Management Plan for the Mountain Goat (*Oreamnos americanus*) in British Columbia

Prepared by the Mountain Goat Management Team

BRITISH COLUMBIA
The Best Place on Earth

Ministry of Environment

May 2010

About the British Columbia Management Plan Series

This series presents the management plans that are prepared as advice to the Province of British Columbia. Management plans are prepared in accordance with the priorities and management actions assigned under the British Columbia Conservation Framework. The Province prepares management plans for species' that may be at risk of becoming endangered or threatened due to sensitivity to human activities or natural events.

What is a management plan?

A management plan identifies a set of coordinated conservation activities and land use measures needed to ensure, at a minimum, that target species or ecosystem do not become threatened or endangered. A management plan summarizes the best available science-based information on biology and threats to inform the development of a management framework. Management plans set goals and objectives, and recommend approaches appropriate for species or ecosystem conservation.

What's next?

Direction set in the management plan provides valuable information on threats and direction on conservation measures that may be used by individuals, communities, land users, conservationists, academics, and governments interested in species and ecosystem conservation.

For more information

To learn more about species at risk recovery planning in British Columbia, please visit the B.C. Ministry of Environment Recovery Planning webpage at:
<http://www.env.gov.bc.ca/wld/recoveryplans/rcvry1.htm>

To learn more about the British Columbia Conservation Framework, please visit the B.C. Ministry of Environment Conservation Framework webpage at:
<://www.env.gov.bc.ca/conservationframework/>

Management Plan for the Mountain Goat (*Oreamnos americanus*) in British Columbia

Prepared by the Mountain Goat Management Team

May 2010

Approved by:

Director, Ecosystems Branch, Ministry of Environment — May 26, 2010 — Date

Director, Fish and Wildlife Branch, Ministry of Environment — May 28, 2010 — Date

Recommended citation

Mountain Goat Management Team. 2010. Management Plan for the Mountain Goat (*Oreamnos americanus*) in British Columbia. Prepared for the B.C. Ministry of Environment, Victoria, BC. 87 pp.

Cover illustration/photograph

Courtesy of Kim Poole.

Additional copies

Additional copies can be downloaded from the B.C. Ministry of Environment Recovery Planning webpage at:

http://www.env.gov.bc.ca/wld/recoveryplans/rcvry1.htm

Publication information

ISBN 978-0-7726-6296-5
Date: June 2, 2010
British Columbia. Ministry of Environment.
Management plan for the Mountain Goat (*Oreamnos americanus*) in British Columbia [electronic resource]

[British Columbia management plan series]

Disclaimer

This management plan has been prepared by the Mountain Goat Management Team, as advice to the responsible jurisdiction and organizations that may be involved in managing mountain goats in British Columbia.

This document identifies the management actions that are deemed necessary, based on the best available scientific information, to prevent mountain goat populations in British Columbia from becoming endangered or threatened. Management actions to achieve the goals and objectives identified herein are subject to the priorities and budgetary constraints of participatory agencies and organizations. Recommendations provided in the plan will be used by the Ministry of Environment to guide the development of new or modification of existing provincial policies and procedures. While the recommendations herein are based on the best available science and expert judgement of the Mountain Goat Management Team, policy considerations may modify these recommendations, while respecting their intent, in order to address social and economic objectives in Mountain Goat management. These goals, objectives, and management actions may be modified in the future to accommodate new objectives and findings.

The members of the Mountain Goat Management Team have had an opportunity to review this document. However, this document does not necessarily represent the personal views of all individuals on the Mountain Goat Management Team.

Success in the conservation of this species depends on the commitment and cooperation of many different constituencies that may be involved in implementing the directions set out in this management plan. The Ministry of Environment encourages all British Columbians to participate in the conservation of mountain goats.

MOUNTAIN GOAT MANAGEMENT TEAM MEMBERS

Chair: Gerry Kuzyk, B.C. Ministry of Environment, Victoria, BC
Co-Chair: Pierre Johnstone, B.C. Ministry of Environment, Cranbrook, BC
Co-Chair: George Schultze, B.C. Ministry of Environment, Smithers, BC
Chris Addison, B.C. Ministry of Environment, Victoria, BC
Bill Arthur, B.C. Ministry of Environment, Prince George, BC
Kim Brunt, B.C. Ministry of Environment, Nanaimo, BC
Pat Dielman, B.C. Ministry of Environment, Williams Lake, BC
Greg George, B.C. Ministry of Environment, Surrey, BC
Steve Gordon, B.C. Integrated Land Management Bureau, Nanaimo, BC
Brian Harris, B.C. Ministry of Environment, Penticton, BC
Doug Jury, B.C. Ministry of Environment, Kamloops, BC
Troy Larden, B.C. Ministry of Environment, Smithers, BC
Chris Procter, B.C. Ministry of Environment, Kamloops, BC
Jennifer Psyllakis, B.C. Ministry of Environment, Victoria, BC
Darryl Reynolds, B.C. Ministry of Environment, Sechelt, BC
Daryl Stepaniuk, B.C. Ministry of Environment, Penticton, BC
Irene Teske, B.C. Ministry of Environment, Cranbrook, BC
Joanne Vinnedge, B.C. Ministry of Environment, Fort St. James, BC
Glen Watts, B.C. Ministry of Environment, Prince George, BC
Rob Woods, B.C. Ministry of Environment, Fort St. John, BC

Technical Advisors
Kim Poole, Aurora Wildlife Research, Nelson, BC
Helen Schwantje, B.C. Ministry of Environment, Victoria, BC

AUTHORS

Mountain Goat Management Team

RESPONSIBLE JURISDICTIONS

The British Columbia Ministry of Environment is responsible for the management of mountain goats.

ACKNOWLEDGEMENTS

We thank Kim Poole, lead author, for his expertise and diligence in developing this management plan. We also thank all team members for their contributions, particularly Gerry Kuzyk (Chair), Pierre Johnstone (Co-Chair of the Habitat Technical Working Group), and George Schulze (Co-Chairing of the Harvest Technical Working Group). Alec Dale (Wildlife Science Section Manager, Ecosystems Branch) and Ian Hatter (Wildlife Manager, Fish and Wildlife Branch) provided much appreciated support throughout this plan development. Doug Martin (B.C. Ministry of Environment, Cranbrook, BC) and Helen Schwantje (B.C. Ministry of Environment, Victoria, BC) provided additional editorial input. We thank the following scientific reviewers for

their input: Marco Festa-Bianchet (Université de Sherbrooke, Sherbrooke, PQ), Steeve Côté (Université Laval, Sainte-Foy, PQ), and Kirby Smith (Alberta Fish and Wildlife Division, Edson, AB). Distribution and survey coverage maps were updated with input from regional B.C. Ministry of Environment staff; Dave Wickstrom (Darkwoods Forestry, Nelson, BC) and Guy Woods (B.C. Ministry of Environment - retired, Nelson, BC) provided additional comments. The North American mountain goat range map was developed with input from states, provinces and territories, and we thank all biologists for their assistance and Byron Woods (B.C. Ministry of Environment, Victoria, BC) for his GIS support. The B.C. Ministry of Environment provided funding and support for development of this management plan.

EXECUTIVE SUMMARY

The purpose of this plan is to provide science-based advice to the Government of British Columbia to help ensure mountain goats (*Oreamnos americanus*) are conserved in perpetuity. The Province of British Columbia is responsible for the management of mountain goats within its boundaries and guidance is required to help inform appropriate management actions. Approximately one half of the world's mountain goats are found in British Columbia, therefore the province has a global responsibility to ensure their long-term persistence. Many view mountain goats as an iconic species, symbolizing rugged mountains and true wilderness. Mountain goats are a valued species, having social and economic value to First Nations for ceremonial use and as a source of food and clothing. There is ample interest in recreational mountain goat hunting; annually, income from licence fees average approximately $110,000 for residents and $300,000 for non-residents.

In B.C., mountain goats are ranked S4 (apparently secure) by the B.C. Conservation Data Centre and ranked G5 (secure) globally (NatureServe 2008). The Conservation Framework has assigned mountain goats a conservation priority 1, the highest priority rank under Goal 2: prevent species and ecosystems from becoming at risk. The Conservation Framework is British Columbia's new approach for maintaining the province's rich biodiversity by selecting appropriate conservation actions for species and ecosystems at risk. A key output from this tool is the requirement to develop a management plan to provide scientific advice on management actions to conserve mountain goats. This plan reviews the most up-to-date science on mountain goats, documents their current threats, discusses available management tools, and provides science-based recommendations to guide management decisions. It includes specific sections on habitat, harvest, human disturbance, and access.

The management goal for mountain goats in British Columbia is to **maintain viable, healthy and productive populations of mountain goats** throughout their native range in British Columbia. The management objectives include (1) to effectively maintain suitable, connected mountain goat habitat; (2) to mitigate threats to mountain goats; and (3) to ensure opportunities for non-consumptive and consumptive use of mountain goats are sustainable.

There are numerous threats to mountain goats, and although individually these threats may have only a low to medium impact provincially, the overall threat impact value is calculated as high due to cumulative effects. Recommended management actions included in this plan try to address ways to mitigate these threats and specifically address issues pertaining to habitat, harvest, disturbance and access. Harvest recommendations are focused on sustainable harvest rates of 1–3% of the population depending upon population size. Populations with less than 50 adults should have no harvest. Harvest of female mountain goats should be minimised because of their low reproductive rates through education and changes in regulation. Mountain goats react more strongly to human disturbance and may be more sensitive to muscle exertion than most ungulates, particularly from the extreme physical exertion and stress caused by helicopter disturbance. Therefore, it is recommended that helicopters have a 2000-m horizontal and 400 m vertical separation from all mountain goat habitat. A habitat risk matrix is provided as a key habitat recommendation and provides advice on the relative risk of physical disturbance to vegetation adjacent to important habitat for mountain goats. Increased access to mountain goat

habitat can have implications to all forms of management and there is a need for integrated management decisions that capture all forms of resource development and recreational activities. Finally, there is a need for research to fill data gaps on mountain goats in British Columbia that could help address management decisions to benefit the conservation of the species.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

Mountain goats (*Oreamnos americanus*) are adapted to live in rugged mountainous terrain. Their global distribution is limited to western North America, where British Columbia is home to over 50% of the world's population. Within British Columbia, mountain goats are found in a variety of habitats, from wet coastal environments that receive heavy snowfalls, to arid regions of the interior such as the Okanagan. Although widely distributed throughout British Columbia, mountain goats are rarely viewed by the general public because of their affinity for high elevations and steep terrain. Mountain goats have long been seen as a symbol of wilderness (Chadwick 1983).

First Nations value mountain goats economically and culturally as a source of meat and for social ceremonial uses. Mountain goats appear sporadically in records from early European explorers. In 1778, Captain James Cook was intrigued by the mountain goat hides of the Pacific Coast First Nations, thinking they may be from polar bears (*Ursus maritimus*) (Banfield 1974; Chadwick 1983), and Captain George Vancouver reportedly gathered a mountain goat hide from the British Columbia coast in 1792–1794. In 1807, David Thompson shipped about 100 mountain goat hides taken near Windermere in the East Kootenay to England (Banfield 1974).

Early management concerns for mountain goats in the 1960s and 1970s were related to overharvest, mostly associated with increased access created by resource industries such as forestry. These roads opened up previously lightly hunted and inaccessible valleys, and resulted in progressive overharvest on a regional scale (Phelps *et al.* 1983). In the 1980s and 1990s, logging pushed to higher elevations, which allowed for easier access for hunting mountain goats and in some areas encroached on their winter range.

In 1979, the British Columbia government released a *Preliminary Mountain Goat Management Plan* (B.C. Ministry of Environment 1979). Since that time, there has been no formalized provincial management plan to guide the conservation and management of mountain goats. In 2008, the British Columbia government adopted the Conservation Framework (Bunnell *et al.* 2009), a new approach to conserving species and ecosystems by prioritizing and managing species in a proactive manner. Using the Conservation Framework as a science-based decision support tool, resource managers ranked the mountain goats as a high priority species for proactive conservation to prevent the species from becoming at risk. A recommended action for conservation was to develop a management plan. Subsequently, in May 2008, B.C. Ministry of Environment initiated the development of a provincial mountain goat management plan.

The purpose of this mountain goat management plan is to provide scientific advice to assist managers and decision makers in guiding management direction and preventing mountain goats from becoming at risk. Specifically, this plan synthesizes global science-based information on mountain goats. Then, on a provincial level, it describes current threats and management tools presently in use, and makes high-level management recommendations that will assist in the conservation and management of the species.

2.0 BACKGROUND

2.1 Description of the Species and Taxonomy

Mountain goats are not true goats, but are bovids (family Bovidea) most closely related to the chamois (*Rupicapra* spp.) of Europe and the goral *(Nemorhaedus goral*) and serow (*Capricornus* spp.) of Asia (Côté and Festa-Bianchet 2003). These mountain-dwelling ungulates are characterized by extraordinary climbing skills (hence the common name goat antelopes), use of steep terrain to escape predators, and presence of horns in both sexes. Although sexual dimorphism is evident, with adult male mountain goats roughly 40–60% heavier than adult females, sexes can appear more similar in size (adult males shoulder height and chest girth are ~5–7% larger than adult females) (Côté and Festa-Bianchet 2003). Thus, it can be difficult to differentiate between sexes in the field. Body mass continues to increase with age up to 6 years for females and beyond for males (Côté and Festa-Bianchet 2003), about 93% of horn growth is completed by 3 years of age, with a peak length at about 6 years of age (Côté *et al.* 1998). While adult horn circumference is substantially larger in males and males initially have longer horns because of their longer first increment, horn length of adults > 6 years is similar for males and females (Côté *et al.* 1998; Festa-Bianchet and Côté 2008). Horn shape differs between sexes; the horns of males curve smoothly backward from the base to the tip, whereas the horns of females tend to grow straight up from the base and then bend more sharply backward near the tip.

There are presently no recognized subspecies of mountain goats (Cowan and McCrory 1970). Current genetic analysis of mountain goats at the continental level suggests that British Columbia may be divided into two broad groupings: northern B.C. and southern B.C. This finding suggests evidence of two glacial refugia, encompassing 12 distinct subgroups in the north, and 8 subgroups in the south (A. Shafer *et al.*, University of Alberta, unpublished data, 2009). There is no evidence of a high degree of inbreeding within mountain goat populations in British Columbia.

However, striking differences in seasonal habitat use and movement patterns between populations from coastal and interior regions of British Columbia have led researchers to recognize both “coastal” and “interior” ecotypes (Hebert and Turnbull 1977). Coastal ecotype mountain goats typically winter at moderate to lower elevations in forested habitats, and interior ecotype animals inhabit areas of generally drier and lower snowfalls at higher elevations. Interior populations in most areas undergo seasonal movements tied to elevation, using higher elevation at or above treeline during summer and fall, and lower elevations including forests during spring and early summer. These movements are primarily related to access to green-up vegetation and mineral licks. Further division within these broad ecotypes may be warranted (Hebert and Woods 1984; Gilbert and Raedeke 1992) (e.g., “outer coastal” populations that may reach sea level during winter, versus “inner coastal” populations).

2.2 Conservation Status

The mountain goat is considered secure globally (Table 1) (NatureServe 2008), and is listed in the International Union for the Conservation of Nature (IUCN) Red List as category Least Concern with a stable population trend (IUCN 2008). The species has not been assessed at the

national level (COSEWIC 2009). In British Columbia the mountain goat is ranked S4, is on the provincial Yellow List, and is considered "apparently secure and not at risk of extinction" (B.C. Conservation Data Centre 2010). Mountain goats rank as priority 1, the highest priority rank, for Goal 2 "Prevent species and ecosystems from becoming at risk" by the British Columbia Conservation Framework, a tool to assess and rank species and ecosystems for conservation action (B.C. Ministry of Environment 2009).

Table 1. Mountain goat status (NatureServe 2008) and estimated numbers (Festa-Bianchet and Côté 2008; several updated for 2008) in British Columbia and adjacent jurisdictions.[1]

	BC	AB	YT	NWT	AK	WA	ID	MT	Canada	USA	Global
Rank [2]	S4	S3	S3	SND	S4	S2S3	S3	S5	N4	N5	G5
Estimate	39 000–65 500	3400	1400	1000	24,000–33,500	4000	2600	2700	--	--	--

[1] AB = Alberta (estimate updated Smith and Hobson 2008); YT = Yukon Territory; NWT = Northwest Territories; AK = Alaska; WA = Washington; ID = Idaho (estimate updated Toweill 2008); MT = Montana (estimate updated Carlsen and Erickson 2008).
[2] Rank: S = State/province; N = National; G = Global; 1 = critically imperilled; 2 = imperilled; 3 = special concern, vulnerable to extirpation or extinction; 4 = apparently secure; 5 = demonstrably widespread, abundant, and secure; ND = Not determined.

2.3 Trends across North America

Native populations of mountain goats are found within the mountains of western North America from Alaska, Yukon, and western Northwest Territories, to Washington, Idaho, and Montana (Festa-Bianchet and Côté 2008) (Figure 1, Table 1). The greatest numbers of mountain goats occur within coastal mountain ranges from Alaska to Washington, but significant populations are found in the interior, primarily within the Rocky Mountain Range. British Columbia (~52%) and Alaska (~29%) have most of the estimated 80,000–120,000 mountain goats within the global population (Festa-Bianchet and Côté 2008).

