my expert opinion on human carrying capacity in the Claim Area, and to develop an upper estimate of the population density of the Claim Area for 1800, considering the technology and resource management system used then by that culture. Through discussions with Jack Woodward the question was slightly modified from "for 1800" to "before European influences and trade."

Because the parameters of this question are clearly defined and measurable, it can be answered through scientific research if the relevant data is available. In other words, the question is neither hypothetical nor conceptually speculative.

Clarifying the concept of "carrying capacity"

The research question focuses on 'human carrying capacity.' In the scientific literature, and particularly in the life sciences, the idea of 'carrying capacity' has been defined to mean the maximum population of a given species that can be supported over time within a certain geographic region. Carrying capacity is calculated from several measures. First is a measure of gross resource availability within a certain area – in other words, how much food or other resources are available for a certain population to consume. The second measure has to do with the efficiency with which the population converts these 'raw' resources into 'usable' ones. And finally, there is the demand for these resources for each individual within the species. These three measures together can be used to estimate the overall theoretical maximum population that can be supported.

While carrying capacity is a theoretical number, it is not hypothetical or conceptually speculative.[1] In essence, it amounts to establishing a 'resource balance' or 'mass balance' between resource availability and human consumption (for a more detailed explanation, see box below). However, carrying capacity is often stated as a range of numbers, and not as a single value, because it cannot always be determined with precision. As with any science, the accuracy of certain measurements is never 100%. Nevertheless, a lack of precision in carrying capacity does not mean that the concept is vague or ill-defined. The idea is quite simple: The food eaten by a population must come from somewhere, and the resources base that provides that food is limited by certain known factors.

From carrying capacity to "biological capacity"

In the case of people, it is generally more useful to talk of 'biological capacity' (also termed 'biocapacity'), as opposed to carrying capacity. Biocapacity is defined simply as the resources available for human consumption – i.e., food, fuel and fiber. This concept is very useful for two reasons. First, the consumption level per person can vary depending on the quantity and quality of what people consume. For example, carrying capacity can be effectively increased if per capita consumption goes down; and conversely, carrying capacity can be effectively decreased if per capita consumption goes up. Given this variability, it is therefore more practical in the course of scientific analysis to study biocapacity itself, because it is the *currency* of carrying capacity.

The second reason is that people's demand on nature is not necessarily constrained solely by the biological capacity of the region in which they live. An animal's immediate surroundings or habitat are typically the basis for measuring animal carrying capacity. Humans, however, are different from most other species in the Animal Kingdom because humans are able to import resources from other places, thus confusing the biologist's conventional understanding of carrying capacity. While the globe's overall carrying capacity is, of course, finite, international trade can effectively alter a nation's carrying capacity. Thus, biocapacity is often a more useful object of study than carrying capacity. For instance, in a series of reports I co-author, WWF (World Wide Fund for Nature)'s *Living Planet Reports*, we document the biocapacity (and not carrying capacity) in 150 countries around the globe.

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[1] Ronald Wright provides a succinct introduction to a ecologically based history of humankind in his 2004 Massey Lectures "A Short History of Progress". It is one that recognizes the role of biophysical limits and its implication for the emergence and decline of civilizations. More detailed human ecologies are presented by Diamond (1997) and Flannery (2001).

In the period before European influence and trade, with more limited capacity for long-distance transportation, the imported fraction of First Nations' overall consumption was relatively modest, particularly in comparison with current Western standards. For the traditional Xeni Gwet'in, there was never an option to import spices from Southeast Asia, rice from India, fruit from New Zealand, or meat from Costa Rica. In other words, the biocapacity of the Xeni Gwet'in's immediate surroundings composed the primary limitations on the population's size. Knowing the Claim Area's biocapacity and estimating the First Nation's consumption level and type of technology allows resource scientists such as myself to estimate the maximum population number supportable in the Claim Area.

In this report, I use the notion 'carrying capacity of the Claim Area pre European influence and trade' as a short cut for 'the number of people the Claim Area was able to support with its biocapacity, recognizing the consumption patterns, the prevalent technology, the resource management strategies, and the trade patterns that typified life in the Claim Area pre European influence and trade.'

Establishing a resources balance for a human population

For any human population, the resource balance follows a simple comparison of supply and demand:

Resource balance

- Human demand for biological resources -- food, fuel, fiber, etc. (in other words, the society's metabolic requirements);

versus

- The Claim Area's effective supply of resources.

***Effective supply of resources** = product of:*

- Biological supply (biological productivity of the region for resources consumed by human societies);

times

- technological efficiency for taking advantage of supply, which is made up of:

    a) harvest efficiency (the percentage of available biological productivity that can be harvested from the region, given prevailing tools and technologies available to the culture at that time) and

    b) transformation efficiency (the percentage of harvested resources that are finally consumed rather than lost in harvesting, processing, storing, and preparing).

***Box 1:** Comparing supply and demand*

There are a number of ways these aspects can be measured or estimated. The results of different approaches will vary depending on the methodology and assumptions used, and the quality of the available data. This is true for any scientific assessment: the scientific method does not ensure that all approaches will yield identical findings. However, by documenting the calculation approach and the assumptions used, the reasoning and the calculations are reproducible, and the results testable. The same applies here: By being explicit about assumptions and justifying each one, a transparent calculation of carrying capacity can be built on empirical facts.

I took six different approaches to answer the question posed to me by Jack Woodward, on behalf of his client Chief Roger William. By using this variety of approaches to answer the research question, I generated a range of answers. In comparing the answers, I was led to my conclusion, which is that the human population range in the Claim Area prior to European trade and influence was most likely to be on the order of 100-1,000 people. As with any scientific examination, reproducibility of results through independent tests bestows greater confidence in the overall result.

4. Limits to this assessment

There are a number of factors that could limit the accuracy of this carrying capacity analysis. First, the availability of data specific to the Claim Area is limited, especially regarding conditions prevailing at the time of the 1800 target era. Even present-day assessments of wildlife populations and estimates of biological productivity of the Claim Area's ecosystems are weak and incomplete. More precise answers about the Claim Area's capacity to directly support people's lives (assuming pre-European influence and trade) would be possible with more research. It is possible that the grey literature, including reports, thesis work, government assessments, hunting records, etc., contains additional relevant data points. Most likely, though, this would need to be complemented by primary research.