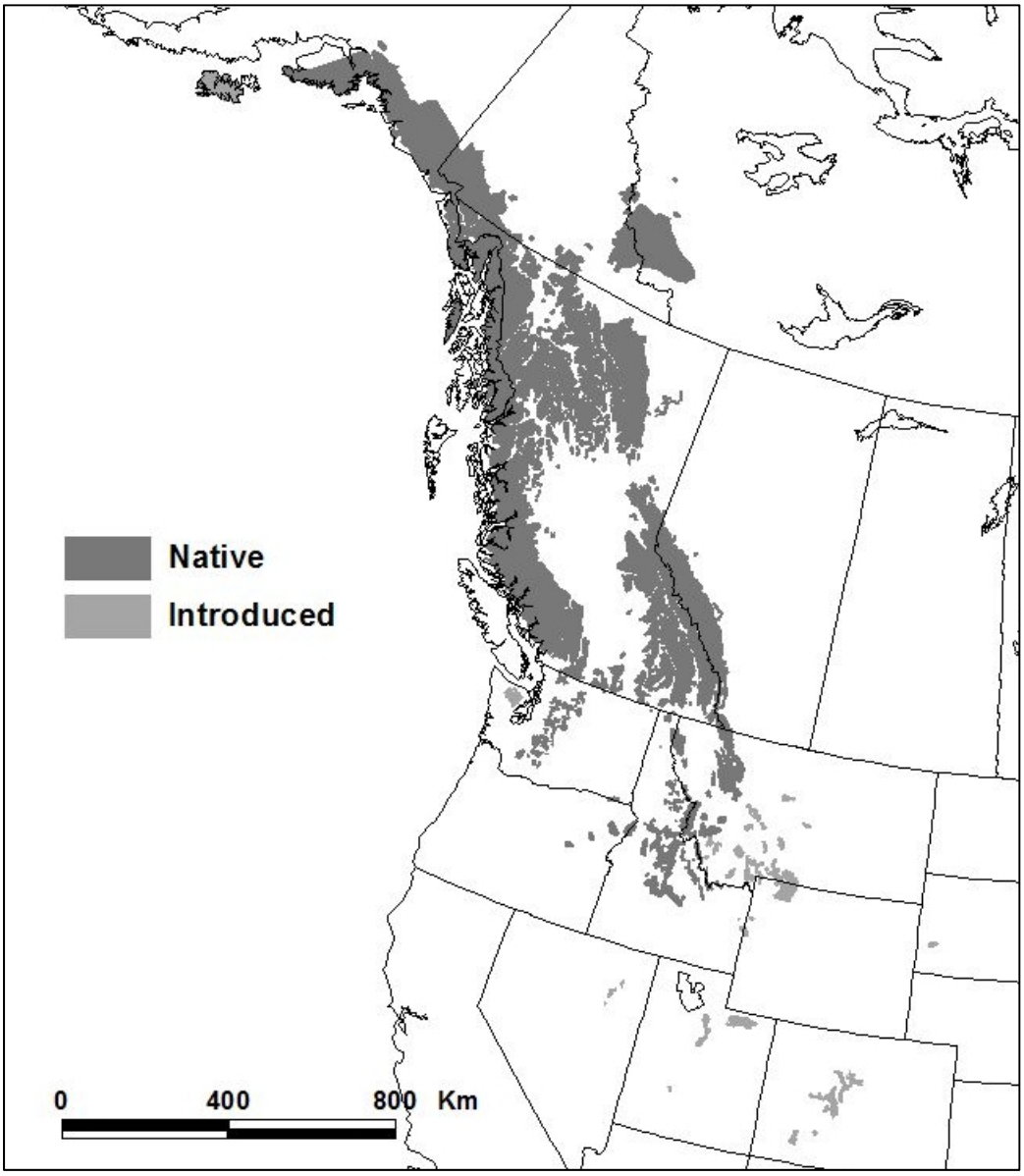

Figure 1. Geographic distribution of mountain goats in North America.

2.4 Distribution/Range of Mountain Goats in British Columbia

Mountain goats are found throughout mountainous regions of British Columbia (Shackleton 1999) (Figure 2). Mountain goat range covers roughly 391,000 km^2, about 40% of the province. Outside of mountainous areas, they are found in only a few isolated locations associated with cliffs and banks along rivers east of the Rocky Mountains in the northeast of the province (EBA Engineering Consultants Ltd. 2004).[1] There are no established natural populations of mountain

[1] Foster, B.R. 1981. Preliminary reconnaissance of wild bovids inhabiting Boat Creek and the Sikanni Chief River, northeastern British Columbia. Progress Report No. 1. Unpublished report submitted to Westcoast Transmission Co. Ltd., Vancouver, BC.

goats on the large coastal islands (e.g., Vancouver Island, Haida Gwaii). There is evidence of mountain goats on Vancouver Island from the early Holocene (post-glacial ~10,000–12,000 years ago; Nagorsen and Keddie 2000).

With the possible exception of the southern fringes of range, the overall distribution of mountain goats in British Columbia has changed little in the past 300–400 years. At least two small (< 30 animals) and relatively isolated populations along the southern edge of distribution in the West Kootenay may have disappeared over the past 10–20 years (Keenleyside dam and Big Sheep Creek; G. Woods, pers. comm. 2008). Hunting may have contributed to the declines, but severe winters in the late 1990s and high cougar (*Puma concolor*) predation may have also contributed to the local extirpations (G. Woods, pers. comm. 2008). Several populations in the Okanagan were extirpated due in large part to over-harvest.[2] The Almond Mountain complex near Grand Forks once held 50–80 mountain goats, but none have been reported in the past 20 years (B. Harris, pers. comm. 2009).[3] The Similkameen/Ashnola population has been reduced by half since the early 1980s, with goats in the Cathedral Lakes, Upper Ashnola River bluffs, and Snowy Mountain areas absent or at very low numbers.[4] However, in parts of the south Okanagan, mountain goat numbers appear to be down, but the distribution is up (i.e., they appear to be abandoning some traditional areas and distributing more thinly in "new" areas) (B. Harris, pers. comm. 2009).

[2] Wilson, S.F. and R.L. Morley. 2007. Mountain goat management and population restoration plan for the Okanagan Region. Unpublished report for B.C. Ministry of Environment, Penticton, BC.

[3] Gyug, L. 2006. Mountain goat population and harvest assessment in the Okanagan Region. Unpublished report for B.C. Ministry of Environment, Penticton, BC.

[4] Gyug, 2006.

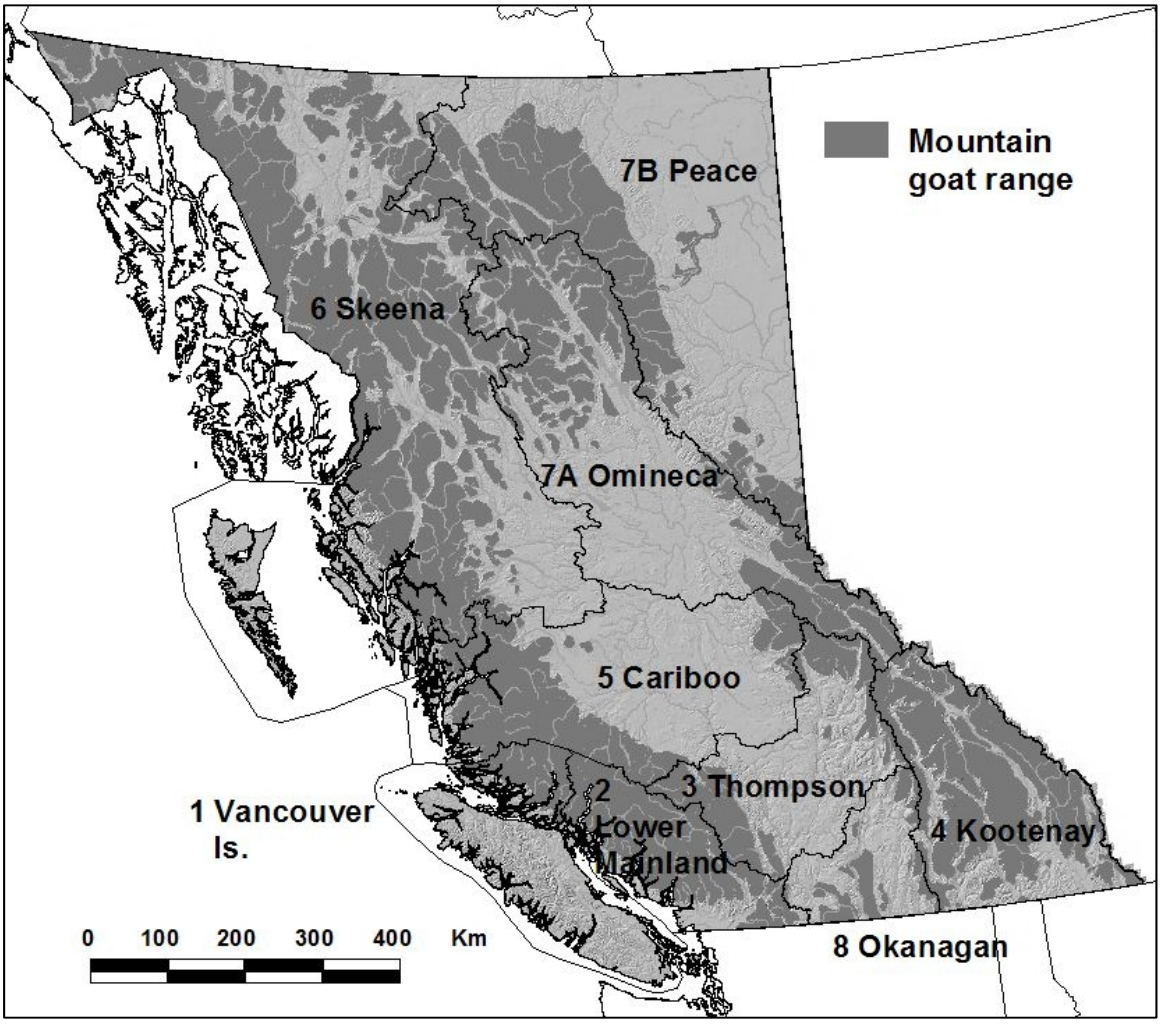

Figure 2. Distribution of mountain goats in British Columbia. Based on a map provided in Shackleton (1999), and updated from B.C. Ministry of Environment biologists in 2008–2009. B.C. Wildlife Management regions are illustrated by number and name.

2.5 Populations within British Columbia

Approximately 39,000 to 66,000 mountain goats are currently believed to inhabit British Columbia (Table 2, Figure 3). The Skeena region has nearly half of the province's total, with the Kootenay region holding nearly 20%. Based on the range around the midpoint of the estimated numbers for each region, Skeena also has the widest confidence in their estimate (37% above and below the midpoint), followed by the Peace (33%), Vancouver Island (24%), Lower Mainland (26%), and Thompson (25%). The Kootenay region had the tightest confidence in the estimate (4% above and below the midpoint), a result of continuing and recent inventories over much of the region.[5]

[5] Poole, K.G. 2006. A population review of mountain goats in the Kootenay Region. Unpublished report for B.C. Ministry of Environment, Cranbrook, BC.

Table 2. Estimated number and trend of mountain goat populations within MoE administrative regions of British Columbia in 2008. Data are based on information supplied by regional wildlife biologists. Estimated numbers are a range from the minimum thought to be present, to a more optimistic estimate for each region.

Region	Estimated number	% of total	Estimated trend[a]
1 Vancouver Island	1900–3100	5%	S-D
2 Lower Mainland	1000–1700	3%	S-D
3 Thompson	1500–2500	4%	D
4 Kootenay	9200–9900	18%	S
5 Cariboo	4000–5000	9%	S
6 Skeena	16,000–35,000	49%	S
7A Omineca	3000–4000	7%	S
7B Peace	2000–4000	6%	S
8 Okanagan	200–300	< 1%	D
Provincial total	39,000–65,500		S-D

[a]Trend: S = stable; D = decreasing.

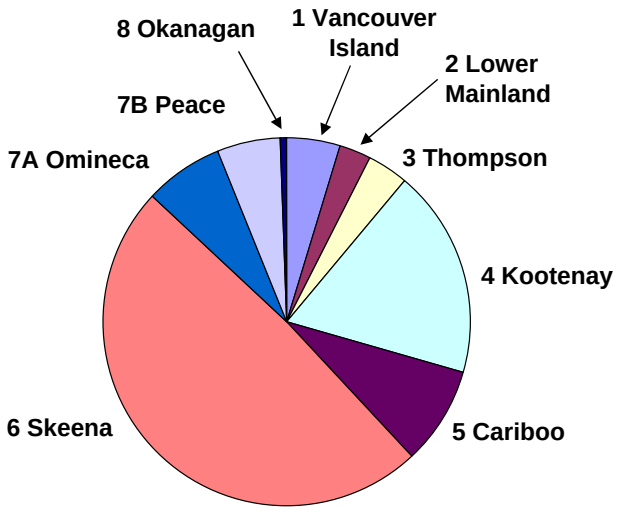

Figure 3. Approximate division of mountain goat numbers among regions of British Columbia (based on midpoint of range estimates from Table 2).

Many interior populations and some coastal populations (e.g., portions of Lower Mainland region) were believed to have declined through the 1960s and early 1970s, primarily as a result of "massive overharvest" of mountain goat populations due to liberal harvesting regulations combined with increased access (Phelps *et al.* 1983). The recent trend in mountain goat numbers within the province is stable in areas with the highest numbers (northern and central British Columbia and the Kootenay), but stable/decreasing or decreasing in southern and south coastal areas where numbers are lower (Table 2). Since most regions lack extensive inventories, trend

data are based in large part on surveys of small portions of each region, or on indices to population trend (hunter harvest, hunter success, observations, kid:adult ratios).

2.6 Transplants

In North America transplants have been used to re-establish extirpated populations, but also to introduce mountain goats into areas where they do not appear to have occurred in the past. For example, mountain goats introduced into Olympic National Park in Washington State increased and spread to the point where there were concerns over their possible negative effects on alpine vegetation (Houston and Stevens 1988). Transplants have established mountain goat populations in Nevada, Utah, and Colorado, well south of historic range, and on some islands in Alaska. Based on a review of Alberta mountain goat transplants, Jorgenson and Quinlan (1996) suggested that due to the great distances moved between the release sites and home range establishment, transplants are not particularly successful in re-establishing populations in desired target areas).

Hatter and Blower (1996) summarized translocations involving British Columbia mountain goats, and Blood[6] further examined ungulate transplants within the province. Regional biologists were polled for updated information to 2008. To date, 151 mountain goats had been transplanted within the province, and 93 mountain goats had been moved out of the province. Almost all transplants occurred between 1983 and 1996. Only one transplant has occurred since the 1996 summary, where 15 animals were moved from three areas in the East Kootenay to the Trail area in the West Kootenay (Kootenay region). Most within-province transplants occurred within the Kootenays (53 animals), Thompson (38), and Peace (29) (Table 3). Most were re-established into areas where mountain goats had been locally extirpated or to augment existing populations, and only one (Fountain Ridge) was a relocation to a site outside of historically known range (Blood 2001). A 1924 transplant of 4 animals from Banff, Alberta, to the Cowichan Valley on Vancouver Island resulted in a small population that may have persisted until the early 1940s (Macgregor 1977). The bulk of out of province transplants were from the Thompson (22), Kootenay (32), and Peace (20), and most of these went to Alberta (79 mountain goats, primarily in the mid-1990s).

With the exception of the Okanagan region, about three-quarters of the transplants appear to have been successful at establishing self-sustaining mountain goat populations within the desired target area (Table 3). There may be a correlation with number of animals transplanted and success. Two of the populations are currently hunted.

[6] Blood, D.A. 2001. Success of ungulate translocation projects in British Columbia. Unpublished report for Habitat Conservation Trust Fund, Victoria, BC.

Table 3. Summary of mountain goat transplants within British Columbia (updated from Hatter and Blower 1996; Blood 2001) and the current (2008) status of populations at the transplant sites.

Region	Transplant location	Years	No. goats	Hunted?	Status (2008)
1 Vancouver Island	Shaw Ck. (Cowichan L.)	1924	4	--	Extirpated in 1940s
3 Thompson	Dunn Peak (N. Thompson)	1985–1990	30	N	Increasing? (20–30)
3 Thompson	Fountain Ridge	1994	8	N	Increasing? (10–20)
4 Kootenay	Slocan Valley	1990–1992	20	Y in 2009	Successful (50–100; R. Milton)
4 Kootenay	Mt. Broadwood	1991–1993	18	N	Unsuccessful (1–2?)
4 Kootenay	Trail	1999	15	N	Increasing (~35; L. Bursaw)
5 Cariboo	Potato Mt.	1984	5	N	Successful (~10–20); ingress from adjacent areas
5 Cariboo	Nemaia/Tsuniah	1989	6	N	Low numbers (~5–15)
7B Peace	Bullmoose Mt.	1983–1984	20	Y	Successful (~110 in ~2002)
7B Peace	Mt. Spieker	1989	9	N	Unsuccessful (no established pop'n)
8 Okanagan	Shorts Ck.	1984	5	N	Unsuccessful (0): Dispersed (Blood 2001)
8 Okanagan	Tulameen Mt.	1986	3	N	Low numbers
8 Okanagan	Snass Mt.	1986	8	N	Unknown

2.7 Importance of Mountain Goats to Humans

The mountain goat is valued by First Nations as a source of meat and for social ceremonial uses. The mountain goat is called *Matx* by the Nisga'a People of western British Columbia (Festa-Bianchet and Côté 2008), and the Klahoose First Nation's symbol (from the Toba Inlet area on the south coast) is the mountain goat. Historically, the Nisga'a and Gitsxan made clothing, drums, implements, and ceremonial regalia from the hide, wool, horns, and hooves, and stored oil in the bladder (Shackleton 1999; Festa-Bianchet and Côté 2008). The Chilkat blanket from the Gitxsan culture was made from mountain goat wool (Shackleton 1999).

Mountain goats are hunted by residents and guided non-residents, and provide significant income and value. Annually, income from licence fees average approximately $110,000 for residents and $300,000 for non-residents (C. Addison, pers. comm. 2010). Although specific goat-viewing industries are limited, the mountain goat is a valued part of the experience in the mountains, and contributes to ecotourism and related non-consumptive use.

2.8 Ecology and Natural History

Presented here is a brief review of the population ecology and dynamics of mountain goats as relevant to this management plan. It is not intended to be an in-depth review of mountain goat ecology. Thorough reviews are provided elsewhere (Chadwick 1983; Côté and Festa-Bianchet 2003; Glasgow *et al.* 2003; Festa-Bianchet and Côté 2008).

Many of the recent insights into mountain goat ecology are based on continuing long-term research that began in 1989 and conducted at Caw Ridge in west-central Alberta, the continent's best-studied mountain goat population (Festa-Bianchet and Côté 2008). Caw Ridge is 28 km^2 of alpine habitat geographically isolated from adjacent suitable habitat in the foothills of the Alberta Rocky Mountains, with a mountain goat population that has increased from approximately 80 to 150 animals during the study. Since there are no comparable long-term studies of individually marked and monitored mountain goats elsewhere in North America, it is difficult to know whether observations and conclusions derived from Caw Ridge directly apply to healthy populations of mountain goats in areas of continuous alpine habitat such as occurs in much of British Columbia.

2.8.1 Habitat needs

Mountain goats primarily inhabit alpine and subalpine areas in northwestern North America (Figure 1), often residing in areas with snow cover for more than half the year. Mountain goats occupy a wide variety of mountainous habitat, from rainforests near sea level in coastal areas, to dry interior peaks > 3000 m in elevation. Climate within mountain goat distribution varies from extremely wet to dry (xeric), with associated winter conditions ranging from coastal temperate to interior continental.

All populations are associated with escape terrain that is critical for predator avoidance. Although mapped definitions of escape terrain vary, these are generally steep slopes usually ≥ 40º or ≥ 84% of shear or broken cliffs where most mammalian predators would be unable to access (e.g., Chadwick 1983; Gross *et al.* 2002; Poole *et al.* 2009). Rock is the main substrate for escape terrain, but for populations living along river valleys, steep mud and clay banks often are used (Harrison *et al.* 1998; Harrison 1999; EBA Engineering Consultants Ltd. 2004). Mountain goats are usually reluctant to venture more than 400–500 m from escape terrain, often less distance during winter (Chadwick 1983; Fox *et al.* 1989; Haynes 1992; Gross *et al.* 2002; Poole and Heard 2003; Taylor *et al.* 2006; Taylor and Brunt 2007), thus it is the juxtaposition of forage and escape terrain that provides quality habitat. Data from Caw Ridge suggests that females may trade off forage abundance, and to a lesser extent forage quality, for safety (nearness to escape terrain; Hamel and Côté 2007).

Cover in alpine areas for mountain goats are generally provided by cliffs and associated features with scattered ledges, overhangs, and caves. Conifer forests may also provide additional shelter from wind and snow, particularly along the west coast where heavy snowfall occurs. Topographic and conifer cover also functions as protection from summer heat.

Winter is a critical season for mountain goats (Chadwick 1983; Fox *et al.* 1989; Côté and Festa-Bianchet 2003; Taylor and Brunt 2007; Poole *et al.* 2009) and movement is restricted, likely because of the energetic cost of moving through deep snow (Dailey and Hobbs 1989). Data from Caw Ridge indicate adult females lose about 27% of late summer mass over winter (Festa-Bianchet and Côté 2008). Foraging in deep snow areas is centred on steep, snow-shedding slopes that expose forage (Foster 1982; Fox *et al.* 1989). In coastal areas with deep snowpacks, mountain goats are often associated with steep slopes on southerly aspects, and low volume stands of scattered short trees, or with moderate volume stands of old, large coniferous trees, which presumably afford greater snow interception (Hebert and Turnbull 1977; Smith 1994; Gordon and Reynolds 2000; Taylor *et al.* 2006; Taylor and Brunt 2007). Interior mountain goats appear to adopt wintering strategies that differ among populations, with animals wintering either on higher-elevation windswept slopes, or inhabiting rocky bluffs at and below treeline in areas of heavier snowfall where wind-swept slopes are unavailable (Poole *et al.* 2009). During periods of heavy snowfall, mountain goats may also use caves and shallow snow wells at the base of large trees in sparsely forested winter ranges (Shackleton 1999). Some interior populations in drier climates winter on exposed ridges and upper elevation grasslands where wind and sun reduce snow depths (Poole *et al.* 2009). Proximity to escape terrain, increased terrain ruggedness, warm aspect, and in some cases increased timber volume are main factors affecting selection of winter range (Smith 1994; Lele and Keim 2006; Taylor *et al.* 2006; Taylor and Brunt 2007; Poole *et al.* 2009).

Summer habitat in parts of the province may reflect areas designed to avoid summer heat. In the southern Okanagan and Similkameen, the hottest and driest occupied mountain goat habitat in British Columbia, mountain goats move off the cliffs into the forest and canyons, presumably to escape summer heat (B. Harris, pers. comm. 2009).

Parturition sites are where nannies give birth and spend their first few days in isolation with their young. These sites are generally widely dispersed within or near winter ranges, and no fidelity to specific parturition ranges is apparent (Lentfer 1955; K. Poole, unpublished data, 2008).[7] Parturition sites are often in rugged, inaccessible cliffs, but in areas with limited precipitous habitat, may occur near treeline within the forest (Holroyd 1967; Festa-Bianchet and Côté 2008). Adults and subadult females, subadult males, and young of both sexes tend to form nursery groups shortly after nannies and kids leave the parturition sites; these groups typically begin moving upslope following green-up to their summer range. Summer range is important during the early rearing period and is typically associated with meadow-like openings that have rich forage and nearby escape terrain.

Mountain goats are generalist herbivores, eating what is available (Côté and Festa-Bianchet 2003), and are considered to be intermediate browsers (Hofmann 1989). Diets vary seasonally, between ecotypes, and among populations, but in general mountain goats focus on grasses, forbs, and browse in descending order of importance (Laundré 1994). Winter diets tend to shift to greater amounts of conifer browse, especially in coastal areas. Litterfall (e.g., fallen lichens and branches) can be an important winter food source (Fox *et al.* 1989).

[7] Lemke, S.L. 1999. Mountain goat population survey Management Unit 3-16. Unpublished report, B.C. Conservation Foundation, Kamloops, BC.

Alpine vegetation contains low sodium content and high potassium levels, thus many populations of mountain goats obtain supplemental minerals to their diet from mineral licks (Hebert and Cowan 1971a; Ayotte *et al.* 2006). While most early evidence pointed to the requirement to maintain sodium balance (Hebert and Cowan 1971a), elevated levels of magnesium, manganese, iron, and copper at lick sites have also been reported (Ayotte *et al.* 2006; Dormaar and Walker 1996). Supplemental sources of magnesium may help offset high dietary potassium levels, and carbonates may help stabilize rumen pH (Ayotte *et al.* 2006). Mineral licks can be characterized into three types: dry earth exposures, muck (wet) licks, and rock face licks (Dormaar and Walker 1996).

The importance of mineral licks among populations seems to vary substantially (Glasgow *et al.* 2003), possibly related to the mineral content of the matrix substrate. Many populations of mountain goats, including most interior populations, generally make extensive use of natural mineral licks, often travelling to low elevation sites or areas distant from their usual home ranges (Hebert and Cowan 1971a; Rideout 1974; Hebert and Turnbull 1977; Hopkins *et al.* 1992; Ayotte *et al.* 2008; Poole *et al.* 2010).[8] Prevalence of mineral lick use by coastal animals may be less than interior populations, possibly due to different geology, as there are no mineral licks currently known on the coast (D. Reynolds, pers. comm. 2008). High elevation licks are also used (Poole and Heard 2003).[9] Lick use occurs primarily between April and early autumn, with males generally using licks earlier in the year, and females and family groups beginning to use licks in early June (Ayotte *et al.* 2008; Poole *et al.* 2010).[10] Mountain goats generally use traditional trails to access licks (Hebert and Cowan 1971a).[11] These trails often traverse extensive areas of forest, and mountain goats may stage and rest at rocky bluffs within the timber as they make periodic excursions to the lick (Hebert and Cowan 1971a). Movements of up to 24 km to mineral licks, often involving low-elevation sites, occur in some populations (Hebert and Cowan 1971a; Poole and Heard 2003; Poole *et al.* 2010).[12] Studies on use of traditional trails and mineral licks after timber removal are underway in the Peace region.[13]

2.8.2 Population ecology

General structure of populations

Management of a species is generally directed at a *population* of that species. Caughley (1977) used the following working definition of a population: "a biological unit at the level of

[8] Rice, C.G. 2009. Mineral lick visitation by mountain goats. Unpublished report, Washington Department of Fish and Wildlife, Olympia, WA.

Corbould, F.B., J.B. Ayotte, M.D. Wood, and G. Blackburn. 2010. Ospika goat adaptive management trial: short-term effects of logging on mineral-lick use by mountain goats. Peace/Williston Fish and Wildlife Compensation Program Report No. XXX. Draft March 2010.

[9] McCrory, W.P. 1979. An inventory of the mountain goats of Glacier and Mount Revelstoke National Parks, British Columbia. Unpublished report. Parks Canada, Western Region, Glacier National Park, Revelstoke, B.C.

Rice, 2009.

[10] Corbould *et al.,* 2010.

[11] Corbould *et al.,* 2010.

[12] Rice, 2009.

[13] Corbould *et al.,* 2010.

ecological integration where it is meaningful to speak of a birth rate, a death rate, a sex ratio and an age structure in describing the properties of the unit." The popular concept is of a group of intermixing animals with a discrete boundary, having little contact with other such groups; these may be termed *local populations* or *subpopulations*, the complex of which can be referred to as a *metapopulation* (Caughley and Gunn 1996). However, at the practical level the definition of a population for management purposes necessitates imposing sometimes-arbitrary boundaries on the landscape. Distinct populations of mountain goats can be surmised in some areas of the province, where individual mountain blocks or groups of mountain blocks where regular exchange is known or suspected can be considered to be relatively discrete. In the Okanagan and Cariboo, these are termed "population units" (P. Dielman, pers. comm. 2009).[14] But in other areas (e.g., sections of the Coast Range in the Skeena; much of the Rocky Mountains in the Kootenay) arbitrary boundaries dividing essentially continuous populations are required. Here we use the term *population* relatively loosely to refer to the managed unit of mountain goats. The term *herd* is generally used synonymously with *population* (Côté and Festa-Bianchet 2003; Festa-Bianchet and Côté 2008).

Other than during breeding, male mountain goats are usually solitary or found in small groups with other adult males (up to more than 20 individuals in early summer), while females are more gregarious and are found in nursery groups (Côté and Festa-Bianchet 2003). The number of animals in nursery groups varies substantially depending upon population size, season, and possibly habitat. At larger scales, distinct groups (herds) of mountain goats may show limited interaction with adjacent groups on an annual basis, with interchange supplied to a large extent by greater movements of males during the rut, and dispersal of young males (generally 2–3 year olds).

Mountain goat females maintain a stable and linear social hierarchy based on dyadic (one on one) relationships (Côté 2000). Social rank increases strongly with age, and adult females are generally dominant over all other age-sex classes (Côté 2000). Conflict is usually avoided, possibly because their sharp horns can inflict injuries if interactions escalate.

Reproduction

For reasons that are not clearly known (but may be related to higher quality habitat in new, lightly browsed ranges), reproductive rates are generally much higher in "introduced" populations of mountain goats transplanted to areas outside of historically occupied range, compared with "native" populations of mountain goats that occur on historically occupied range (e.g., Adams and Bailey 1982; Swenson 1985; Houston and Stevens 1988; Williams 1999; Lemke 2004). It is not clear how many years must elapse before an introduced population takes on more characteristic "native" reproductive parameters.

Mountain goats are polygynous (a male may mate with more than one female), and breed from early November to early December, normally peaking 15–20 November (Brandborg 1955; Côté and Festa-Bianchet 2003). Males can start participating in the rut at 3 years, but most have success when 6 years and older (Mainguy *et al.* 2009). Males may travel longer distances during this period seeking females in estrous, reduce feeding, and as a result come out of the rut and enter winter in poor body condition (Mainguy and Côté 2008).

[14] Wilson and Morley, 2007.

Parturition is highly synchronized and occurs between mid-May and mid-June. Females disperse and isolate themselves from other animals just before parturition (Holroyd 1967; Côté and Festa-Bianchet 2001b, 2003). Within 5–14 days of birth, nannies and kids rejoin other females and young in nursery groups (Côté and Festa-Bianchet 2003; Glasgow *et al.* 2003).

Female mountain goats appear to follow a conservative reproductive strategy by delaying age of first reproduction (primiparity) and reduce frequency of breeding to minimize the cost of reproduction (Festa-Bianchet and Côté 2008; Hamel *et al.* 2009). Data from Caw Ridge show females produce their first kid at an average of 4.6 years of age (most at 4–5 years; range 3–7 years), although females in introduced populations can produce their first kid at 2 years of age, or more normally at 3 years (Houston and Stevens 1988; Côté and Festa-Bianchet 2001b). Age at first reproduction in coastal Alaska also appears to be at 4 years (K. White, pers. comm. 2008), although data from Alaska suggest about 40% of 2-year-olds produce young even in native populations (Smith 1984). Kid production at Caw Ridge peaks from ages 8 to 12 (Festa-Bianchet and Côté 2008), later than other populations (Côté and Festa-Bianchet 2003). Reproductive senescence normally begins at 10–12 years of age (Côté and Festa-Bianchet 2003, Festa-Bianchet and Côté 2008). About 25% of adult females are in reproductive pause each year at Caw Ridge (Festa-Bianchet and Côté 2008), although in one study in coastal Alaska all females ≥ 5 years (n = 33) gave birth (Smith 1984). Limited sample sizes from British Columbia suggest, as determined by progesterone levels in the blood, lower pregnancy rates in some areas (55% ≥ 3 years, n = 11, Ospika area in northeastern British Columbia[15]; 38% ≥ 3 years, n = 13, East Kootenay; K. Poole, unpublished data. 2008).

Females normally have one kid but twins have been reported in some native populations (e.g., Holroyd 1967; Foster and Rahs 1985; Festa-Bianchet *et al.* 1994), and are more common in introduced populations (Lentfer 1955; Hayden 1984; Houston and Stevens 1988). Triplets have been reported in introduced populations (Lentfer 1955). Kids are precocious (rapidly able to move about independently), and can move about on steep slopes within hours of birth. Kids remain with their mother during their first winter, and may associate with their mother as yearlings and occasionally as 2 year olds (Festa-Bianchet and Côté 2008).

Kid production appears to be negatively associated with winter severity during pregnancy (Adams and Bailey 1982; Swenson 1985) and April–May snowfall and snow depth (Thompson 1980; Hopkins *et al.* 1992). The causal mechanism for this may be large inter-annual variation in crude protein in the diet, which is a measure of habitat quality. Similarly, in coastal Alaska snow depth during February to May had the greatest influence on survival of older animals (K. White, pers. comm. 2008).

Studies at Caw Ridge (Festa-Bianchet and Côté 2008) highlight the following characteristics of reproduction in mountain goats. Female body mass and social rank affect the probability of giving birth (Côté and Festa-Bianchet 2001b). Older females contribute the most to the population, and tend to produce more males (Festa-Bianchet and Côté 2008); these males are larger and of higher phenotypic quality. Male breeding success is related to larger body mass but

[15] Corbould *et al.,* 2010.

not horn size, with older males generally tending the oldest females (Mainguy and Côté 2008). For example, at the Caw Ridge population (currently numbering ~150 animals), about half of the offspring in the last 10 years have come from five individual males (Mainguy *et al.* 2009). The largest male mountain goats produce the largest sons, but the smallest daughters (Mainguy *et al.* 2009).

Mortality factors

Causes of natural mortality are numerous, and include predation, accidents as a result of falls, falling rock, avalanches, and starvation (particularly of kids) (Côté and Festa-Bianchet 2003). Predation is likely the most important mortality factor. Grizzly bears (*Ursus arctos*), wolves (*Canis lupus*), and cougars are cited as the most important predators, although wolverines (*Gulo gulo*), coyotes (*Canis latrans*), and black bears (*Ursus americanus*) are other potential predators (Côté and Festa-Bianchet 2003; Glasgow *et al.* 2003). Golden eagles (*Aquila chrysaetos*) prey on kids in some areas (Brandborg 1955; Smith 1976; Hamel and Côté 2009), although they likely have limited impact at the population level. Predation may primarily affect young (kids and yearling) and older animals (> 8 years of age; Smith 1986). Mountain goat populations are unlikely to support a predator population, which would be maintained mostly by sympatric cervid populations—deer (*Odocoileus* spp.), elk (*Cervus elaphus*), and moose (*Alces alces*). Predation may be considered a stochastic event; one individual, such as a single cougar, may specialize or focus on mountain goats and have serious consequences to a particular herd (Côté and Festa-Bianchet 2003). Severe winters may weaken animals or force them to take greater risks to obtain forage, pre-disposing them to higher levels of predation or risks of accident (e.g., avalanche).

Mountain goats have an increased risk of predation at and below treeline (Festa-Bianchet *et al.* 1994; Côté and Beaudoin 1997). This risk may be compounded if cutblocks alter the prey and predator community at these lower elevation sites. Increases in early seral habitats may increase populations of deer, elk, and moose such that potential predators of mountain goats–wolves, cougars and bears (Côté and Festa-Bianchet 2003)–may become more numerous within the forest matrix. The result is higher levels of predators being supported by higher numbers of prey, and mountain goats therefore may be taken more often as secondary prey. However, the consequences of altered predator-prey relationships are unpredictable (Festa-Bianchet and Côté 2008), and to our knowledge have not been examined in mountain goats.

Although not thought to be a frequent mortality factor, deaths from falls and avalanches have been reported (Brandborg 1955; Holroyd 1967; Chadwick 1983; Taylor *et al.* 2006). Virtually no mountain goats are killed by vehicle collisions within British Columbia (Sielecki 2004) because of the scarcity of high velocity roads in their natural range.