Second, there are a large variety of potential food sources, and details were not uniformly available regarding relative dependence on and abundance of each of these food sources, seasonal and annual variations in availability, frequency and timing of limiting factors such as sudden declines in the supply of critical food sources, storage technology to extend availability of particular foods beyond normal seasonal limits, harvest efficiency, competition with other species for shared sources of food, and so on. I made an attempt to circumvent these limitations by supplementing the data with reasonable estimates from comparable land areas, and by extrapolating from what is known about the lifestyles of similar societies.

With these caveats in mind, the findings in the following sections do not pretend to be exact values. Nevertheless, I believe they are reasonable estimates based on the assumptions used and the data that were available.

5. Assumptions

Not being an anthropologist, I used accounts from anthropologists as a starting point for my analysis of human demand on nature. I assume that:

1. The Xeni Gwet'in and the Tsilhqot'in did not engage in large-scale, intensive agriculture but did use burning and other plant management techniques to perpetuate or enhance the availability of certain food plants.
2. The Xeni Gwet'in and the Tsilhqot'in had a large range of skills and indigenous technologies for hunting (bows and arrows, fences, traps), food gathering, food preservation, and shelter building. Not before 1700, but prior to contact with Europeans, they had access to horses. The Xeni Gwet'in and the Tsilhqot'in did not have guns. Neither did they have access to metal or glass containers for preparing and preserving food. They did not have guns until the early 1800s, and the use of guns appears not to have been widespread until the late 1800s.
3. The Xeni Gwet'in and the Tsilhqot'in practiced seasonal rounds with winter camps close to the lakes. This translated into a seasonal use of foods (mountain potatoes, salmon, deer).
4. There are historical records and oral histories demonstrating that the Tsilhqot'in took action to protect their Territory against unauthorized intrusion by other First Nations and by non-indigenous settlers. This fact meant that there would have been an incentive to prevent population levels from dipping significantly *below* the biological capacity of the region, the primary reason being that it takes people to defend territory. The fact that the Tsilhqot'in had to defend their territory historically suggests that they would have maximized their population size rather than leaving biocapacity vacant. Thus, I have assumed that they utilized the full biological capacity of their territory.
5. Considering the descriptions of the traditional diets, I assume that protein from animal products (mainly mammal meat and fish) made up a significant portion (roughly half) of the overall food calorie intake of the Xeni Gwet'in and the Tsilhqot'in, complemented by plant-based carbohydrates from wild potatoes, berries, etc.

6. Results, and Six Arguments Supporting the Conclusion

Results

I used six different approaches for assessing the carrying capacity of the Claim Area prior to European influence and trade. All approaches consistently point to the finding that the Claim Area supported a human population most likely on the order of 100-1000 *people. Hence I conclude that the carrying capacity of the Claim Area prior to European influence and trade was between 100 and 1000 people. This also means that the carrying capacity of the Claim Area was less likely to be in the range of 1,000-10,000 people, or in the range of 10-100 people.*

Pieces of Evidence – in six segments

Data on the Claim Area's biocapacity and on the population's demand and its technological efficiency are not complete. However, with data on aspects of the ecosystems in the Claim Area and historical records of the Xeni Gwet'in and Tsilhqot'in, crude assessments can be provided. Numerical results for quantifying the human population size of the Claim Area were generated using five different approaches. These diverse, simple calculations generate a range of possible results. This range indicates an approximate number for the population size that was likely to have lived in the Claim Area before the time of European influence and trade.

The sixth segment argues that seasonal and year to year fluctuations in the availability of food and resources are a significant aspect when assessing population size. For human populations, size is generally limited not by the average year but by the worst year in terms of hunting, crop yield, and weather patterns. Similarly, a wild population is limited by its ability to live through the harshest season.[2] The population is inevitably thinned by starvation and lack of resources, and these events occur in the resource-scarcest seasons and resource-scarcest years.

Recognizing these various seasonal constraints posed on regionally based[3] human (and non-human) populations, diet composition and availability of one key component allows researchers to extrapolate population size.

i) Extrapolating from Population Data of a Regional Key Species: The Wild Horse Population

A significant portion of the Xeni Gwet'in and the Tsilhqot'in diet consisted of animal products (Alexander et al 1985: 53). Fish was an important source of both calories and proteins, but its availability was seasonally limited (Alexander 1985 (table2) p50). The largest supply of fish was associated with the salmon runs. For the rest of the year, when the salmon were not available, the consumption of animal products would be dependent on mammals that could be hunted - in addition to resident fish populations (and particularly ice fishing during the winter).

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[2] A domesticated herd may be able to reach higher carrying capacity, since forage availability is artificially spread over the year by stocking hay for the winter. Hence, estimates of domestic animals exaggerate a region's capability to support wild species.
[3] Regionally based populations live to a large extent off the local resources with few supplements from the outside. In other words, that population's metabolism is limited by the availability of local resources.

The wild horse population can be used as a proxy number for other large herbivores, such as caribou, mule deer, elk and mountain goats, in order to quantify the availability of animal protein for humans. Wild horses are well-suited for comparison with other ungulates because their food niches overlap substantially (F. Wagner, 1978). Horses may not use these ecological niches in the same way other ungulates do, and they may not access the entire capacity because of landscape constraints. Nevertheless, the fact remains that if there are more horses, there must be more available biocapacity. The horse population can thus act as a rough barometer of grazing capacity. The horse population number is thus proportionally related to the other non-horse ungulates living in the Claim Area.

According to present-day observations, horses seem to represent a significant portion of the total ungulate biomass. One indication of their relative abundance is the percentage of times horses were sighted by automatic cameras set up by a research project of Wayne McCrory (2002: p.v). In his research, horses were seen at about the same frequency as moose and mule deer. Considering horses' relative weight[4] compared to other wild ungulate species, it seems reasonable to assume that horses represent one third of the total ungulate biomass in the Claim Area. (Note that this compares horse biomass with total ungulate biomass, not the number of horses with the total number of ungulates. This is an important distinction, because horses have a larger body mass than all other ungulates in the region except moose – see footnote 3 above). With more research, a more accurate number describing this ratio between horse and other ungulate biomass could be calculated.