Weather can affect animal condition through the quality and quantity of forage produced and accessed. Winter severity appears to influence kid production and survival. Severe winter weather with deep or heavily crusted snowpacks can result in population declines through increased starvation, predation, and possibly avalanches (Adams and Bailey 1982; Hebert and Langin 1982; Bailey 1991).

Survival

Kid survival to 1 year of age is highly variable, and at Caw Ridge ranged from 38 to 92% ($\bar{x}$ = 64%; Festa-Bianchet and Côté 2008), and in Montana averaged 69% (Smith 1976). These values are higher than reported for most other ungulates (Gaillard *et al.* 2000). Yearling survival is less variable, but greater for females (85%) than males (74%). Survival of 2 year olds and older mountain goats remains lower for males than females at Caw Ridge. As a result, the sex ratio in a population favours females. Between 1994 and 2003, the adult sex ratio in the unhunted Caw Ridge population averaged 49 males/100 females, with a range from 27 to 72 males/100 females in different years (Festa-Bianchet and Côté 2008). A range of 23–56 males/100 females has been reported from other areas (Chadwick 1973; Rideout 1974; Foster and Rahs 1985; Houston and Stevens 1988).

Population modelling of small- to medium-sized mountain goat populations in western Alberta suggests that while recruitment is more variable, survival of adult females > 5 year olds has the greatest potential to influence population changes (Hamel *et al.* 2006).

Density dependence

Density dependence occurs when vital rates of the population (e.g., births, deaths) and its growth rate vary with the density of the population. For example, as a population approaches theoretical carrying capacity (K, the limit to the number of individuals the area can support), pregnancy rates should decline in a density-dependent population. Introduced herds of mountain goats have reported annual growth rates as high as 15% and evidence of density-dependence in reproduction (Adams and Bailey 1982; Swenson 1985; Houston and Stevens 1988; Bailey 1991; Williams 1999; Lemke 2004). However, most studies suggest that native (non-introduced) populations of mountain goats have limited ability to withstand harvest, likely because of low kid production, either-sex harvest, and additive hunting mortality (reviewed in Côté *et al.* 2001a; Gonzalez-Voyer *et al.* 2003; Hamel *et al.* 2006). It is unclear when the characteristics of an introduced population evolve into those of a native population, with the consequential lower sustainable harvest level.

Toweill *et al.* (2004) suggested that density-dependent factors limit further expansion of transplanted populations after the initial expansion phase. However, no density-dependent responses or compensatory reproduction (increased pregnancy and fecundity in response to lower densities) to harvest or natural declines have been reported for native populations (Côté *et al.* 2001; Gonzalez-Voyer *et al.* 2003). Most of this debate has been framed around Caw Ridge; with a doubling of the population over the past 15 years (Hamel *et al.* 2006), there has been no evidence of density dependence in kid production or survival, recruitment (Festa-Bianchet and Côté 2008), or adult survival (Festa-Bianchet *et al.* 2003). However, nutrient availability may limit the reproductive performance of mountain goats by retarding their growth (Festa-Bianchet *et al.* 1994), litter size (twinning) may be related to resource availability (Houston and Stevens 1988), and there may be density dependence in costs of reproduction (Hamel *et al.* 2010), suggesting that some density-dependent response should occur. Theoretically, a density-dependent response should be most noticeable near carrying capacity, and it is possible that most native populations are held at densities below carrying capacity such that responses by the population are difficult to detect (Festa-Bianchet and Côté 2008). An alternative hypothesis is that most populations are near carrying capacity and the harvest does not decrease the population

below carrying capacity enough that density dependence is apparent; however, empirical data in support of this latter theory are limited (Côté *et al.* 2001). That mountain goat populations appear to be very weakly density-dependent means that population dynamics are more difficult to predict, and argues for comparatively cautious management compared to species that are known to show stronger responses to density.

2.8.3 Movements and range use

There are large differences in daily, seasonal, and annual movement rates, migrations and home range sizes, and few patterns seem to hold constant across populations. Daily and short-term movement patterns for mountain goats could be described as relatively rapid movement to a new focal area, followed by days or even weeks concentrating and feeding in the same general area. Although there are wide differences among areas and seasons, male mountain goats may move < 1 km each day, and females may move 2–5 km per day or more (Côté and Festa-Bianchet 2003). In the East Kootenay, mean movement rates as calculated from 6-hour GPS collar fix intervals peaked in June through mid-August for both females (~100–125 m/hr) and males (~85–100 m/hr) and were lowest during winter (~5–15 m/hr for both sexes), with a 5- to 6-fold difference in average movement rates between these two extremes.[16] Activity generally peaks in early morning and late afternoon/evening, and can be affected by weather conditions (Singer and Doherty 1985; Romeo and Lovari 1996).

Migration between seasonal ranges generally involves movements in elevation, with or without significant horizontal movements of up to 35 km (Nichols 1985; Poole and Heard 2003).[17] Migration between seasonal ranges occurs in many populations (Côté and Festa-Bianchet 2003), but the degree of movement is highly variable – generally a blend of horizontal and elevational movements (Rice 2008). Concurrent with smaller overall range sizes, maximum migration distances for females were about 25% less than males for a population in the East Kootenay.[18] Seasonal migration in coastal areas tend to be shorter than in interior areas, often averaging < 2 km (Schoen and Kirchhoff 1982; Taylor *et al.* 2006). Analysis of only horizontal movements by mountain goats may be somewhat misleading, and analysis of elevational movement may better reflect ecological conditions affecting animals (Rice 2008). There is a continuous response among individuals and populations in the degree of elevational migration (Rice 2008), a comment that applied equally well to horizontal migration.

Many populations move to lower elevations during winter, presumably to find habitats with lower snow levels or associated forests with higher snow interception to reduce costs of locomotion and foraging. Some populations, associated with drier snow and wind-swept slopes, remain in higher-elevation habitats (Poole *et al.* 2009). Elevational movements are associated with changes in forage quality and quantity; in east-central British Columbia mountain goats moved lower with the first heavy winter snowfall and with the onset of the spring vegetation green-up (Poole and Heard 2003), and moved up through late spring and summer, likely coinciding with greening up of vegetation and snow melt at progressively higher elevations, as

[16] Poole, K.G., I.E. Teske, and K. Stuart-Smith. 2008. Kidding areas, high use areas, and movement patterns of mountain goats in the East Kootenay, 2004–2005. Unpublished report, Aurora Wildlife Research, Nelson, BC.
[17] Poole *et al.,* 2008.
[18] Poole *et al.,* 2008.

found in other studies (Stevens 1983; Varley 1994). Elevational movements in both coastal and interior populations can occur rapidly (Taylor *et al.* 2006).[19]

Annual home ranges can vary from 3 to 90 km^2, and ranges appear to be smaller in coastal populations (Rideout 1977; Singer and Doherty 1985; Fox *et al.* 1989; Lemke 1999; Côté and Festa-Bianchet 2003; Poole and Heard 2003; Taylor *et al.* 2006; Poole *et al.* 2009). While annual ranges of males are typically larger than females, female ranges appear to be equal or even larger than males in some studies, especially during summer (Festa-Bianchet and Côté 2008). Seasonal ranges may overlap to a large extent, or be distinct.[20] Range size is often much smaller during winter, when snow depths impose high costs of locomotion, and may be as small as 8–20 ha (Fox *et al.* 1989; Taylor *et al.* 2006). Winter range comprises < 14% of annual range in a recent East Kootenay study, emphasizing the importance and the degree of restricted movement shown during this season (Poole *et al.* 2009). Crust conditions that form in late winter facilitates easier movement.

In general, mountain goats show high fidelity to annual ranges (Smith and Raedeke 1982; Nichols 1985; Taylor *et al.* 2006), but seasonal differences are apparent. Males may show lower (Nichols 1985; Poole *et al.* 2009) or similar (Taylor *et al.* 2006) fidelity to winter ranges than females. Reported home range sizes vary widely among areas, in large part likely related to topography, forage, and wintering areas, but also with method used to obtain locations (e.g., VHF vs. GPS locations) and method used to calculate ranges (e.g., minimum convex polygons, kernels).

Little is known about dispersal patterns in mountain goats, although there have been a number of reports of mountain goats moving very long distances. Dispersal distances of 16–93 km were reported from a high-density, introduced population on the Olympic Peninsula in western Washington (Stevens 1983), and distances of 12–35 km were reported from the Caw Ridge population isolated by 12 km of coniferous forest in Alberta (Festa-Bianchet and Côté 2008). At both the Olympic Peninsula and Caw Ridge, most of the known emigrants were 2–3 years of age, where males were far more likely to emigrate than females and most dispersal occurred during late summer (Stevens 1983; Festa-Bianchet and Côté 2008). Sporadic observations have been reported of likely dispersing subadult animals in unusual locations well removed from mountainous terrain (e.g., in central Prince George, and in an industrial yard in Fort Nelson; H. Schwantje, pers. comm. 2009).

2.8.4 Interspecific relationships

In British Columbia, mountain goats share portions of their distribution with bighorn sheep (*Ovis canadensis*), and parts of their northern range with thinhorn sheep (*Ovis dalli*). Distribution also overlaps with white-tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus*) and elk in some interior areas, and with black-tailed deer (*Odocoileus hemionus columbianus*) on coastal winter range. The relationship between native populations of mountain goats and wild sheep or other sympatric wild ungulates is poorly known. Laundré (1994) suggested that while substantial overlap in forage classes of diet occur between mountain goats and wild sheep (less

[19] Poole *et al.*, 2008.
[20] Poole *et al.*, 2008.

so during winter; Dailey *et al.* 1984), there is little evidence of resource overlap and competition within sympatric populations, largely due to differences in selection of habitat. Some introduced mountain goat populations may compete for forage or habitat with bighorn sheep (Hobbs *et al.* 1990), and may deter sheep from some resources through behavioural dominance (Reed 2001). Such inter-specific competition may be more expressed in areas lacking natural predators (e.g., Colorado), where mountain goats are less limited to steep terrain (Hobbs *et al.* 1990). Simulation modelling in national parks in Colorado suggested that once established, introduced mountain goats would reduce bighorn sheep populations by 10 to 50% through competition and disease (Gross 2001). The concern from infectious diseases is likely due to a unique situation rather than a concern for all sympatric wild sheep and goat populations. Johne's disease or paratuberculosis is a common, chronic bacterial infection of domestic livestock that is rarely seen in free-ranging wildlife. Clinical disease is reported to occur in some herds of mountain goats and bighorn sheep in Colorado and Wyoming for over 25 years where efforts to control it with culling have been unsuccessful (Williams 2001). As is evident from the references in this section, this issue has been largely examined only in Colorado with an introduced population of mountain goats that suffers from a chronic bacterial condition, likely introduced from cattle or other domestic species.

Contact between mountain goats and domestic species is considered a higher risk than contact with other wild ungulates due to the potential transmission of pathogens. British Columbia's silviculture industry has used domestic sheep and goats for vegetation management of forestry lands to varying degrees since the 1980s. Tens of thousands of domestic sheep were transported from prairie provinces to clearcuts of many areas of British Columbia to spend months grazing and browsing to reduce competition in tree plantations. Recently, the technique has become less popular but domestic goat herds were trialed for efficacy in the British Columbia interior in the early 2000s. Concerns for infectious disease transmission to wild sheep and mountain goats, and susceptibility to a variety of pathogens carried by domestics, led to standards and guidelines designed to locate browsing activities away from known wild populations and actions to ensure and maintain the health of the domestic sheep (Province of British Columbia 2007).

The use of camelid species (llamas and alpacas) for trekking activities also raised concerns for disease transmission. A risk assessment concluded broadly that the introduction of disease into wild populations must be considered with greater concern than for domestic animals because there are few viable options for controlling and eradicating introduced diseases in wildlife.[21] Risks from camelids to wildlife in British Columbia remained hypothetical, as no direct evidence was found to implicate camelids as sources of significant diseases in wildlife in the province or elsewhere. However, since introduced disease agents can and have had important negative effects on wildlife populations, and wildlife under population stress at the time of pathogen or parasite exposure are more susceptible, the authors believed there was enough concern to advise precautionary approaches to managing disease risks to wildlife from camelids.

[21] Schwantje, H. and C. Stephen. 2003. Communicable disease risks to wildlife from camelids in British Columbia. Unpublished report for B.C. Ministry of Water, Land and Air Protection, Victoria, BC. <http://www.env.gov.bc.ca/wld/documents/wldhealth/camelid_risk03.pdf> [Accessed Feb. 1, 2010]

2.8.5 Health

Reviews of parasites and diseases present in mountain goat populations are available elsewhere (Côté and Festa-Bianchet 2003; Glasgow *et al.* 2003; Jenkins *et al.* 2004; Toweill *et al.* 2004; Garde *et al.* 2005) and only general statements are presented here. Infectious organisms of various types are reported in mountain goats where health studies and opportunistic sampling data are available, which should be representative for most mountain goat populations. Some diseases and parasites do cause mortality and compromise health of individuals, but there is limited evidence of serious wider-scale consequences at the population level. Within shared range, mountain goats and wild sheep can harbour the same parasite species (Jenkins *et al.* 2004) and a number of other organisms can infect both species. However, there is no clear evidence of disease transmission from wild sheep to mountain goats.

Parasites known to be present in mountain goats in British Columbia include a range of helminths (nematodes, cestodes [tapeworms]) and protozoa (coccidian) of the gastro-intestinal tract, lungworm (*Protostrongylus stilesi* and *Protostrongylus rushi*), muscleworm (*Parelaphostrongylus odocoilei*), and ectoparasites such as ticks (*Dermacentor* spp.) (Cowan 1951; Jenkins *et al.* 2004). Some of the parasites may be potentially pathogenic but no studies have addressed their impacts at an individual or population level. The prevalence (percent of samples positive) and intensity (mean number of eggs or larvae per sample) of gastro-intestinal parasites were greatest in mountain goats from coastal British Columbia compared to interior populations (Jenkins *et al.* 2004).

The most common ectoparasites on mountain goats are single host ticks (*Dermacentor andersoni* and *Dermacentor albipictus*). *Dermacentor albipictus*, or winter tick, has significant effects on northern moose populations; however, when they occur on mountain goats they may cause hair loss around the shoulders and lower neck from animals scratching and rubbing. High numbers of winter ticks have not been reported to occur on British Columbia mountain goats. The spinose ear tick (*Otobius megnini*) is reported to have occurred historically in British Columbia mountain goats but not cause significant effects (Cowan 1951).

Mountain goats are reported to die from fatal pneumonia similar to bighorns (Schommer and Woolever 2008) but only individuals, rather than herds, have been affected. Contact between domestic sheep or goats and wild sheep is considered high risk and likely to predispose to pneumonia die-offs and separation of the species is highly recommended; therefore, management of mountain goats to ensure their separation from domestics is also prudent (Toweill *et al.* 2004). A risk assessment and review for the Northwest Territories concluded that substantial negative and long term effects on population dynamics and sustainability of wild sheep and mountain goat populations would likely result from contact with domestic sheep and goats (Garde *et al.* 2005).

Other infectious diseases reported in mountain goats in British Columbia include lumpy jaw, an infection of the jawbone, usually caused by one or more bacteria (*Actinomyces* or *Arcanobacterium* spp.) entering through the oral cavity and causing noticeable hard swelling of the mandible or lower jaw. Teeth may be loosened, resulting in their loss and/or improper growth. Infections generally stay in the jaw but may occasionally spread to other body locations.

Animals may live for years or die as a result of poor body condition from difficulty in feeding. These infections are considered opportunistic and no control is possible.

One of the most commonly reported viral diseases of mountain goats is contagious ecthyma (or soremouth). It appears to be endemic in some British Columbia mountain goat populations and can be fatal. It is a virus shared with wild and domestic sheep and goats, but whether the origin of the infection is from direct contact is unclear. Affected animals may have scabs around and in their mouths and other areas of the body but these lesions usually resolve within 4-6 weeks. The virus can survive in the scabs for years. Any management strategies that concentrate infected animals may also increase the likelihood of disease transmission to unaffected animals.

Mountain goats survive predation attempts by retreating to escape terrain quickly. Any chases that result in sustained muscle activity can produce a peracute or more chronic degenerative and often fatal muscle condition or myopathy that can occur with capture attempts and is then referred to as capture myopathy. Low levels of selenium may predispose animals to this condition (also referred to as white muscle disease) and there is evidence that some populations may have reduced levels of this mineral (Hebert and Cowan 1971b; Fielder 1986). Animals may die acutely if heart or other vital muscle areas are affected or have chronic scarring of large leg muscles and be therefore predisposed to predation within weeks of muscle injury. Mountain goats are one of the more sensitive ungulate species to capture myopathy and any capture attempts by humans for management purposes must be done quickly and efficiently by experienced personnel that understand this risk.

Chronic stress is known to affect long-term health and fitness through secretion of corticosteroids and the depression of the immune system. Although well known in many species and an often-quoted issue for mountain sheep (e.g., Spraker *et al.* 1984; Moberg 2000; Millspaugh *et al.* 2001), the implications of chronic stress are expected to apply to mountain goats but are not well researched. Joslin (1986) suggested that stress caused by human activities can make mountain goats more susceptible to disease, similar to what happens with wild sheep.

Health assessments of individuals and populations of British Columbia mountain goats have been done opportunistically, but sample analysis, collation, and interpretation of results have not been done on a systematic basis. New techniques are now available that should be used to improve baseline data on mountain goat populations and monitoring over time. A health assessment and management protocol for species at risk (SAR) was developed for British Columbia, and is designed to identify health threats and improve management and recovery planning.[22] Wildlife health in the province is prioritized by species and disease, with SAR given the highest priority. Health evaluations are carried out using opportunistic sampling as well as more formal risk assessment and monitoring. For mountain goats, this should include evaluating the demographics of the herd, sampling individuals for disease exposure, and examining herd genetics for the degree of genetic diversity. The general approach is to (1) sample and monitor

[22] Fraser, E. and J. Parmley. 2008. Health assessment and management resource for Species at Risk in British Columbia. Unpublished report for B.C. Ministry of Environment, Ecosystems Branch, Victoria, BC.

the population in question; (2) gather more data through targeted sampling to include collecting and archiving samples; and (3) implement and assess intervention strategies.