With this ungulate biomass estimate, one can estimate food availability for the local human population. This, in turn, gives us an indication of an upper limit of the human population size, since ungulate meat was a significant portion of the human population's diet. While horse meat was not a significant part of First Nations' diets, the wild horse population merely serves as an indication of the population of other large herbivores, some of which were hunted by the Xeni Gwet'in and Tsilhqot'in.[5]

The wild horse population seems stable in its size and amounts to 75-200 individuals for the Brittany Triangle (McCrory 20: p 36; lower estimate based on reported 'communication from Range manager', upper estimate of 140-200 based on McCrory's own estimate). This number would be Brittany Triangle's carrying capacity for horses. This area constitutes about one-third of the total Claim Area, but judging from the maps, its topography and position, this Triangle is most likely the most bioproductive (highest biomass regeneration per hectare) in the Claim Area (see also reference to bioproductive grasslands in Silva Forest Foundation July 2002 p 16-17). Hence this horse population

[4] An adult feral horse and moose may weigh 500 kg (http://www.agric.nsw.gov.au/reader/1038, http://www.britishcolumbia.com/Wildlife/wildlife/landmammals/cw/cw_moose.html), while mule deer are less than one third the size of horses or moose (http://www.dto.com/hunting/species/generalprofile.jsp?speciesid=170&state=co).

[5] "It is unlikely that the horse fundamentally altered basic subsistence strategies of Plateau peoples, as gathering and fishing continued to provide the bulk of subsistence needs well into the late nineteenth century" Walker in Sturtevant, 1998:545

number can be used as a starting point for estimating a "carrying capacity" for large herbivores. The reasoning proceeds as follows:

Using the upper population estimate of 200 horses, and multiplying this number by three to include other ungulates (based on the estimate explained above) would lead to an estimated wild ungulate population of 600 horse equivalents. Typically, seven percent of ungulates can be harvested by people per year while another 14 percent is harvested by predator species (Alexander in Hayden, 1992, p 113)[6]. This would suggest a maximum sustainable yield for people of 40 horse equivalents per year (7% of 600 units).

It is reasonable to assume that, for a culture living very close to the land and not wanting to extinguish their primary food resource, hunting the 'sustainable yield' would be at their upper limit. If the Xeni Gwet'in or Tsilhqot'in ever hunted at levels above the sustainable yield, this could increase their human population on a short-term basis but would ultimately lead to a decline in ungulate food availability and therefore human population.

With horses and huntable ungulates having a similar metabolism for transferring primary productivity (grass and forage) into meat, this 'yield' can be used as an approximate value of the animal-based calories available for human consumption. This means that the amount of harvestable food energy for people from large ungulates is the following:

Estimate for available animal-based calories from ungulates

500 kg per horse harvested (or per equivalent amount of ungulate)[7]

multiplied by

60% dressing percentage, or amount of live weight that can be eaten[8]

multiplied by

12,200 kj/kg of food energy[9]

multiplied by 40 horse equivalents per year

= 500 kg/horse* 0.6 [edible percentage] * 12,200 [kj/kg]* 40 [horse equivalents]

[6] This number is consistent with an expected population dynamics of ungulates, that without carrying capacity constraints can double every 4-5 years.

[7] http://www.gov.on.ca/OMAFRA/english/livestock/horses/facts/98-093.htm

[8] See http://ars.sdstate.edu/MeatSci/May99-1.htm for typical numbers

[9] See: http://www.nal.usda.gov/fnic/cgi-bin/list_nut.pl ('Beef, carcass, separable lean and fat, choice, raw') One kcal of food (or colloquially called 'calorie') is equal 4.18 kilojoules or kj; kj is the energy unit in the metric system, calories are a measure from the imperial measurement system.

= 145,000,000 kj of ungulate-meat based food per year (just from the Brittany Triangle) = 145 Gj/yr (just from the Brittany Triangle)

Box 2: *Food available to humans from ungulate populations*

How many people would this feed, and for how long?

The basic food requirement of a moderately active adult male is 10-15,000 kj per person per day (Smil 1999:92). In fact, this may be a low estimate of food consumption, considering harsh climate and high physical activity most likely necessary to maintain the lifestyle of people living in the Claim Area before European trade and influence. Vaclav Smil, a leading energy scholar from the University of Manitoba, cites lumberjacks requiring 30,000 kj/day and long distance runners and skiers up to 45,000 kj/day (Smil 1999:80,92). **Using 15,000 kj/person/day** seems to be a reasonable low-end average even though it is higher than recommended Western diets (2,000 diet calories is approximately equivalent to 7,400 kj). Xeni Gwet'in and Tsilhqot'in living in the Claim Area were more physically active compared to the more sedentary members of industrial societies, and they also needed more food for heating their bodies than people living in climate-controlled environments. But the average was not as high as for lumber jacks during an active workday since people in the Claim Area did rest some days, and not all were adult males. This caloric requirement estimate would lead to a caloric demand of (15,000 kj/day * 365 days/year) = 5,500,000 kj/year per person. Assuming that half of the total caloric intake comes from animal-based food, one average person's animal-based food demand would add up to 2,700,000 kj/yr.

In other words, huntable ungulates in the Brittany Triangle would provide animal-based food calories for 54 people (145 million kj per year/2.7 million kj per year).

The Brittany Triangle represents only 1/3 of the surface of the Claim Area, but probably more than 1/3 of the overall carrying capacity. Assuming that the Brittany Triangle represents half of the Claim Area's total biocapacity (simply because the Brittany Triangle is more biologically productive), this would suggest an annual supply of 290 million kj of ungulate meat for human consumption. This could maintain a population number of about 110 people (assuming all animal-based food comes from ungulates). If Brittany Triangle was only one-third of Claim Area's biocapacity, then this would translate into 435 million kj of annual ungulate meat for human consumption, then 165 people that could be supported (assuming all animal-based food comes from ungulates).

Considering that meat from large herbivores is not the entire contribution to the diet, the population number could be even higher. Ungulate meat was supplemented with a number of other sources. Additional animal protein sources included (see Walker in Sturtevant, 1998: p526-545 for both plant and animal species used):

- mainly fish (particularly salmon during the runs, and to a lesser extent, Dolly Varden, trout, whitefish, turbot & suckers, the last four available in lakes all year . Fish, including salmon, was a significant food source, and the food value of these local species may have been greater than that of the spawning salmon, especially in years with poor salmon runs (Lane in Alexander et al 1985: p48).

- limited amounts of non-ungulate mammals such as grizzly and black bear, marmots, snowshoe hare and rodents, and
- possibly some birds (e.g., grouse, geese);

Supplementary plant-based food included:

- berries,
- potato (mountain potato),
- bear tooth plant, and
- the cambium layer under the bark of pine trees.

Recognizing the importance of fish, but also their seasonal limitations, large herbivores may have contributed half of the overall demand on animal-based food (and as stated above, I assume about half of the caloric intake to be animal-based) this would double the population estimate to about **220 to 330 people** in the Claim Area. This population number would go up to **550 to 800 people** if ungulate meat would only represent 10 percent of people's caloric intake (rather than one quarter, or 50% * 50%, as assumed before). However, the human population number in the Claim Area would be smaller if:

- dependence on ungulates was more extensive;
- horse population represents a more significant portion of the total ungulate biomass;
- only a smaller percentage of the total ungulate population could be hunted;
- the worst winters reduced ungulate populations to a level significantly under their typical carrying capacity number (since it is the year with worst supply of food that limits overall population).

Conversely, the human population estimate would get larger if:

- dependence on ungulates is less extensive than assumed;
- horse population represents a less significant portion of the overall ungulate biomass.

ii) A second approach to estimating the population of huntable ungulates: extrapolating from a key predator in the area, the wolves

The overall ungulate population can also be estimated from the size of predator populations, since ungulate availability limits their predator's populations. This provides an independent check of our estimates of ungulate biomass.

Estimating ungulate population from wolf population:

80 wolf population in Brittany Triangle (4-7 packs of 6-12 wolves) (McCrory 2002)
240 wolf population estimate for whole Claim Area (assuming proportional occurrence per unit of territory)

with
3716 kj/day per wolf food demand
http://animal.discovery.com/news/briefs/20040913/dogwolf.html

This adds up to:
325 million kj/yr food demand of wolves
or 33,000 kg/yr caught animals (assuming 80 percent of animals are eaten by wolves, and ungulate are main food source of wolves)

Building on Alexander (in Hayden p113) that about 22% of the ungulate biomass can be harvested annually by all predators, and 1/3 of that is harvested by people, it is reasonable to assume that the other two-thirds of the 22% are shared equally between wolves and other predators (rest bears, cougars, lynx, coyotes). In other words, this assumes that wolves, in the Claim Area, take 50 percent of what all predators in the Claim Area take combined.

Assuming 33,000 kg of annual harvest = 7% of total ungulate biomass translates into a standing stock of 950 horse equivalents or 6000 mule deer equivalents of ungulate population in the Claim Area (one animal unit is typically defined as a 1000 pound cow, similar to the horse, a mule deer is assumed to be 80 kg heavy, on average). Or recognizing that people may only be able to eat 60 percent rather than 80 percent of the animal, the corresponding amount for people would be 25,000 kg/yr or 240 Gj/yr.

Assuming half of people's diet was animal based food, and half of that from ungulates, this would translate into a yearly demand per person of 1.4 Gj of ungulate meat. Hence there would be sufficient resources for **180 people** in the Claim Area. Assuming half of people's diet was animal based food, and only one fifth from ungulates, this would translate into a yearly demand per person of 0.5 Gj of ungulate meat. Hence there would be sufficient resources for **450 people** in the Claim Area.

If wolves were eating only half the amount of ungulates, or for other reasons represented only $1/4^{th}$ of the predator demand for ungulate meat, rather than 1/2 as assumed above for the calculation, the population estimate for the Claim Area pre European influence and trade would be **360 to 900 people**.

Box 3: *Wolf calculation*

iii) Extrapolating from Population Data of a Species that Competes for Similar Food Niches: The Bear Population

Rather than trying to estimate carrying capacity from a direct analysis of bioproductive capacity (an analysis which the above question implies, but which is fraught by lack of data on yields of all types of food plant and animal populations within the Claim Area, rates of human harvesting of all the various food sources, and the extent of competition for these food sources with other species), one other way to estimate human carrying capacity of the Claim Area is to look at the population size of a species with a similar diet, occupying similar food niches. The ecologically most similar competitor to people is the grizzly bear, also an omnivore and top predator. This approach uses caloric requirements to compare bear and human population sizes of the area that could be sustained.

Grizzly bears (and, to a lesser extent, black bears), more than any other species in the Claim Area, have diets that overlap the most with the diet spectrum of a human population living off the land.[10] Bears have different food gathering strategies, but overall their food patterns appear to be similar to what anthropological reports identify as traditional food sources.

Hamilton et al. (2004) suggests that in the South Chilcotin Ranges, the capability per square km to support grizzly bears is only 58 % of the British Columbia average.

REGION	**AREA**	**Capability**	**Density**
	km^2	**# bears**	**bears/1000km^2**
ALTA	13256	204	15
BABINE	14039	510	36
BLACKWATER-WEST CHILCOTIN	20630	396	19
BULKLEY-LAKES	23521	549	23
CASSIAR	36374	759	21
CENTRAL MONASHEE	6349	198	31
CENTRAL PURCELL	4619	162	35
CENTRAL ROCKIES	6923	246	36
CENTRAL SELKIRK	5681	214	38
COLUMBIA-SHUSWAP	14927	493	33
CRANBERRY	11649	405	35
EDZIZA-LOWER STIKINE	17122	396	23
FINLAY-OSPIKA	30302	721	24
FLATHEAD	3434	215	63
FRANCOIS	8087	160	20
GARIBALDI-PITT	6463	226	35
HART	19661	540	27

[10] See for example http://www.nrmsc.usgs.gov/projects/igbst_BB.htm; or food habits of bears: www.nps.gov/yell/nature/animals/bear/infopaper/info3.html).