2.9 Management/Conservation Issues and Threats

2.9.1 Threat classification

To understand broad-scale threats to mountain goats, we followed the classification system adopted from the International Union for the Conservation of Nature (Salafsky *et al.* 2008), which has been previously used for many species (Master *et al.* 2009). The output from this analysis was low to medium threat impacts determined for 10 of the 11 threats categories (Appendix A). However, the overall impact value was calculated as high because of the large number of medium and low values (i.e. > 2 medium and 2 low). Detailed information on threats to mountain goats is provided within the provincial management framework.

2.9.2 Habitat threats

The relative importance of potential threats to mountain goat habitat varies among regions of the province. Most threats relate to habitat effectiveness, an area's actual ability to support mountain goats given the quality of the habitat and the extent of human disturbance. Threats reduce habitat effectiveness by altering its suitability and function, or changing the quality and/or quantity of forage and/or cover available.

Removal of forest cover increases exposure to the elements, while reducing the availability of forage during winter. Of particular concern is the removal of mature or old-growth forest cover from winter range associated with forest harvesting or other development activities (e.g., transmission line corridors), particularly in coastal and interior wet-belt areas, where lower elevation commercial forests are used by mountain goats for snow interception and foraging habitat during winter. Examples of this occur in coastal areas in the Kispiox, North Island – Central Coast, Campbell River, Sunshine Coast, and Kalum Forest Districts (Gordon and Wilson 2004; Taylor *et al.* 2006; Taylor and Brunt 2007), but it also occurs in other mature and old forest mountain goat habitat, such as in the Robson Valley of east-central British Columbia (Poole and Heard 2003). Use of early forest (20–40 years old) by mountain goats has occurred in some populations, primarily during summer (Gilbert and Raedeke 1992; Poole and Heard 2003), and to a lesser degree during winter, which may be related to snow level (Taylor *et al.* 2006).

Direct habitat loss can occur due to road construction within or adjacent to sensitive habitats (e.g., winter range, parturition sites) associated with forest harvesting, mineral exploration, mines, independent power producers, oil and gas exploration and development, backcountry tourism, and roads from other industrial activities. In some cases vertical road cuts and fills across an already steep slope create upslope to downslope movement barriers causing mountain goats to expend additional energy to move around them. In other situations, roads in goat habitat can reduce habitat connectivity, increase fragmentation, and improve access.

Habitat fragmentation can have several consequences, including isolation of individual herds and sub-populations, reduction of suitable habitat, loss of connectivity and increased energy

expenditures to reach suitable habitat (which may reduce fitness), and increased predation (from reduced fitness and the increased exposure to predation that is facilitated by roads). Indirect habitat loss primarily occurs in the form of human disturbance, which temporarily or permanently affects habitat effectiveness, and may indirectly affect animal and population health (disturbance is covered later in this document).

Alteration of habitat within mountain goat areas may cause animals to abandon a feature and use other, possibly less suitable locations. For example, mountain goats frequent important mineral licks, primarily in interior populations. If cover is removed (particularly where mountain goats focus on minerals under mature conifer trees), these features may be abandoned (Taylor and Brunt 2007; Poole *et al.* 2010), with secondary effects on animal health.

Fire suppression, which contributes to habitat succession and forest in-growth, may affect forage quality and quantity in subalpine and even alpine areas. Declines in mule deer populations have been attributed in part to fire suppression that has altered the natural pattern of forest succession, resulting in forest regeneration, forest canopy closure, and reduction in shrub cover (Peek *et al.* 2002), and concomitant declines in forage conditions across broad areas of the west (Peek *et al.* 2001). Similar broad changes in mountain goat habitat quality may occur over time, possibly resulting in changes to recruitment and survival. Mountain goats are thought to have increased in Penticton Creek and Okanagan Mountain Park in the Okanagan following fires in 1971 and 2003, respectively.[23] Wildfire can alter mountain goat habitat in parks, as witnessed during the 2003 fire season in the Rocky Mountain National Parks when substantial areas of subalpine habitat was burned.

Where mountain goat habitat occurs within national and provincial parks and other conservation areas, it will generally be protected from industrial development by those designations. Within the province, approximately 14% of the land base is within parks, where no industrial activity may occur (this includes Class A, B, and C parks; conservancies; recreational areas; ecological reserves; protected areas; wildlife management areas; other undesignated conservation lands for fish and wildlife; and national parks). Approximately three-quarters of the area covered by parks in British Columbia is mountain goat habitat. Other threats to mountain goat habitat in parks may occur, such as recreation activities that may reduce habitat effectiveness.

2.9.3 Population threats

A number of factors may separately or cumulatively affect mountain goat populations. Many of these factors are associated with or made more important because of the impacts of habitat loss and fragmentation discussed above that isolate herds, cause chronic stress, and amplify the risk of local extirpation (Hamel *et al.* 2006; Festa-Bianchet and Côté 2008). The relative importance of these factors is poorly understood, and may include regulated and unregulated hunting, predation, severe winter weather, disease, disturbance associated with human access, and demographic stochasticity (variability in population growth rates arising from random differences among individuals) and loss of genetic diversity.

[23] Wilson and Morley, 2007.

Regulated hunting
Regulated hunting of mountain goat populations in British Columbia occurs through a combination of allocation and/or season restrictions. Allocations are based on population estimates or trend data. Problems with sustainable harvests may occur when inventory data are poor, excessive numbers of female mountain goats are harvested, or the harvest is not distributed proportionately to the distribution of the population. Problems may also occur when incorrect assumptions are made regarding sustainable harvest rates (due to poor understanding of recruitment rates), or lack of understanding of specific population dynamics and distribution.

Mortality associated with hunting can be entirely additive to population losses from natural events because of relatively low reproductive rates, low propensity for dispersal, and limited ability of any density-dependent response in reproductive and survival parameters (Toweill *et al.* 2004). This problem is magnified in small, relatively isolated populations.

Hunting is allowed in many Provincial Parks and Protected Areas in the province, where a more conservative harvest is generally set. Provincial policy directs that harvest be managed more conservatively within British Columbia Parks than outside of parks. Activities within parks are also influenced by Park Management Plans specific to each park. When compared to management of opportunities outside of parks the seasons in parks may be shorter, the allowable harvest determination with in a park may be lower or the harvest guidelines may be worded differently.

Resident and guided hunting is not legal in national parks. National parks comprise only 0.6% of the provincial land base, and with the exceptions of coastal national parks (Pacific Rim National Park Reserve, Gwaii Hanaas National Park, and Gulf Island National Park Reserve) occur only within the Kootenay region. About 8% of mountain goats in the Kootenay region reside within national parks.[24]

Not all mountain goat populations on provincial lands can be hunted, for reasons often related to small or isolated populations. The regional percentage of mountain goats residing in areas that can be hunted ranges from 94 to 100% of mountain goats (Vancouver Island, Kootenay, Skeena, Omineca, and Peace Regions) down to 75–85% (Lower Mainland, Thompson, and Cariboo Regions), and as low as 30% (Okanagan Region).

The degree of wounding losses during mountain goat hunting in British Columbia is unknown.

Unregulated hunting
The levels of unregulated hunting of mountain goats in the province are largely unknown, but not thought to be significant. Unregulated hunting levels are also thought to be insignificant in Alberta (Glasgow *et al.* 2003). Generally most people do not consider mountain goats as a primary source of sustenance because they are generally difficult to hunt and are not considered the best table fare, so it is unlikely that many mountain goats are being illegally harvested. Mountain goats taken illegally from specific areas are likely reported as having been killed in other areas, making the kill appear legitimate. The degree of opportunity, the accessibility of the

[24] Poole, 2006.

animals, and the size of the hunting zones likely influence the risk of this occurring (i.e., the more numerous and smaller the zones, the greater likelihood).

Levels of First Nations harvest of mountain goats within the province are poorly known, but are thought to be minimal in most areas. The exception may be in the Skeena region, where First Nations harvest surveys suggest that First Nations harvesters could account for about 10–15% of the total harvest from some areas (G. Schultze, pers. comm. 2009). The number of mountain goats harvested by First Nations likely depends upon a variety of factors including the availability of alternate (perhaps more preferable) food animals, the ability to access mountain goats, and the societal significance of harvesting a mountain goat. Annual harvest will likely fluctuate from year to year similar to provincially licensed harvest and will likely be most concentrated in areas of easiest access.

Harvest rates

Native populations of mountain goats are sensitive to high harvest rates (Festa-Bianchet and Côté 2008). Modelling from Alberta data suggest a 1% harvest (assuming equal harvest of males and females) for small, native populations may be sustainable (Gonzalez-Voyer *et al.* 2003; Hamel *et al.* 2006). However, implicitly acknowledging that the ecology of mountain goats at Caw Ridge (an isolated population of 100–150 mountain goats in the foothills of the Rocky Mountains) may not reflect other situations, Côté and Festa-Bianchet (2003) suggest that the best management strategy for native populations of mountain goats is to combine a 2–3% annual harvest of a population with a strong encouragement to harvest adult males. Coupled with these suggestions, Côté and Festa-Bianchet (2003) recommend annual monitoring of population size, an approach that is not fiscally and logistically practical across the broad expanse of mountain goat range in British Columbia. Within North America, the targeted harvest rate ranges from 2 to 10%, although most jurisdictions aim for 3–5% of the population (Toweill *et al.* 2004).

Significant reductions in mountain goat numbers throughout much of their North American range during the 1950s through to the 1980s were likely a result of application of management principles taken from other ungulates with greater productivity and less susceptibility to harvest. Harvest is the primary cause of declines of mountain goats in many areas (Phelps *et al.* 1983; Hamel *et al.* 2006; Rice and Gay 2010), and mountain goat may be the only North American ungulate to have suffered local extirpation through regulated hunting (Glasgow *et al.* 2003). Introduced herds in non-native habitat can tolerate much higher harvest levels than native herds because of higher productivity (Swenson 1985; Houston and Stevens 1988; Williams 1999, but see Côté *et al.* 2001).

Female harvest

Mountain goat populations are sensitive to adult female mortality because of comparatively late age at first reproduction (e.g., 4–5 yrs at Caw Ridge) and low production and survival of kids (Festa-Bianchet *et al.* 1994; Côté and Festa-Bianchet 2001b; Hamel *et al.* 2006). Hunter harvest tends to be concentrated on the largest individuals, consequently harvested females are often the dominant animals of the most productive age group (Côté and Festa-Bianchet 2001b), which has a significant impact on recruitment (Festa-Bianchet *et al.* 1994; Côté and Festa-Bianchet 2001b). Females aged ≥ 7 years, those of the highest social rank, and females of the highest body mass account for most of the kid production and recruitment of yearlings to the population (Côté and

Festa-Bianchet 2001; Festa-Bianchet and Côté 2008). Population modeling of small to medium size (25–50 animals) mountain goat populations in western Alberta suggests that while recruitment is more variable, survival of adult females > 5 year olds has the greatest potential to influence population changes (Hamel *et al.* 2006). Modelling by Hatter (2005) suggested that smaller populations require lower harvest rates on females to remain stable. Many jurisdictions in North America report the proportion of females in the harvest between 20 and 40% (Toweill *et al.* 2004). The negative impact of female harvest on small populations is probably magnified (Hamel *et al.* 2006).

Increased access

Access related threats are associated with the development of wilderness areas for industrial or recreational purposes. One of the most pervasive threats of increased access is that it can facilitate increased hunting activity. Many populations in the Kootenays were believed to have declined in the 1960s to early 1970s, primarily as a result of "massive overharvest" of mountain goat populations due to increased access combined with liberal harvesting regulations (Phelps *et al.* 1983). Similar scenarios occurred in the Okanagan region,[25] and in portions of the Skeena region and were realized when hunter success rates were declining. Other access issues occurred in parts of the Lower Mainland region, and in the Omineca region. In the Kootenays, each new road opened access to previously inaccessible watersheds, which resulted in high and continued harvest rates. This continued until most drainages had been substantially impacted (Phelps *et al.* 1983). In some areas in the Lower Mainland region (e.g., Chilliwack Forest District), local populations have not recovered from the decline despite more than 20 years of closed hunting seasons. In such cases other forms of ongoing human disturbance, habitat loss, and cumulative effects are believed to be the reasons for a lack of recovery.

Population size, stochastic events, and small populations

Small populations are at greater risk of extirpation simply by being relatively few in number and therefore more vulnerable to stochastic variation. Three main categories of risk characterize small populations of a species (Caughley and Gunn 1996). Demographic stochasticity may affect small numbers of animals simply by chance, such that the individual fortunes of each animal (e.g., breaking a leg, succumbing to a predator, producing only males) swamp probabilities that would determine the outcome for larger populations. Environmental stochasticity—the variation in environmental conditions (e.g., drought, severe winter)—has an unpredictable influence on population persistence that can have greater impact on small numbers. Finally, low population levels and reduced genetic variation may induce inbreeding depression and reduced genetic fitness.

Small population size is recognized in management of mountain goats. Populations of less than 50 individuals are generally not hunted in Alberta, British Columbia, and Alaska (Glasgow *et al.* 2003; Hatter 2005; Hamel *et al.* 2006; McDonough and Selinger 2008). Washington State recently increased the minimum population size that can be hunted from 50 to 100 (Washington Department of Fish and Wildlife 2008; Rice and Gay 2010).

[25] Gyug, 2006; Wilson and Morley. 2007.

2.9.4 Disturbance and access

Sensitivity to disturbance

The potential effects of human disturbance on mountain goats have been well summarized (Hurley 2004; Goldstein *et al.* 2005).[26] Human proximity can cause disturbance that varies from short term (e.g., increased vigilance and short flight response) to long term (displacement from preferred habitat). Population demographic effects may also occur from human disturbance, as has been shown for elk through reduced calf production (Shively *et al.* 2005). The effects vary depending on the type of access and approach (i.e., zone of influence and mountain goat response are different for walking, horseback, motorized, and aerial) (Thompson 1980).[27]

Mountain goats appear to react to human disturbance to a higher degree than most ungulates. Although some apparent habituation has been observed in some populations to predictable, continuous, non-threatening stimuli (Singer 1978; Singer and Doherty 1985; Pedevillano and Wright 1987; Penner 1988; Goldstein *et al.* 2005),[28] no habituation has been observed in other populations (Foster and Rahs 1983; Côté 1996). Extreme alarm responses can occur from sudden, loud noises (Singer 1978; Singer and Doherty 1985; Pedevillano and Wright 1987; Penner 1988), and sensitization (progressive amplification of a response) to hydroelectric exploration activity has been reported (Foster and Rahs 1983). Nannies appear to be most sensitive to disturbance during the kidding and post-kidding (early rearing) seasons (Penner 1988). Chronic disturbance may make mountain goats more susceptible to disease that over time depresses the immune system (Joslin 1986).

Helicopter and fixed-wing aircraft disturbance

Mountain goats show high sensitivity to helicopter disturbance (Côté 1996; Gordon and Wilson 2004; Goldstein *et al.* 2005). Behavioural response of mountain goats to helicopter disturbance ranges from weak (e.g., no observed disruption, increased vigilance), to strong (e.g., severe flight response to escape terrain either forest cover or cliff terrain and temporary abandonment of range), and is inversely related to the distance of the helicopter from the group. Strong responses are very likely to increase the risk of muscle damage or myopathy or accidents and may lead to direct mortality (Spraker 1993). Whether weak or strong, repeated responses likely lead to higher than normal levels of corticosteroids and populations suffering from increased stress (Kraabel and Miller 1997). Côté (1996) observed that mountain goats walked or ran > 100 m or were alert for > 10 minutes 85% of the time when flights were < 500 m, and 37% of flights at < 1500 m caused at least a moderate reaction (animals moved 10–100 m or were alert 2–10 minutes); one female broke a leg while fleeing a helicopter. Goldstein *et al.* (2005) found less reaction in four areas studied in Alaska, with > 90% of disturbances not causing a response if distance to a group was > 990 m, > 1320 m, > 1480 m, and > 1730 m among the four areas. Reaction to helicopters varies among areas, and may be related to the degree of prior exposure to helicopters

[26] Wilson, S.F. and D.M. Shackleton. 2001. Backcountry recreation and mountain goats: a proposed research and adaptive management plan. Unpublished report, Wildlife Research Group, Agroecology, Faculty of Agricultural Sciences, University of British Columbia, Vancouver, BC.

[27] Wilson and Shackleton, 2001.

[28] Churchill, B. and S.F. Wilson. 2008. Environmental management plan recommendations, mountain goats Highway 97 - Bentley Road to Okanagan Park. Unpublished report for B.C. Ministry of Transportation, Kamloops, BC.

(habituation) and topography (Goldstein *et al.* 2005). A lower alarm response was observed in a river canyon dwelling population in northeast British Columbia, where only 18% of mountain goat groups showed concern or took flight at approach distances < 500 m (EBA Engineering Consultants Ltd. 2004). However, a fright response that involves freezing on the spot rather than running does not necessarily mean a lower level of stress.

Fixed-wing aircraft appear to be less disruptive than helicopters for mountain ungulates, including mountain goats (Frid 2003),[29] but little empirical data are available for comparison. Fixed-wing telemetry flights on mountain goats appeared to cause an increase in movements subsequent to telemetry flights (Poole and Heard 1998), especially during winter.[30]

Although helicopter and human disturbance are likely to affect mountain goats at both the individual and population scales, the physiological and demographic impacts are poorly understood due to the difficulty of field studies of this nature. Studies to further examine this topic are currently being conducted in the Skeena Region (Wilson *et al.* 2007), where the objective is to determine whether helicopter disturbance leads to changes in seasonal movement behaviour, habitat selection, or temporary range abandonment (Cadsand 2009).