HYLAND	17268	347	20
KETTLE-GRANBY	6585	167	25
KHUTZEYMATEEN	8069	475	59
KINGCOME-WAKEMAN	5442	253	46
KITLOPE-FIORDLAND	10336	370	36
KLINAKLINI-HOMATHKO	13643	152	11
KNIGHT-BUTE	6620	235	35
KWATNA-OWIKENO	10650	347	33
MOBERLY	7577	210	28
MUSKWA	36108	815	23
NATION	18128	502	28
NORTH CASCADES	9801	319	33
NORTH COAST	6776	269	40
NORTH PURCELL	5470	238	44
NORTH SELKIRK	6003	276	46
NULKI	16796	369	22
OMINECA	29171	739	25
PARSNIP	10999	487	44
QUESNEL LAKE NORTH	9100	365	40
ROBSON	20078	716	36
ROCKIES PARK RANGES	5850	184	31
ROCKY	38085	822	22
SOUTH CHILCOTIN RANGES	16125	237	15
SOUTH PURCELL	6898	198	29
SOUTH ROCKIES	8306	402	48
SOUTH SELKIRK	4074	131	32
SPATSIZI	21702	562	26
SPILLAMACHEEN	4069	148	36
SQUAMISH-LILLOOET	5689	165	29
STEIN-NAHATLATCH	7710	217	28
STEWART	11342	360	32
TAIGA	50046	128	3
TAKU	32315	650	20
TATSHENSHINI	19216	395	21
TOBA-BUTE	7606	99	13
TWEEDSMUIR	18458	323	17
UPPER SKEENA-NASS	16999	673	40
VALHALLA	3479	111	32
WELLS GRAY	12837	430	33
YAHK	2719	101	37
Total	**791182**	**20381**	**26**
South Chilkoton compared to Total			**58%**

Table 1: *Bear Population capability according to Hamilton et al (2004)*

Using this number, and distributing the total BC bear population present in 790,000 square kilometers of British Columbia evenly to the 4,300 square kilometers of the Claim

Area, yields a grizzly population within the Claim Area of 65 grizzly bears (assuming a BC grizzly population of 16,000). With a BC black bear population of 120-160,000, we can use the ratio between BC black bears and BC grizzlies to estimate a black bear population for the Claim Area. This amounts to about 520 black bears.

This estimate is NOT based on actual bear occurrences, since some of the potential bear populations do not exist. Currently, some of the potential bear population is out-crowded by human activities. Hence, current bear counts do not represent, or cannot be used as a proxy for, the bioproductive potential of a region. In consequence, as a proxy for bioproductivity, I use the estimates of potential bear populations (or **capability**) to support bears. These estimates are supplied by the BC government.

The above estimate for potential bear populations in the Claim Area would assume that the concentration of bears (per km^2) is the same as the average for the South Chilcotin Ranges.

Another number for potential bear populations is quoted in Wane McCrory (2002: p33), using BC Wildlife numbers claiming one grizzly per 140-160 square kilometers. This would lead to 31 grizzly bears in the total Claim Area. McCrory estimates that there is at least the same amount of black bears as brown bears in the Claim Area, hence another 31 black bears.

Food requirements of bears are 8,250 kcal/day for grizzly bears.[11] This is a weighed average over a one-year period. The corresponding number for black bears may be about 4,000 kcal/day.[12]

If we assume 15,000 kj/day food requirement per person (as discussed above), the bears' overall consumption indicates a population of **100 people** (based on McCrory 2002 estimate) to **720 people** (based on Hamilton et al estimate).

Note that this is a rough assessment, merely based on the fact that food sources of bears and people strongly overlap, and that they may exploit ecosystems in similar ways. It does not look at the competition between people and bears. If competition between people and bears for the same food sources was significant, more bears would trade off against fewer people and vice versa.

Also, people will probably get a larger portion of their diet from ungulates. Also note that the bear populations use here are crude estimates based on land area and not in-depth ecosystem assessments. Nevertheless, the resulting numbers are reasonably consistent with the other assessments herein.

[11] http://7thfloormedia.com/projects/exwork/best/bearden/brown.htm
[12] www.abbeyinn.com/html/smoky_mountains_black_bear_fac.html

iv) Extrapolating From Population Data of Harvestable Animals: The Predator Prey Balance

Another possible approach is to extrapolate availability and demand on ungulates using British Columbia estimates of population sizes. The table below summarizes official population numbers from BC ministries.

	B.C.		Total Claim Area		body weight	food demand	ungulate based food	annual ungulate-based food demand		available to people
	Lower #	Upper #	Lower #	Upper #	kg/unit	kj/day	%	Lower Gj/yr	Upper Gj/yr	Gj/yr
Predators										
Wolf	7,500	7,500	20	20	42	15,559	50%	56	56	
Cougar	3,000	3,000	8	8	52	24,400	82%	58	58	
Grizzly bear	17,000	17,000	45	45	193	34,543	10%	57	57	
Black bear	120,000	160,000	318	424	182	16,748	5%	97	130	
								268	**301**	
Prey								gross unglulate-based food supply		
Elk	40,000	40,000	106	106	270			61	61	15
Moose	170,000	170,000	450	450	388			375	375	94
Whitetail deer	65,000	65,000	172	172	97			36	36	9
Mule deer	150,000	250,000	397	662	80			68	114	28
Caribou*	16,500	16,500	44	44	158			15	15	4
Mountain goat	50,000	50,000	132	132	71			20	20	5
								575	**621**	**155**

Table 2a: *Calculating the expected gross ungulate-based food supply for predators in the Claim Area, and the amount that would be available for a human population. Source of ungulate and predator populations: BC government (For references used see section on populations and weights in the Reference section of this document)*

First, this table calculates the “percentage share” for the Claim Area, multiplying the BC population by the percentage of the size of the Claim Area as compared to the total BC territory, and reducing the populations to 58%, a proxy number of the lower productivity of the Claim Area as compared to BC average as reported above and extracted from Hamilton et al 2004 (Ministry of Water, Land and Air Protection: Biodiversity Branch’s report on "Grizzly Bear Population Units"[13].) This leads to a similar bear population estimate as Hamilton suggests (but slightly different since this is scaled down from the entire BC territory, not only from those areas in BC that still have grizzlies present).

Please note: This is an aggregate ‘portfolio’ approach. This approach does **NOT** assess the species composition of a particular sub-area, but estimates how much overall ungulate meat is generated in BC (or its sub-regions) by using population estimates of ungulate prey species and translating them into total amount of meat available for human consumption. Depending on the particular landscape effects and local ecosystems, certain species will do better than others, and their relative numbers will shift. This analysis does not predict the actual species composition, nor is this relevant for assessing a region’s overall capability for regeneration of herbivore biomass (or production of meat of ungulates). In other words, this aggregate approach is useful not to predict composition,

[13] http://wlapwww.gov.bc.ca/wld/documents/gb_bc_pop_est.pdf

but to predict overall productivity of meat from herbivores that can be consumed by predators or by people.

The table 2a, above, presents the result of the analysis (Table 2b translates results in "mule deer equivalents"). It shows that predator demand for ungulate meat is lower than amount available. The numbers suggest that the supply of ungulate prey is about double the expected demand from the predator population (calculated for British Columbia as a whole – and scaled down to the Claim Area, this produces the same ratio). The fact that the calculated ratio between supply and demand is physically possible, i.e., predators can be supported by this prey population (calculated supply exceeds calculated demand), gives confidence in the validity of numbers.

Prey	Claim Area Upper #	body weight kg/unit	mule deer equivalents in Claim Area #
Elk	106	270	358
Moose	450	388	2183
Whitetail deer	172	97	208
Mule deer	662	80	662
Caribou*	44	158	86
Mountain goat	132	71	117
TOTAL			**3614**
	equivalent in moose		746

Table 2b: *ungulate prey availability in the Claim Area expressed in mule deer and mosse.*

The supply of ungulate prey can then be translated into anticipated human population size. Recognizing that people eat a smaller fraction of hunted animals than wolves or cougars would, and recognizing that typically, as discussed above, one third of the total regeneration rate can be harvested by people (i.e., 7 percent per year), this population estimate suggests an availability for humans of 155 Gj of ungulate per year. This is about 54% of the lower estimate of assessment i) which suggested 290-435 Gj of ungulate meat availability each year.

This leads to a human population estimate of **100 to 300 people** for the Claim Area pre European influence and trade.

This estimate is potentially the most robust of all the presented approaches, since it starts from a state-wide ungulate population estimate and scales the numbers down proportional to the territory size of the Claim Area and an estimated relative bioproductivity of the Claim Area as compared to the BC average. Since ungulates move around, estimates based on proportional allocations do not double count ungulate populations that move across territories. They also make sure that the magnitude of the estimate is reasonable, since the macro assessment averages out possible uncertainties and random estimation errors of local population assessments.

v) Other approaches: comparing to current livestock densities in industrial societies (US), and other carrying capacity estimates.

One way to estimate the ratio between available resources and population densities is to extrapolate this ratio from the current situation in the U.S. with domesticated ungulates. Even though current populations have more access to plant based food due to large-scale agriculture, wealthy industrial societies have a large portion of animal-based food-intake.

Assuming that the present-day North American population eats as much animal based food as people did in the Claim Area before European influence and trade may underestimate the Claim Area's population animal-based food consumption for two reasons:

a) The portion of animal-based food may have been larger historically, as indicated by anthropological accounts of typical diets.

b) People pre European influence and trade were physically much more active than most people living current industrial lifestyles, leading to larger caloric requirements.

Hence, looking at the ratio of livestock units in current industrial societies per capita provides an underestimate of amount of wildlife necessary to support a population pre European influence and trade.

Currently, in the U.S., production and consumption of animal products is nearly identical. Net imports are small, comparatively. (Source FAO FAOSTAT database for 2001). For instance, the table shows, that with a population of 288 million people in the US, there are nearly 7 chickens per person, and one cow for three people.

USA: 2001 source: FAO apps.fao.org

Livestock tons & stocks

	Production [t/y]	Imports [t/y]	Stock Changes [t/y]	Exports [t/y]	Consumption [t/y]	Live Animal Stocks [head]
poultry meat	16,813,300	23,910	39,500	3,134,363	13,742,347	1,996,700,000
eggs	4,405,300	8,575	710	97,675	4,316,910	0
pigmeat	8,691,000	437,797	-26,300	643,788	8,458,709	59,138,000
bovine meat	11,983,000	1,541,042	-37,200	1,149,810	12,337,032	97,277,000
mutton & goat r	103,000	66,778	500	3,567	166,711	8,365,000
milk	75,600,120	4,440,094	0	2,294,979	77,745,235	0
equines	5,380,000				5,380,000	5,380,000

Table 3: *Production and consumption of animal products in the US for 2001*

This amount of animal product consumption can be translated into a corresponding mule deer population that would produce the same amount of animal products. This is done by dividing the consumption amount (tonnes per year) by 7 percent, which is a typical sustainable yield figure as discussed above. As shown in table below, whether including only ungulates (but also their milk) or all animals (but excluding milk), this consumption corresponds to 650 million tonnes of wild animal stock, or 6 billion mule deer (assuming 60 percent edible and average weight of 175 kg).[14] In other words, animal product consumption in the US corresponds to living off a wild population of 46 mule deer per US resident. Approach i) and iv) suggest that Claim Area residents consumed animal products at a rate corresponding to an equivalent of what a herd of 60 mule deer would have been able to provide. Food from mammals however (excluding fish and fowl), may have corresponded to a herd of 10-30 mule deer to sustainably meet the demand of Claim Area residents, a number similar to the current ratio in the US.