Industrial disturbance and access

Industrial activities that can cause disturbance to mountain goat populations primarily include exploration and development for oil, gas, coal and minerals, pipelines, transmission line corridors, independent power projects, wind power projects, and forestry development. Most of these activities are mechanized in nature and require heavy equipment for sustained periods of time, and may use helicopters. Road construction is associated with almost all industrial activities, and road construction in steep terrain often requires blasting and sustained heavy equipment use. Threats to mountain goats include habitat changes that facilitate access and disturbance that displaces mountain goats from preferred habitats (Pendergast and Bindernagel 1977). For example, removal of forest cover near escape terrain may increase human access and lead to frequent disturbance and subsequently lower use by mountain goats of otherwise suitable habitat (Hengeveld *et al.* 2004).

Timber harvesting can affect various seasonal mountain goat habitats. Harvesting in areas previously considered marginal for forestry development is encroaching on winter habitat in some areas (Demarchi *et al.* 2000; Taylor and Brunt 2007). In steep coastal terrain, helicopter logging in areas earlier thought inaccessible by conventional logging also exacerbates this concern. Winter range is generally thought of as a critical component of mountain goat habitat, with specific requirements and restricted distribution within the annual range. There appears to be relatively low risk of disturbance from logging on most winter range in the Kootenay and east-central British Columbia (Poole and Heard 2003; Poole *et al.* 2009) and in some inner coastal areas (Lemke 1999), but disturbance from forest development can occur in coastal areas and wet interior climates where heavy snowpacks result in mountain goats wintering at lower

[29] Wilson and Shackleton, 2001.

[30] Keim, J. and C.L. Jerde. 2004. Measuring spatial movement responses from GPS collared mountain goats and mountain caribou during periods of aerial telemetry occurrence. Unpublished report prepared for B.C. Ministry of Water, Land and Air Protection, Smithers, BC.

elevation in sites often associated with high volumes of merchantable timber (Gordon and Wilson 2004; Taylor *et al.* 2004; Taylor and Brunt 2007). On the north coast, 90% of mountain goat habitat is outside of the timber harvesting land base (THLB), however much of the productive forest available for snow interception may be in the THLB (Horn 2009). Logging near or adjacent to winter range may displace animals to lower quality habitat, and reduce the proportion of time spent feeding or resting (Gordon and Wilson 2004). The timing of logging operations (winter vs. summer/fall), method (conventional vs. helicopter), or distance (within 2000 m) can also affect disturbance of seasonal mountain goat habitats. Timber harvesting may also affect use of mineral licks and trails to licks.[31]

Activities related to mining and mineral and oil and gas development can have similar impacts as timber harvesting on mountain goats. In northern British Columbia, mountain goats abandoned an area subject to drilling disturbances (helicopters, drilling, noise), but returned after the disturbance was removed (Foster and Rahs 1983). Studies in Montana suggested that while mountain goats did not abandon home ranges because of seismic activities, declines in adult female numbers, kid numbers and productivity occurred, which were postulated to be a result of cumulative stress (Joslin 1986).

Some habituation of goats to industrial disturbance has been documented. Mountain goats near Summerland, B.C., displayed little observable reaction to proximity to the highway and extensive blasting to construct a new highway.[32] Working with a canyon-dwelling population in Alberta where noise stimuli was pre-recorded and delivered at 400–600 m distance, Penner (1988) stated "mountain goats appeared to develop a tolerance of indirect and persistent noise stimuli in their environment, but continued to exhibit elevated behavioural response levels to initial, novel or sudden noise and visual stimuli" (i.e., they did not habituate to periodic or inconsistent noise). Penner (1988) later stated "Goats exhibited their greatest sensitivity to unusual or sudden stimuli such as rock falls, aircraft overflights and predators… The goat's response to fixed wing aircraft was usually unconcerned while the sounds of a helicopter frequently elicited concerned or alarm responses." Whether populations are hunted or not may influence their readiness to habituate to disturbance.

The potential impact to mountain goats from the recent increase in independent power projects throughout British Columbia is not well documented, but the impacts caused by associated road access, development of transmission lines, and use of mechanized equipment may be similar to other industrial activities.

Recreation disturbance and access

Activities associated with backcountry tourism and recreation can result in disturbance or displacement of mountain goats. Examples include a variety of heli-recreation (heli-skiing, heli-hiking, heli-sightseeing), hiking, rock climbing, summer ATV use, ski touring, snowmobile use, and motorized access to recreation facilities (Canfield *et al.* 1999), all of which have increased dramatically through much of British Columbia in the past three decades. Legal hunting and illegal poaching can also affect mountain goat populations, through disturbance and removal of animals.

[31] Corbould *et al.*, 2010.
[32] Churchill and Wilson, 2008.

The direct impact of many outdoor recreation pursuits on mountain ungulates is poorly quantified. Presumably mountain, rock, and ice climbing would place humans closest to mountain goat habitat. Simulated non-mechanized recreational impacts had a negligible effect on mountain goat activities in Colorado (Thompson 1980) and disturbance due to human foot traffic appears to be generally minor,[33] but may be more important at some times of the year (e.g., calving; Shively *et al.* 2005). However, research on reindeer (*Rangifer tarandus tarandus*) in Norway observed that provocations by skiers or snowmobiles revealed similar behavioural responses (Reimers *et al.* 2003). In addition to increasing energy costs for wintering animals, recreational activity often results in displacement of animals to less desirable habitat (Cole *et al.* 1997; Canfield *et al.* 1999). Varley (1998) concluded that during winter, conflict between mountain goats and most types of non-mechanized recreation are rare because of spatial segregation. However, increases in the use of snowmobiles and snowcats for winter recreation, and technological advances in machinery that enable people to travel farther, faster, and in steeper terrain, may have reduced spatial segregation in recent decades (Canfield *et al.* 1999).[34] In Montana, a decrease in a mountain goat population and reproduction is attributed to an increase in snowmobile use.[35] Intensive snowmobile activity on mountain caribou (*Rangifer tarandus caribou*) winter range resulted in complete displacement of caribou from an entire mountain block of high quality habitat (Seip *et al.* 2007). The increased access for recreation (and the potential impacts this may bring) and the relative lack of integrated access management for resource development access are clearly linked.

2.9.5 Climate change

Potential impacts of climate change to mountain goats are not well understood, but are expected to strongly affect northern and alpine areas (IPCC 2007). Global mean annual temperatures could increase by 4ºC over the next century. Climate change is already driving changes in ecosystem structure (vegetation, species composition), function (productivity, decomposition, water and nutrient cycling), processes (disturbance regimes, successional pathways, hydrological regimes), and species distribution (Pojar 2009). Existing ecosystems will lose some species, gain others, and experience changes in abundance and dominance of the species that persist.

Evidence of changes observed include shrinkage of glaciers in most areas of British Columbia in recent decades. Most climate change models suggest an average 1ºC increase over the next 50 years, which will force a shift of ecosystems a predicted 300 m higher in elevation and 150 km farther north (IPCC 2007). The IPCC (2007) also forecasts that more than 50% of the alpine tundra ecosystems will eventually disappear as subalpine forests shift up in elevation, affecting the location of the alpine treeline ecotone (the area between forest and tundra). A reduction of moist forests and an expansion of dry forests in the southern portion of the province are also expected.

[33] Wilson and Shackleton, 2001.

[34] McCarthy, F.G. 2008. The impact of snowmobiles on the Bridger-Teton National Forest: considerations for winter travel plans. Unpublished report, The Wyoming Wilderness Association, Sheridan, WY.

[35] McCarthy, 2008.

Thus, a climate change scenario in British Columbia is predicted to include increased winter and summer temperatures (greater increase in winter), greater warming in the north and least in coastal areas, wetter winters, drier summers in the south, generally wetter conditions in the north, increased intensity and amount of precipitation, and increased extreme weather events, all of which in part will result in smaller and fewer glaciers (Rodenhuis *et al.* 2007; Spittlehouse 2008). Although greater precipitation is predicted in the winters, average snowlines will be found farther north in latitude and higher in elevation, snow accumulation will decrease and the spring snowmelt may occur later in the season.

Mountain goat distribution will continue to be limited by the availability of steep rugged escape terrain. With an upward shift in treeline, mountain goat may move to higher elevations where that opportunity exists, effectively becoming forced to rely on continually shrinking islands of suitable habitat. An indirect implication of this is that there may be an increased risk of predation when animals must move through more forested habitat to access suitable escape terrain.

The timing of spring green-up is very important for body size in young of the year, which has implications for survival and reproductive output (Côté and Festa-Bianchet 2001a). Greater variability in green-up will likely affect kid survival and health, and therefore recruitment. However, due to the more generalist feeding strategy used by mountain goats and their ability to tolerate deeper snowpacks, mountain goats should hold their own and could increase and thrive (Pojar 2009).

Short-term adaptation strategies may include increasing a species resistance to change (i.e., by reducing other pressures upon these species from other sources), promoting resilience to change (i.e., by changes to hunting regulations to counter the effects of sudden habitat alteration), and enabling ecosystems and resources to respond to change (which may include assisted migration of wildlife).

2.10 Conceptual Ecological Mountain Goat Model

A conceptual model of the interactions among mountain goat habitat features, stressors, and vital rates was developed by S.F. Wilson (Ecologic Research, Gabriola, B.C.) to help understand interactions and relationships among parameters (Figure 4). The model can help clarify relationships among habitat features and stressors that affect key vital rates, and ultimately population size.

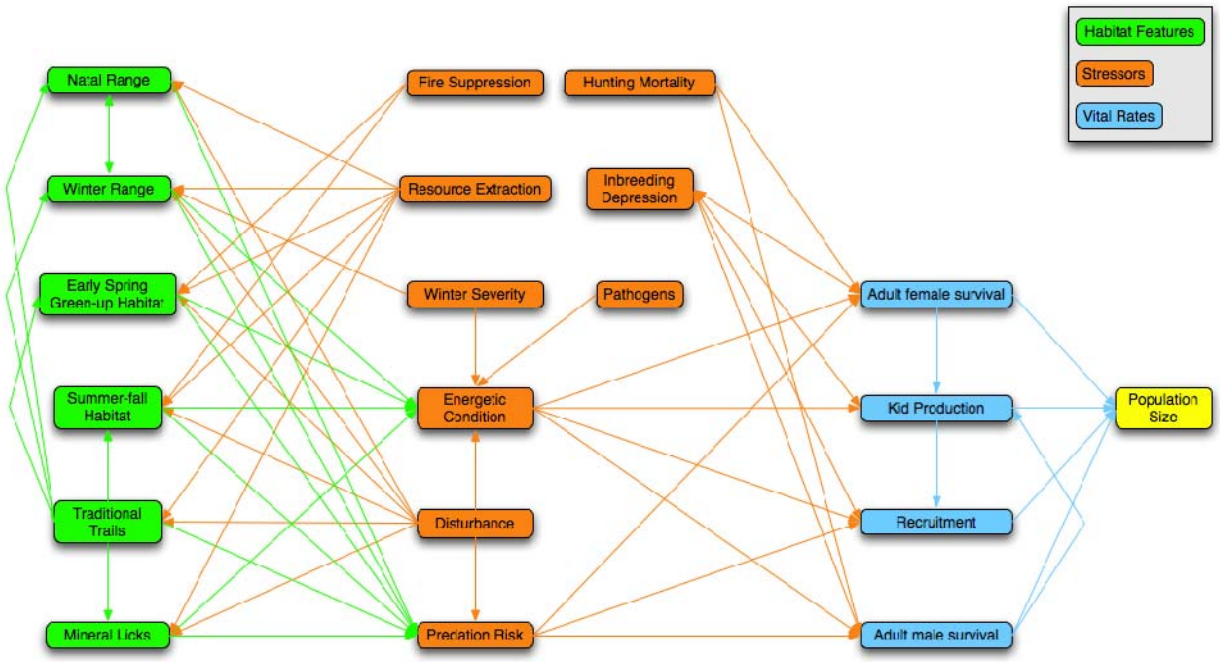

Figure 4. Conceptual model of interrelationships among mountain goat habitat features, stressors, and vital rates. Definitions accompanying the model are presented in Appendix B. Developed by S.F. Wilson, with assistance from K.G. Poole.

2.11 Knowledge Gaps / Research Needs

There has been relatively limited research conducted on mountain goats in British Columbia in recent years. Much of the recent data and understanding of mountain goats comes from intensive research conducted at Caw Ridge and surrounding small- to medium-sized, discontinuous populations in the western Alberta foothills (Festa-Bianchet and Côté 2008), which arguably may not be indicative of larger populations residing in the continuous alpine and subalpine habitat of British Columbia. Knowledge about the ecology of coastal mountain goat populations is limited. Following is a list of research needs and data gaps that could be considered.

Impacts of habitat alteration: Little is known about the implications of the loss of forested winter ranges (primarily coastal) to mountain goat survival. Properly designed experimental research is required to determine the effects of forest removal on mountain goats. There are many examples of forest harvesting in and adjacent to occupied mountain goat winter range; suitable study areas are thus available. The long-term impacts of forest canopy removal are of particular concern in relation to population viability, migration routes and travel corridors, trail use to and use of mineral licks, and habitat selection. In addition, little is known about the impacts of forestry on predator-prey relationships as they relate to mountain goats.

Population dynamics: Many aspects of mountain goat ecology are unknown or poorly known, in particular the dynamics surrounding the apparent lack of density dependent responses in established, native populations (Festa-Bianchet and Côté 2008). Research programs focussed on clarifying parameters of fecundity and mortality (e.g., female age at first reproduction,

productivity, optimum sex ratios for recruitment) could be linked with data and models derived from Caw Ridge and elsewhere in Alberta (Gonzalez-Voyer *et al.* 2003; Hamel *et al.* 2006) to examine population dynamics and refine levels of sustained yield. Potential differences in coastal and interior ecotypes should be considered.

Population viability: We can best address questions of minimum population size that can sustain harvest with better demography data from British Columbia. These data could feed into models to address population size, percent females in harvest, and sustainable harvest rates. Sensitivity analysis in modelling could be conducted.

Dispersal and seasonal movements: Little is known about dispersal patterns in almost all mountain goat populations. Even basic data on seasonal movements are not available in many areas (e.g., the Okanagan).[36] This information would contribute to further understanding of population viability and genetic exchange among populations.

Response to fire: Little is known about whether mountain goats respond numerically or spatially to prescribed fire. There are many opportunities throughout the province to study this relationship with wildfire or, if an opportunity exists, with prescribed fire.[37]

Sensitivity analysis of harvest data: A provincial level analysis of the compulsory inspection and Big Game Harvest Questionnaire data has not been conducted, but could provide insights into trends and regional differences in mountain goat harvest parameters. Hunter effort and success, harvest age, and sex ratio in the harvest can be used to index trends in populations. Preliminary summaries are presented in this management plan.

Non-consumptive use: There are limited data on the response of mountain goats to non-consumptive use. Suitable sites where the public can observe mountain goats should be identified and developed with site management plans. Viewing sites should be developed to control vehicular traffic and to keep mountain goats and people safely separated (i.e., the mountain goats should be easily viewed without disturbing them). Appropriate on-site interpretive and educational materials about the life history, behaviour, and management of mountain goats can be developed. If mountain goat viewing is the priority for an area, then a hunting closure might be considered for those populations.

Inventory methodology: A criticism of most aerial mountain goat inventories is the lack of a reliable sightability correction, and no statistical bounds to population estimates. The first stages of a regression-based sightability model for the species have been developed (Poole 2007b; Rice *et al.* 2009). Further work with marked animals could develop and refine a British Columbia based model. The models would likely be specific for ecotypes within the province. Additional testing of population estimates derived from DNA obtained from non-invasive sampling of scat or hair should be conducted, as the initial results appear promising (Poole and Reynolds, in prep.).

[36] Wilson and Morley, 2007.
[37] Wilson and Morley, 2007.

Climate change: Climate change may produce increased risks to mountain goat populations. Conservation needs during climate change are poorly understood, but if populations are assessed as high priority and at risk, then management options could be developed. It is unknown whether expanding forests into higher elevations will result in shifts in mountain goat distribution, abundance, or differences in predator/prey dynamics. It is also not clear whether warmer or wetter conditions might change parasite loads and life cycles, and affect disease transmission vectors (Jenkins *et al.* 2004). Baseline data collection with ongoing monitoring is needed.

Develop baseline health assessment: Whenever mountain goats are handled, individual animals should be sampled by applying a standard sampling and collection protocol (provided by the B.C. Ministry of Environment Wildlife Health Program). When mortality or illness is observed or suspected, consultation with the Wildlife Health Program for a follow-up investigation of the cause and sampling should occur.

The British Columbia species at risk (SAR) health assessment tool (http://www.env.gov.bc.ca/wld/documents/wldhealth/SARfinal072009.pdf) should be applied to mountain goat herds of concern or of high management interest such as translocation donor herds[38] and should include the initiation of health sampling programs. Herd health assessments should include an evaluation of herd demographics, individual animal sampling for disease and parasite exposure, examination of herd genetics for the degree of genetic diversity, as well as other individual and herd-related information since all of these parameters can influence wildlife population health. Further attention to the assessment of the impacts of interactions between mountain goats and sympatric ungulates in British Columbia is necessary. Health monitoring should be repeated periodically to monitor for the effects of climate change and to assess the risk from infectious disease and parasites following contact with other wild and domestic species.

Mountain goat samples previously archived should be analyzed and the results collated and interpreted for the database. New research techniques that include stable isotopes, genomics, and noninvasive sampling methods should be examined as they may play an important role to improve knowledge of the effects of various factors on goat population health over time. Also, their use may reduce the necessity to directly handle and cause stress to live animals.

Disturbance thresholds and buffers: Limited data are available that link disturbance events to long-term demographic consequences. More information is needed about the effects of different types of helicopter activity (e.g., predictable and repeated vs. unpredictable and short term) on mountain goat behaviour, fecundity, habitat selection, and movement patterns. The study currently underway in the Skeena region will provide new information (Wilson *et al.* 2007); however, additional research is still needed. Similarly, mitigation of the impacts of industrial development on mountain goats would benefit from studies on behavioural and physiological reactions to different stimuli over a range of distances.

Consider a reassessment of the provincial listing: The mountain goat in British Columbia is on the Yellow List (ranked S4, apparently secure and not at risk of extinction) (Table 1). Not all populations (primarily some southern populations) throughout the province are considered stable

[38] Fraser and Parmley, 2008.

(Table 2). It may be necessary to consider re-evaluating this designation for some southern populations.

3.0 CURRENT MANAGEMENT FRAMEWORK

3.1 Review of Management Frameworks in Other Jurisdictions

Most jurisdictions adjacent to British Columbia provide goals that address mountain goat habitat. For example, the first state-wide goal in the Washington mountain goat management plan is to "preserve, protect, perpetuate, and manage mountain goats and their habitats to ensure healthy, productive populations" (Washington Department of Fish and Wildlife 2008). Alberta, however, proposed a number of key elements to address their goal "to maintain viable, productive and interconnected habitats for mountain goats throughout their range in Alberta" (Glasgow *et al.* 2003). The Alberta objectives were determining the distribution, suitability, and effectiveness of the habitat that can support mountain goats; establishing habitat targets in concert with population targets; developing habitat management strategies to meet established targets, including the development and implementation of habitat protection guidelines for all human use activities in mountain goat habitat; and developing cooperative programs with British Columbia and the national parks in Alberta to manage and protect the habitat of interjurisdictional herds.

All jurisdictions address harvest management in much greater detail. Toweill *et al.* (2004) summarized the various mountain goat harvest management approaches used in North American jurisdictions. Almost all jurisdictions have hunter orientation (primarily aimed at sex identification in the field), and an "any goat" regulation with a bag limit of one (some specify an adult or minimum horn restrictions, and/or no harvest from larger groups or adults accompanied by kids). Many jurisdictions do not permit hunting of herds with less than 50 individuals (Alaska, Alberta, British Columbia, Idaho, Oregon, and Washington) (Toweill *et al.* 2004, and see below). Season length varies widely (11–153 days), but most have 45–75 day seasons.

Alberta has set population goals for its four management areas, including minimum population sizes, and has restricted hunting to a nil to low harvest rate in these areas to meet these (Glasgow *et al.* 2003). Populations of less than 50 mountain goats are not hunted. A form of double-quota system is used, where if more than one-third of the harvest within a management unit is females, the season may be closed for one or more years unless there are data that indicate this closure is not necessary. Regular surveys are conducted in areas where hunting is permitted, and hunting is suspended where observed numbers or sex ratios drop below established targets. Compulsory education covering sexing of mountain goats in the field is required for all hunters. Successful hunters are required to complete compulsory registration, and to submit the lower incisor bar for aging. At present, eight licences are available to residents in Alberta under a once in a lifetime opportunity.

Most game management units in Alaska have adopted a point system for mountain goat harvest management that uses criteria to achieve a harvest rate based on recruitment levels, and recognizes the negative implication of harvesting females (McDonough and Selinger 2008; K. White, pers. comm. 2008). Explicit criteria for the number of hunting permits issued consider past harvest rates, the sex and age structure of the harvest, population size and trends, the age of

the survey data, access, ecotype, winter severity, and other factors (McDonough and Selinger 2008). Briefly, harvest levels are set at 5–6 points per 100 mountain goats observed during aerial surveys, based on assumed rates of recruitment. Surveys assume 45–65% sightability, thus the maximum harvest rate (assuming a male-only harvest) is about 3.5%, but in reality the actual harvest rate is lower. Harvested females (2 points) are rated twice that of males (1 point). Therefore, using a 5-point system for a population of 200 mountain goats observed during surveys in southeast Alaska (K. White, pers. comm. 2008), the annual harvest could be 10 males, or 5 females, or some combination thereof. Legislation is in place to close the harvest mid-season by emergency order should a harvest cap be reached. More conservative harvest rates may be chosen after extreme winters when survival is assumed to be reduced, or when kids comprise < 18% of the population and the population is assumed to be declining. No permits are issued in areas with < 50 mountain goats.

Washington State monitors mountain goat numbers and trends within hunted range by conducting frequent surveys. Management units with < 100 mountain goats are not subject to harvest in Washington (Washington Department of Fish and Wildlife 2008). Mountain goat hunting within the state is an once-in-a-lifetime opportunity. Legal animals are limited to those with horns > 4 inches (10 cm); hunters are urged not to harvest a nanny and it is unlawful to harvest a nanny accompanied by a kid.

3.2 Management Tools and Approaches Used within British Columbia

Management of mountain goats and their habitats has occurred in British Columbia since the mid-1900s, but was characterized by a lack of inventory and use of a poor approach to managing conservatively when those inventory data were lacking (B.C. Ministry of Environment 1979; Phelps *et al.* 1983). Changes in harvest management by the mid-1970s halted the declines observed in many areas of the province. Progress on habitat management generally lagged behind harvest management, but advancements were observed by the 1980s and early 1990s. Components of mountain goat habitat (e.g., winter range affected by forest practices) were provided an opportunity for legal protection beginning with the *Forest Practices Code of British Columbia Act* in 1995 (Province of British Columbia 1996a), and reaffirmed by the *Forest and Range Practices Act* in 2004.

3.2.1 Habitat management

The following planning and management tools are currently available for mountain goat habitat in British Columbia. Some of these tools are proactive (e.g., strategies related to the *Forest and Range Practices Act* [FRPA], *Land Act* reserves) and some are reactive (e.g., reclamation plans); however, in all cases, high value mountain goat habitat must be identified before these tools can be applied. Most tools currently being deployed are under the authority of FRPA.

***Forest and Range Practices Act* (FRPA)**
The *Forest and Range Practices Act* (FRPA) and its regulations govern the activities of forest and range tenure holders in British Columbia (Province of British Columbia 2002a, 2004a, 2004b, 2008a). The statute sets the requirements for planning, road building, logging, reforestation, and grazing. The minister responsible for the *Wildlife Act* has several authorities

related to wildlife and habitat management enabled by the Government Actions Regulation (GAR) of FRPA. Specifically, the minister may identify species at risk (SAR), regionally important wildlife species (RIW), or a specified ungulate.

Once a species has been identified in one of these categories, areas of special management may be designated including Wildlife Habitat Areas (WHAs) for SAR and RIW, and Ungulate Winter Ranges (UWR) for ungulates. Special management of these designated areas is delivered through establishing objectives or General Wildlife Measures (GWMs) that restrict or prohibit forest or range practices. GWMs may also be applied to specified areas (e.g., an area surrounding ungulate winter range), if the measure is deemed necessary to protect and conserve the species in that area. Objectives become planning requirements that must be addressed in a tenure holder's Forest Stewardship Plan or range use plan, whereas GWMs become practice requirements, like those in regulation. WHAs and UWRs were established for some species in some localities under the *Forest Practices Code of British Columbia Act* (FPC), before FRPA; those established under the FPC are continued under FRPA.

Under FRPA, mountain goat is currently listed as a specified ungulate species for which winter range habitat can be conserved, and is a candidate for listing as RIW (no species have yet been identified as RIW). A list of Wildlife Habitat Features (WHFs) is also being considered for identification under the GAR. Identified WHFs must not be damaged or rendered ineffective by forest or range activities. Currently, significant mineral licks are being proposed as candidate WHFs.

Ungulate Winter Range (UWR)

The establishment of Ungulate Winter Ranges is one of the most important tools for managing mountain goat habitat. The Government Actions Regulations (GAR) lists mountain goat as a species for which UWR can be established under FRPA. The Ministry of Environment retains authority to establish UWR, subject to limitations set under GAR (e.g., the order must be consistent with established objectives, the order would not unduly reduce the supply of timber from British Columbia's forests, the benefits to the public outweigh any material adverse impacts on delivered wood costs, and the order must provide an opportunity for review and comment). Wilson (2004) reviewed desired conditions for UWR in the Coast Mountains, and stated that UWR areas must meet at least one of the following criteria:[39]

- a combination of topographic and vegetative features defining high-quality winter range, as appropriate for the species and the locality, as determined by Ministry of Environment regional staff in consultation with species experts;
- a documented history of winter use, as determined by Ministry of Environment regional wildlife staff; or
- in localities that are regularly occupied by an ungulate species during the winter but that do not have sufficient high-quality winter range as defined under points 1 or 2, winter range areas can be identified by recognizing a combination of topographic and vegetative features that provide the most suitable habitat available for winter range. This is the least

[39] Wilson, S.F. 2004. Desired conditions for Coastal Mountain goat winter range. Unpublished report for B.C. Ministry of Water, Land and Air Protection, Biodiversity Branch, Victoria, BC.

preferred of these three criteria and should be used only when options 1 or 2 cannot be met.

Ungulate Winter Ranges specific to mountain goats have been established in numerous forest districts across the province; however, there are still high-priority areas that remain to be legally designated (e.g., Sunshine Coast, North Coast) (http://www.env.gov.bc.ca/wld/frpa/notices/uwr.html).

General Wildlife Measures (GWM)
The Minister responsible for the *Wildlife Act* by order may establish a GWM, to be applied to an UWR, WHA, or specified area, for a category of species at risk (Identified wildlife and specified ungulate species), regionally important wildlife, or specified ungulate species, if satisfied that: (1) the measure is necessary to protect or conserve the species in the category in the area to which the measure relates; (2) the measure is necessary to protect or conserve the wildlife habitat area or ungulate winter range; and (3) this regulation or another enactment does not otherwise provide for that protection or conservation. General Wildlife Measures are used to set restrictions related to forest and range harvesting activities (e.g., no timber harvesting, no road construction, timing restrictions during winter). All holders of agreements under the *Forest Act* or *Range Act* must follow approved GWMs (Province of British Columbia 2008b); this includes minor tenure holders (when consulted) and holders of temporary licences (such as an Occupant Licence to Cut for mineral tenure holders or an independent power producer). Because GWMs are legally required, provisions are in place to enable exemptions, which are approved by the Ministry of Environment Regional Managers of Environmental Stewardship Division.

Regionally Important Wildlife (RIW)
This category of identified wildlife includes species that are considered important to a region of British Columbia, and relies on habitats that are not otherwise protected under FRPA and that may be adversely impacted by forest or range practices. Work is currently underway to develop a species account for mountain goat as RIW (J. Psyllakis, pers. comm. 2009). At the time of printing of this document, no species has been legally designated as RIW in the province.

Wildlife Habitat Areas (WHA)
Wildlife Habitat Areas for mountain goats are intended to protect small-scale features such as critical, non-winter habitats (e.g., parturition sites, escape terrain, mineral licks). WHAs exist for mountain goat parturition sites and escape terrain, and in one case, for a significant mineral lick feature (P. Johnstone, pers. comm. 2009). A total of 11 WHAs for mountain goat exist in the province, all of which are in the Peace Region. At this time, under FRPA, Identified Wildlife Management Strategy (IWMS) does not currently include mountain goat (Province of British Columbia. 2004b), but this is currently under review.

Wildlife Habitat Features (WHF)
Wildlife Habitat Features are small-scale, important points that are used by identified wildlife. High significance mineral licks would include those that are relatively rare on the landscape, requiring individuals to travel relatively long distances from traditional escape terrain (> 1 km) and/or be used annually by multiple species, or by many individuals within a species. WHF have

not been designated for mountain goats, and until that occurs it is optional for proponents to plan for their protection.

The Wildlife Act

The provincial *Wildlife Act* provides several tools for managing mountain goat habitat (Province of British Columbia 2002b). The Minister of Environment can designate areas of value to wildlife as Wildlife Management Areas (WMAs). Land or resources in a WMA cannot be used without the written permission of the Regional Manager of Environmental Stewardship Division, who has the power to impose restrictions for access and development. Access management provisions also exist through the *Wildlife Act*. The minister may make regulations that prohibit, restrict or allow access by members of the public to designated areas of British Columbia, for the purposes of wildlife management. Examples of these are regulations restricting motor vehicle use in high elevation ungulate habitat, and the Muskwa-Kechika access management area in northern British Columbia. The Minister of Environment may also, with the approval of the minister responsible for the highway or road, temporarily close or impose restrictions on vehicular access to a highway or road for the purpose of protecting wildlife.

Mining legislation

Wildlife biologists can use existing mining legislation to manage mountain goat habitat in certain specific instances. The *Health, Safety and Reclamation Code for Mines in British Columbia* (B.C. Ministry of Energy, Mines and Petroleum Resources 2008) requires proponents to deactivate and reclaim exploration impacts (grids, camps, roads, trails, landing pads, etc.) within 1 year of cessation of exploration activities (unless authorized by an inspector), and recommends that the Ministry of Environment be consulted for access management, and to avoid sensitive wildlife areas. Notices of work are required, and are referred to provincial agencies for review and comment; mountain goat habitat concerns can be identified at this time. Under the *Mines Act* (Province of British Columbia 1996b), proponents are required to reclaim their developed tenures according to an approved plan. The Act also allows the Chief Inspector to require, as a condition of issuing a permit, that the owner, agent, manager, or permittee provide a security, subject to conditions, specified by the Chief Inspector, which can be used to pay for "mine reclamation and protection of, and mitigation of damage to, watercourses and cultural heritage resources affected by the mine." Permits may include conditions that require proponents to provide monitoring and mitigation of impacts to specific valued ecosystem components.

Oil and Gas Activities Act (OGAA)

The *Oil and Gas Activities Act* (OGAA) and its regulations will govern oil and gas activities in British Columbia. The Lieutenant Governor in Council may make regulations authorizing the minister responsible for administering the *Wildlife Act* to designate categories of wildlife and as such establish wildlife habitat areas (WHA), ungulate winter ranges (UWR), and associated measures for the protection and effective management of the environment. The Lieutenant Governor in Council may also authorize the minister responsible for administering the *Wildlife Act* to identify wildlife habitat features. OGAA is not in effect at this time, but regulations are currently being finalized.

Parks and protected areas
Much habitat that is suitable for mountain goats in the province occurs on land with some form of conservation, but often mountain goat habitat in parks is not specifically identified for management. When known, this habitat can be identified and managed through provincial park and protected area management plans; for example, Elk Lakes Provincial Park in southeastern British Columbia has a separate mountain goat management plan (M. Holley, pers. comm. 2009). In the Peace Region permanent mountain goat monitoring plots are located in two provincial parks: Gwillim and Sikanni Chief Canyon.

Conservation lands
Conservation lands are not considered formally under the Parks and Protected Areas system, but are designated to conserve and manage habitat for the benefit of regionally, nationally, and internationally significant fish and wildlife species. Conservation lands administered and managed by the Ministry of Environment include the following:

- Wildlife Management Areas;
- conservation land acquisitions (acquired through purchase, exchange or donation);
- transfers of administration to Ministry of Environment for conservation purposes; and
- privately owned sites under long-term lease to the ministry from conservation organizations such as The Nature Trust of BC.

Conservation lands can be established by several administrative instruments under the *Land Act* (Province of British Columbia 1996a, 2008b). Those most likely to be useful for management of mountain goat habitat include the following:

- Order-in-Council Reserve;
- Map Reserve;
- Land Act Designation (e.g., old growth management areas); and
- Notation of Interest.

These provisions allow the Minister responsible for the *Land Act* (or an authorizing agency) to withdraw an area from disposition or establish reserves for various specified short or long terms, depending on the provision.

Guidelines and Best Management Practices
Guidelines and Best Management Practices (BMPs) are available for mitigating impacts of resource development, recreation, and tourism. Guidelines can define results, desired behaviours, indicators, and limits for resource use, development, and enjoyment activities. Direction given in guidelines is only enforceable if written into a government instrument (e.g., development permit, management plan) by a decision maker, and are consequently not always followed. The provincial *Wildlife Guidelines for Backcountry Tourism/Commercial Recreation* were developed to ensure that backcountry recreation activities do not compromise the current distribution of wildlife, the sustainability of their populations, or the integrity of their habitats (B.C. Ministry of Environment 2006).

Commercial tourism operators, tenured under the *Land Act*, are required to develop a management plan and incorporate guidelines specific to their activity and season (e.g., aerial-related recreation in all habitats in winter and snow-free seasons; motorized recreation in alpine

tundra, forest and grasslands during snow-free seasons). Guidelines list the results to be achieved, along with desired behaviours designed to meet those results.

Monitoring plans are currently in development and research is underway in the Skeena Region via a partnership among Ministry of Environment, Helicat Canada, University of Northern British Columbia, and a heli-ski operator to determine the medium- and long-term effects of helicopter activity on mountain goat behaviour and habitat use patterns (Wilson *et al.* 2007).

Landscape-level habitat management

Several planning tools can be useful for managing mountain goat habitat at the landscape level. Regional Land and Resource Management Plans, Sustainable Resource Management Plans, and other landscape-level planning documents currently exist for many areas of the province. Resource development industries may have planning processes that include wildlife values for various certification and permitting requirements (e.g., Forest Stewardship Plans and oil and gas pre-tenure plans). These higher level plans give strategic direction for large areas, and may include specific objectives and strategies for managing mountain goat habitat.

Direct habitat management

Direct management techniques have been used to improve or provide important habitat for mountain goats. Important habitat can include winter range, kidding/early rearing areas, escape terrain (including forested), mineral licks, and travel corridors. Prescribed burning of range areas can promote growth of preferred forage and reduce ingrowth of less desirable species. In other situations, maintaining or establishing mature forest cover may be the objective, and planting or thinning may be the preferred prescription to reach optimal stand conditions. Discrete important habitat can be identified and managed within other processes, such as fire management planning and resource development project reviews.