USA: 2001

Livestock tons & stocks

	Consumption [t/y]	Stocks [head]	Corresponding stock if hunted (only ungulates but including milk) (assuming 7 percent annual yield) [t]	Corresponding stock if hunted including all meat and eggs (assuming 7 percent annual yield) [t]	mule deers (assuming 60% edible) [#]
poultry meat	13,742,347	1,996,700,000		196,319,243	4,089,984,226
eggs	4,316,910	0		61,670,143	1,284,794,643
pigmeat	8,458,709	59,138,000	120,838,700	120,838,700	2,517,472,917
bovine meat	12,337,032	97,277,000	176,243,314	176,243,314	3,671,735,714
mutton & goat r	166,711	8,365,000	2,381,586	2,381,586	49,616,369
milk	77,745,235	0	291,049,847		
equines	5,380,000	5,380,000	76,857,143	76,857,143	1,601,190,476
TOTAL			**667,370,589**	**634,310,129**	**13,214,794,345**
				people in US	288,000,000
				mule deer equivalents/person	46

Table 4: *Translating US animal-product consumption into an equivalent mule deer stock that could supply this amount*

If this U.S. ratio of mule deer equivalent to people was applied to the estimated ungulate population in the Claim Area (as estimated in Approach iv), the 3600 mule deer equivalent would feed 80 people. However, since ungulates may only represent about half of the animal-based food intake in the diet of residents of the Claim Area pre European influence and trade residents' this doubles the population estimate. Hence, if this amount of mule deer was the limiting factor of human population in the Claim Area, it would support **160 people**.

[14] A smaller domesticated herd stock could generate the same amount of animal products, since they are managed for maximizing output per unit of input. In industrial agriculture domestic animals for meat are slaughtered once their growth slows down, while they could survive for much longer in the wild.

Yet another way of estimating ungulate densities is to build on grazing capacity assessments. For instance, Silva Foundation claims that ecosystems in the Claim Area can support ungulates at the rate of 4-6 ha per animal unit month (Silva Forest Foundation July 2002 p 16). While it may be true that this level of grazing can be sustained with farmed animals during the summer time, this number may be far too high for year-long populations whose survival is not determined by what is available on average over a year, but what is available during the food scarcest part of the year, i.e., during the winter.

Using this high year average estimate would lead to a population of 6,000 animal units of ungulates, or 36,000 mule deer equivalents. This number is unlikely high and inconsistent with observed numbers of ungulates in the Claim Area. By averaging out supply over the year, rather than having ungulate populations limited by the worst times in the year, it may be physically possible to maintain such a population. But this would require collecting hay for the winter and transferring food from more abundant summer to food scarce winter. Hence this estimate of 'grazing capability' does not lead to a useful population estimate for ungulates, and cannot be used for assessing human population numbers living in region before European influence and trade.

vi) Anthropological documents about varied diet also support the assertion that the estimate is a maximum rather than a minimum number of individuals[15]

Extrapolating from the food habits and cultural accounts, it appears that inhabitants of the Claim Area would put significant effort into preserving and storing food (Alexander in Hayden p 129-133). Most of the storage was aimed at evening out food availability through seasons (particularly winters).

However, there seems only to be some seasonal storage: Salmon, meat and berries were dried over the summer and fall, used during the winter along with fish caught in lakes; stored provisions were low or exhausted by late February or March. Some anthropological sources say that dried salmon could last two years, but most likely in quantities insufficient to even out poor harvests. Hence hunting ungulates was a necessity (and would even be pursued during mild days in winter or when the snow had a firm crust) and became more important at that time (p.69). Thus, although there was some seasonal overlap in the use of resources, no single type of resource was available for the entire year; a limit on any single critical resource could therefore serve as a limiting factor on human carrying capacity (e.g., salmon runs failing required them to engage in trade with neighboring nations).

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[15] From Traditional Use Study Volume 1: Report Prepared for the Aboriginal Lands and Resources Branch, Ministry of Sustainable Resource Management, October 2001, Section 4.4--The Seasonal Round, pp. 69-71

It appears that the varied diet was not mainly driven by "food preference" but seasonal availability. This points to the possibility that none of the food sources were overabundant, and if they were, that collecting and storing such a food source had also its limitations. From the accounts it seems that conservation of food was labor intensive and long term storage problematic as conserved food may attract predators, can be stolen by neighboring nations, or may be devoured by competitors (from fungi/bacteria to mice to bears).

With these difficulties, they did not store significant food amounts over several years. Hence their population size was limited by the worst year – possibly the worst year within a 25-50 year span, since it takes at least one generation to recover from a famine.

This means that population estimates need to be based on worst year's supply. This means that food reserves were limited, and that limits in any key resource put constraints on the population size. This would also suggest that the above estimates of up to **800 to 900 people** (argument i and ii) is a maximum, considering the technology and food gathering strategy used.

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Appendix 1: Facts identified describing Xeni Gwet'in and Tsilhqot'in lifestyle

1. Diet: salmon, berries, wild game (squirrels?—or marmots? (Section 2, p.28), mule dear, moose, horses, grizzly bear, black bear?), wild potato? bear teeth plant?
2. Other wildlife includes good populations of hares and rodents. (Section 1, E)
3. Presence of horses was noted in 1808. Wild horses populations in Canada and British Columbia are much reduced from historic times.
4. Seasonal diet: Spring—salmon; Winter—dried salmon (& other fish?), dried meat, stored berries
5. Historical diet: May have been few deer or moose
6. Prevalence of wildlife depends on type of habitat.
7. Salmon habitat values for the Brittany are very high. The Chilko River has large runs of Sockeye, Chinook and Coho, with lesser numbers in the Taseko. There is an average of 1.7 million Sockeye or 27% of the entire Fraser run. Elkin Creek in the Brittany is the only tributary of the Chilko/Taskeo Rivers that have salmon. Runs in Elkin Creek average about 600 Chinook annually.[16]
8. For large carnivores, a high salmon biomass is available thereby enhancing the values of adjacent vegetation and "security" habitats. Signs of high bear use were evident but our surveys were limited. High grizzly bear use of salmon is reported at the main spawning grounds below the outlet of Chilko Lake.
9. Brittany Triangle appears to support an abundant prey biomass of large and small species. For top predators such as the wolf, mountain lion, grizzly bear and black bear, feral horses likely contribute a valuable food resource that supplements their diet of native species.
10. Both grizzly and black bears are common in the Brittany Triangle and, although largely vegetarian and salmon-eaters, may prey on weakened or young wild horses. Other prey species for these predators in the ecosystem would include small animals, mule deer and moose. Horses and moose winter in the area, while mule deer migrate to areas with less snow.
11. Claim Area is very cold and dry (other than seasonal wetland), therefore plant growth of all types is quite limited. (Section 1, B). Short growing season, frost can occur at all elevations any time of year. Rainshadow, causing summer moisture deficits. (Section 1, F)
12. Range carrying rates in dry pine forests in the Claim Area are very low, 4-6 hectares/animal unit month, with little wildlife forage. Availability of latter is primarily in sedge meadows and riparian zones. (Section 1, B, F).
13. Sustenance activities of Xeni Gwet'in include trapping, hunting, medicinal plant gathering, grazing. But not clear if these apply to pre-1800. (Section 1, E).
14. Mule deer winter critical winter range in study area is limited. (This would help determine worst case carrying capacity). Grizzly bear and moose require forest cover. (Section 1, E)
15. Animal hides, furs traded. (Section 2).
16. 60 men plus "many more" observed in 1808. (Section 2)

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[16] http://www.fonv.ca/BT/Articles/FONVsumm/Summary.htm

17. 1808—Moose (?), red deer, chevreau, beaver very numerous, and the natives have horses. (Section 2)
18. 1822—Beaver furs seem to be an important component of their clothing. (Section 2)
19. 1822—131 families living along the southerly running river. (Section 2)
20. 1824—200 Chilkootin families reported. (Section 2, p.6)
21. 1827—Population of Tsilhqot'in estimated at 130 married men between the ages of 20 and 40 (Section 2, p.7)
22. 1830—Population of Tsilhqot'in "greatly reduced" since 1825, subsistence resources extremely scanty, salmon runs said to fail three years out of four forcing migration to the sea coast for relief. (Section 2, p.8) *Useful for establishing worst case scenario? Although not known if this is due to changes post 1800.*
23. Soil is poor for vegetable farming (1831—Section 2, p. 9).
24. 1839—Natives (sic) kill a great number of deer. (Section 2, p.10)
25. 1872—Population of the Chilcotin tribes about 500. (Section 2, p.19)
26. 1875—Indians eat cambium layer under bark of pine trees (Section 2, p.24)
27. Possibly also ate cow parsnip and fireweed (Section 2, p. 25)
28. 1880s—European settlers now outnumber First Nation member in the area. (Section 2, p.25)
29. 1893—Tsilhqot'in of Chilcotin River pop. estimated at 460.
30. 1925—First registration of traplines with the province. (Section 2, p. 36).
31. See Section 4, A, pp.69-71 for discussion of seasonal resource use by the Tsilhqot'in in the Claim Area
32. Seasonal use of resources by Tsilhqot'in—see table Section 4, A, p.70. Annual round of relocations were designed to exploit "seasonally fluctuating abundant resources." (p.69)
33. Social organization varied based on season and resource availability: nuclear family ⇒ camp of closely related families ⇒ associated camps working together on larger projects (*fish weirs, game fences*) ⇒ band (all camps wintering together in one locality) (p.69).
34. Seasonal use of resources reveals different limits at different times of years. Salmon, meat and berries were dried over the summer and fall, used during the winter along with fish caught in lakes; stored provisions were low or exhausted by late Feb or March, so hunting game (which also did go on during mild days in winter or when the snow had a firm crust) became more important at that time. (p.69). Thus, although there was some seasonal overlap in use of resources, no single type of resource was available for the entire year; a limit on any single critical resource might could therefore serve as a limiting factor on human carrying capacity (e.g., salmon runs failing 3 years out of four required them to desert the area and migrate to the coast for a period).
35. Moose were not available as a resource until the 20th century. (p.69) Fall migration of caribou and elk were intercepted; dried meat serves as a major source of winter provisions.
36. European goods first reached the Tsilhqot'in around 1790; first direct contact with Europeans in 1808. (Section 4, C, p.38). Therefore, EF estimated for before 1800

can ignore impact of contact with Europeans—e.g., hunting was without the use of guns. However, Tsilhqot'in did have horses before then.

37. Fish include Chinook salmon pink salmon, trout, Dolly Varden, whitefish, burbot & suckers. (4C, p.83). Fish = most important source of food. Trout, whitefish, burbot & suckers available in lakes all year, salmon more abundant, esp. in peak years (Highly variable—peak run every 4 years on the Fraser River, probably several million, p.86); some available via trade with other groups. Fish, esp. salmon was the basic protein source in the diet, as well as fatty acids; estimated early contact population of 2500 Tsilhqot'in consumed 600 lbs per capita annually, for total Tsilhqot'in consumption of 1.5 million fish (p.64). Fishing methods and techniques included weirs, dip netting, gaffing, hook and line, and gill netting,
38. Tsilhqot'in traveled extensively throughout their territory to fish. (p. 97)
39. Late July & Aug devoted almost entirely to catching and drying salmon. (p.98)
40. Dried salmon could be stored for 2 years or longer. (p. 98)
41. Hunting supplemented meager diet, with rabbit as starvation food. (p. 100) *Not clear if this is traditional or modern phenomenon.* Small game mostly sought for furs, although meat not wasted. Birds also hunted for food. (p.101) *Same comment…*
42. Caribou disappeared from the area around 1800, were common before then. (p. 102) Before moose arrived in 1920s, hunters relied on elk, deer & caribou. Also eat some mountain goat. They speared and snared lots of caribou. Bighorn sheep common but not abundant in the study area (p. 107)
43. Bears (grizzly and black) hunted and eaten, but selectively and not by all, considered too respected and human-like. (p.108) Bear fat used for cooking and eating.
44. Beaver eaten (p.109). No indication that squirrels were eaten. Marmots eaten. Rabbits eaten.
45. Trapping was a vital component of food and resource accumulation. (p.116) *Not clear when this began…*
46. In addition to berries, mountain potatoes and other edible roots were gathered, dried and eaten. (p.125) These were an important source of supplementary calories, but also required significant time and energy to collect. (p.125)
47. Medicinal plants were gathered. (p.125)
48. Location of water sources defined camping sites, but water is abundant in the area and not a limiting factor (p. 152).
49. Tsilhqot'in probably needed hay for their horses prior to 1800. Hay was wild, swamp hay (p. 154). In modern times hay is cultivated.
50. Evaluation of above research in terms of representativeness, comprehensiveness, reliability and validity—see Section 4E.

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