Provincial databases and mapping

The province currently has a large amount of stored data that relates to mountain goat habitat use and management. For example, all Ungulate Winter Ranges and Wildlife Habitat Areas approved for mountain goats are available online (http://www.env.gov.bc.ca/wld/frpa/iwms/index.html); simple searches on the Species Inventory Database website (http://www.env.gov.bc.ca/wildlife/wsi/siwe.htm) will yield regional informal surveys to telemetry data to summary reports; searching Ecocat (https://a100.gov.bc.ca/pub/acat/public/welcome.do) provides links to regional mountain goat habitat management projects; and searching the BC Species and Ecosystems Explorer (http://a100.gov.bc.ca/pub/eswp/) provides information on the conservation status, conservation framework priority and other general information on mountain goats. The available information varies throughout the province, and both the databases and the regional offices should be consulted. The British Columbia Integrated Land Management Bureau manages the Land and Resource Data Warehouse (LRDW) (http://www.lrdw.ca/), where capability and suitability mapping, as well as some Terrestrial Ecosystem Mapping, Predictive Ecosystem Mapping, and Vegetation Resources Inventory can be found. The LRDW also houses the Broad Ecosystem Inventory tool, which can be queried to produce mountain goat habitat reports at a relatively coarse scale (1:250,000).

3.2.2 Harvest management

Past and current harvest management

Historic management of mountain goats within British Columbia through to the 1960s led to reductions in populations in many areas (B.C. Ministry of Environment 1979). Liberal seasons and unrestricted hunter numbers often resulted in unsustainable harvests. As an example from the Kootenay Region, this overharvest occurred as a result of (1) a philosophy of maximizing harvest, (2) the low management priority assigned to the species, (3) a lack of understanding of the vulnerability of the species, and (4) the proliferation of uncontrolled access (Phelps *et al.* 1983). Beginning in late 1960s across much of the province, hunting closures and progressive restrictions in mountain goat season length and bag limit halted the decline, and allowed the next phase of mountain goat management to proceed. Beginning in mid-1970s, mountain goat hunting in some closed parts of the province was re-instated under a Limited Entry Hunting (LEH) system (Phelps *et al.* 1983), but most northern areas and areas with limited access were managed under General Open Seasons (GOS). In west-central British Columbia, which was still felt to have high densities of mountain goats, a system was implemented in 1971 to regulate the number of hunters and mountain goats harvested by distributing hunters in relation to the mountain goat densities (Sumanik 1970) that was similar to today's LEH strategy. LEH subzones within management units were used more regularly starting in the 1980s in an effort to distribute hunting pressure more evenly.

Management of mountain goat harvest in British Columbia since the 1990s (Hatter 2005) has been based on a combination of estimated population size and proportion of females in the harvest derived from the literature and modelling in the program RISKMAN (Taylor *et al.* 2002), in large part using data from Caw Ridge in west-central Alberta. Mountain goat harvest allocations across the province vary with estimated population size, with a recommended maximum of 4% allocation for populations > 200 individuals and ≤ 30% females in the harvest, and a lower allocation with smaller populations (down to 2% allocation for populations of 50–100 mountain goats with ≤ 25% females in the harvest) (Table 4). This protocol applies to populations that have been surveyed at least every 5 years (Hatter 2005). Note that this management protocol has been in place in most of the province, but regional variations occur. For example, in the Skeena Region, management was based upon an assumed allowable harvest rate of 4% applied to the specific population of mountain goats where the female harvest cannot exceed 30%, but no clear minimum population size was identified before harvest was considered (G. Schultze, pers. comm. 2009). In that instance, populations estimated to have less than 25 animals were generally not hunted.

Table 4. Maximum acceptable harvest rates for British Columbia mountain goat populations (Hatter 2005).

Population size	Maximum desired harvest rate	Maximum % females in harvest
< 50	0%	n/a
≥ 50 to < 100	2%	≤ 25%
≥ 100 to < 200	3%	25–30%
≥ 200	4%	≤ 30%

Currently, the provincial bag limit is one mountain goat of any age or sex, and the species requires compulsory inspection (the horns must be submitted to a compulsory inspector within

30 days). Mountain goat harvests within the province are managed under both GOS and LEH. GOSs limit the timing of the season over large areas, whereas LEH provides additional control over allocations and areas (smaller LEH zones distribute hunting effort). GOSs are the primary harvest management tool in the Vancouver Island (2 management units), Cariboo, Skeena, Omineca, and Peace Regions. LEH management predominates or is used solely within the Lower Mainland (3 authorizations only), Thompson, Kootenay, and Okanagan (1 authorization only) Regions. An LEH archery-only season is available in the Kootenays covering 10 days before the opening of the firearms season.

Mountain goat hunting season lengths vary across British Columbia, with most seasons in the southern half of the province beginning in early September, and running until the end of October or the end of November. Most seasons in the northern half of the province begin in early August to early September, and end in mid-October or mid-November. However, most LEH seasons in the southern half of Skeena run to 28 February, in part to address low success rates (G. Schultze, pers. comm. 2009). The current hunting synopsis is available at http://www.env.gov.bc.ca/fw/wildlife/hunting/regulations/.

All hunters are encouraged (but not required) to select males. A video "Is It a Billy or Is It a Nanny?" is available to hunters (Duncan Gilchrist Productions), and further information is presented in the annual hunting synopsis ("Important notice for mountain goat hunters"; http://www.env.gov.bc.ca/fw/wildlife/hunting/docs/notice_to_mtn_goat_hunters.pdf). In addition, a mountain goat sex identification presentation courtesy of the Utah Division of Wildlife Resources is available on the Ministry of Environment website (http://www.env.gov.bc.ca/fw/wildlife/hunting/docs/goat_orientation_08Utah.pdf).

Mountain goat harvest is currently allocated to resident and non-resident hunters according to a suite of 8 policies and procedures collectively referred to as the "Wildlife Allocation Policy'' (http://www.env.gov.bc.ca/fw/wildlife/harvest_alloc/). This process considers the relative importance and degree to which each residency group uses their allocated share. Mountain goats are an important species for guide outfitters, and guide outfitters are assured no less than 20% of the annual allowable harvest (AAH). Similarly, residents are assured no less than 60% of the AAH. The current allocation period is 2007–2011, to be followed by the next period covering 2012–2016.

Harvest data

Over 28,500 mountain goats have been recorded as harvested in British Columbia between 1976 and 2008 (Figure 5). Since 1976, the annual harvest has ranged from 600 to 1160 animals ($\bar{x}$ = 865 mountain goats per year), with the annual harvest peaking in the late 1980s and early 1990s (Figure 6). The division of harvest among regions has varied over time, but averaging over the period the Skeena and Kootenay Regions have produced 34% and 30% of the harvest, respectively (Figure 7). The Omineca and Peace Regions have collectively contributed 28% of the harvest.

Much of the change in provincial harvest over time is attributed to changes in the Kootenay harvest. This appears primarily related to changes in hunting opportunity and hunter interest. Between 1979 and 1984, the number of LEH authorizations available in the Kootenay Region

increased from about 100 to over 1100 annually, during which time the number of mountain goats harvested annually increased from 75 to almost 450 animals. Between the mid-1990s to mid-2000s, the number of LEH authorizations allocated increased from 1500 to 2200 annually, yet the annual harvest has declined from roughly 350–430 animals in the early to mid-1990s, to 160–230 during the 2000s. This may in large part be related to the number of active hunters in the region, which peaked at roughly 700–850 in the mid-1990s, and declined to 400–500 during the 2000s, despite the increase in LEH authorizations available.

Overall, residents took 52.2% of the harvest during 1976–2008, with guided hunters (generally non-residents of Canada or Canadians from out of province) taking the remainder. Since the mid-1980s, the proportion of the mountain goat harvest taken by residents has steadily declined from 57–58% to approximately 43% for the past 5 years of record (Table 5). The proportion of mountain goats harvested by non-residents varies among region, with the highest proportion in the Omineca and Peace Regions (Table 6).

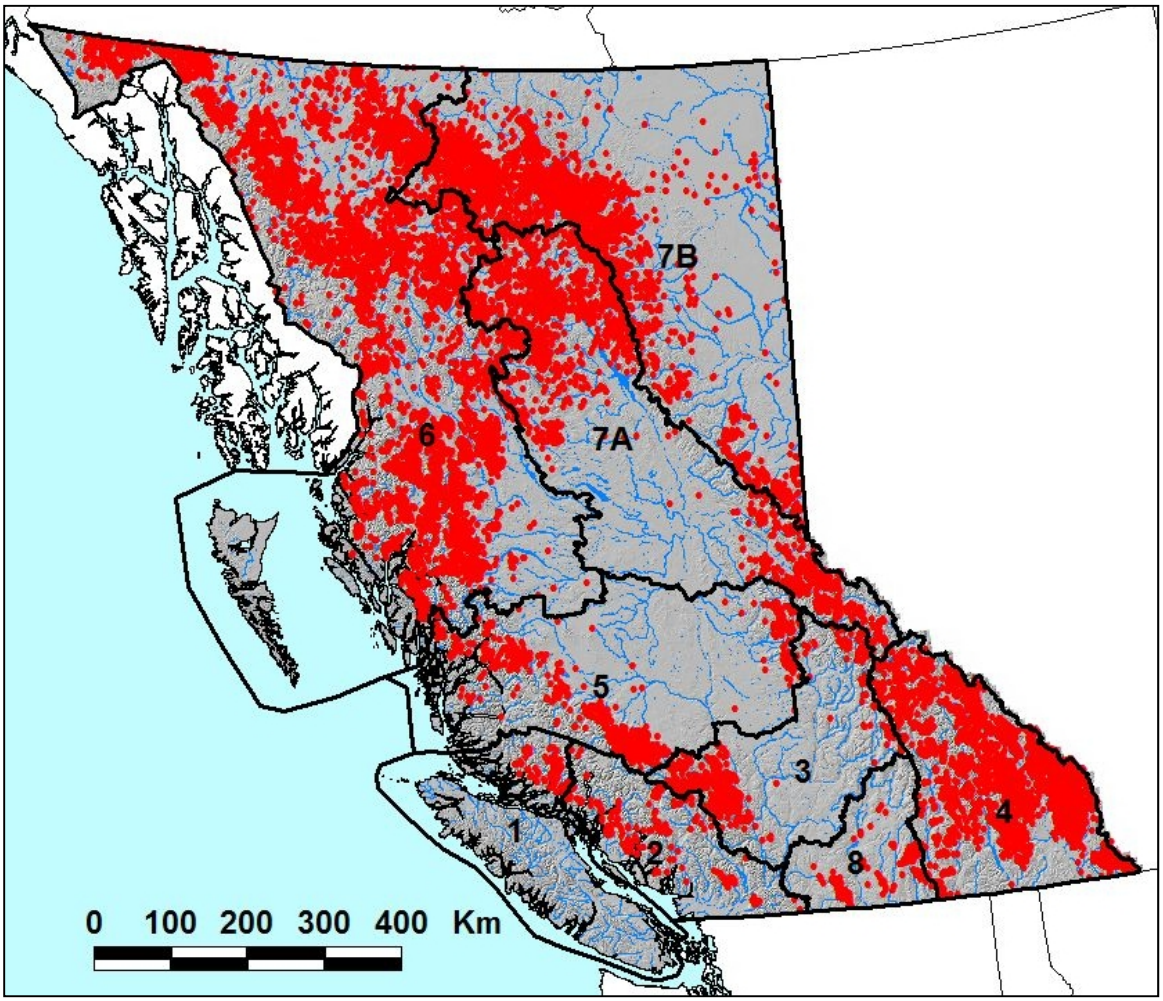

Figure 5. Map depicting compulsory inspection harvest data (red dots) for British Columbia, 1976 to 2008 (*n* = 28,533 records). MoE regions: 1 Vancouver Island; 2 Lower Mainland; 3 Thompson; 4 Kootenay; 5 Cariboo; 6 Skeena; 7A Omineca; 7B Peace; 8 Okanagan.

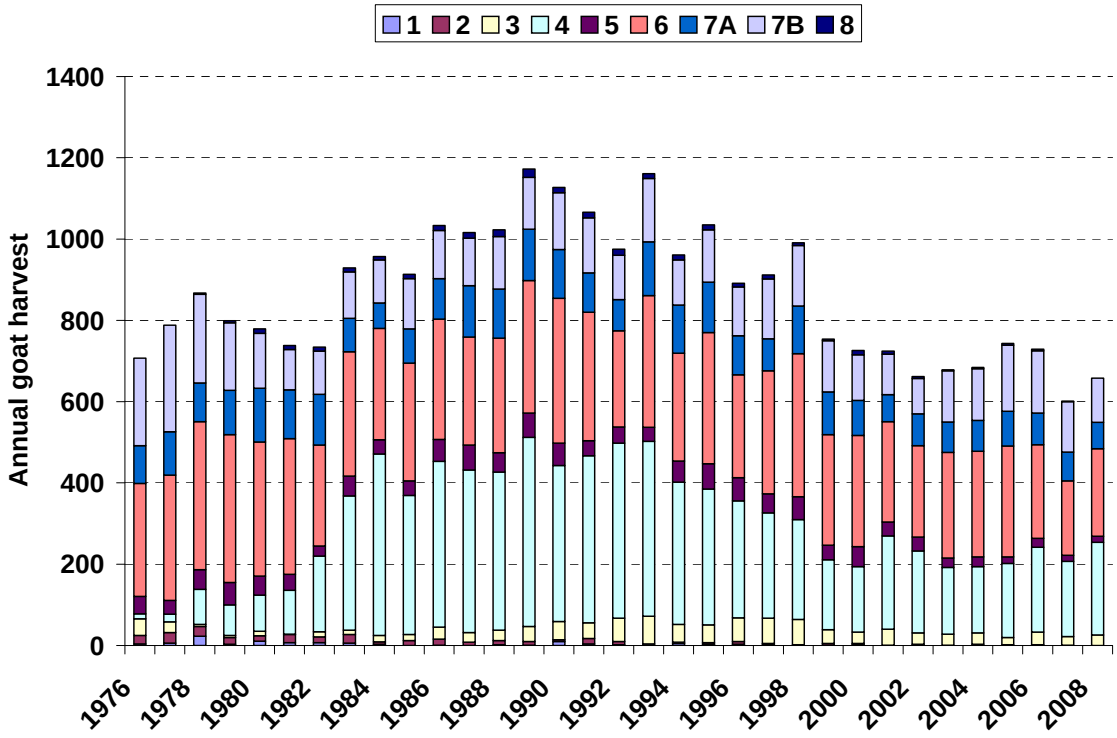

Figure 6. Annual mountain goat harvest by MoE region, 1976 to 2008. Data from compulsory inspection reports. MoE regions: 1 Vancouver Island; 2 Lower Mainland; 3 Thompson; 4 Kootenay; 5 Cariboo; 6 Skeena; 7A Omineca; 7B Peace; 8 Okanagan.

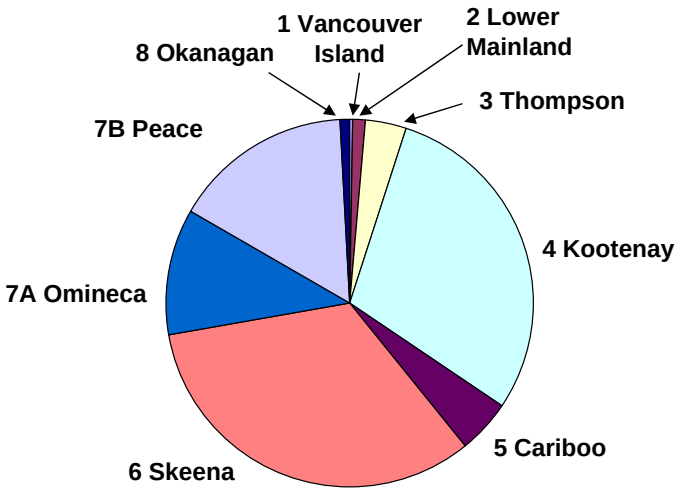

Figure 7. Division of mountain goat harvest among MoE regions of British Columbia, 1976 to 2008. Data from compulsory inspection reports.

Table 5. Proportion of British Columbia mountain goat harvest by residents and non-residents by 5-year period, 1979 to 2008.

Time period	Residents (%)	Non-residents
1979–1983	54.3	45.7
1984–1988	57.0	43.0
1989–1993	57.6	42.4
1994–1998	53.3	46.7
1999–2003	45.9	54.1
2004–2008	42.9	56.5

Table 6. Proportion (%) of mountain goat harvest between residents and non-residents in British Columbia, 1999 to 2008.

MoE region	% Resident harvest	% Non-resident harvest	Total number harvested
1 Vancouver Island	100	0	5
2 Lower Mainland	89	11	18
3 Thompson	55	45	280
4 Kootenay	66	34	1896
5 Cariboo	47	53	268
6 Skeena	41	59	2439
7A Omineca	20	80	785
7B Peace	32	68	1227
8 Okanagan	49	51	41

Proportion of females in the harvest

The proportion of female mountain goats in the harvest has averaged 30% province-wide since 1976; however, the trend indicates a significant decline over time (Figure 8). In the most recent 5 years of data, the proportion of females in the overall provincial harvest averaged 20%. On average, the proportion of females in the harvest has declined 6% per decade in absolute terms since 1976. Non-residents typically harvest 9–15% fewer females in their harvest than residents (Table 7). Increased hunter education and heightened awareness of the importance of sex identification during hunts likely resulted in this decline.[40], [41] The proportion of females in recent harvest is 39% in Alberta (Smith and Hobson 2008) and 28% in Idaho (Toweill 2008).

The proportion of females in the harvest varied among regions (Table 8). Since the late 1970s, the Skeena, Omineca, and Peace Regions have consistently had the lowest proportion of females in the harvest, in part because of the higher non-resident harvest. During the latest 5-year period (2004–2008), the Kootenay, Skeena, and Peace Regions had the lowest proportion of females in the harvest (Okanagan was also low, but the sample size was only 12 animals).

[40] Poole, 2006.
[41] Poole, K.G. 2007a. A population review of mountain goats in the Thompson Region. Unpublished report for B.C. Ministry of Environment, Kamloops, BC.

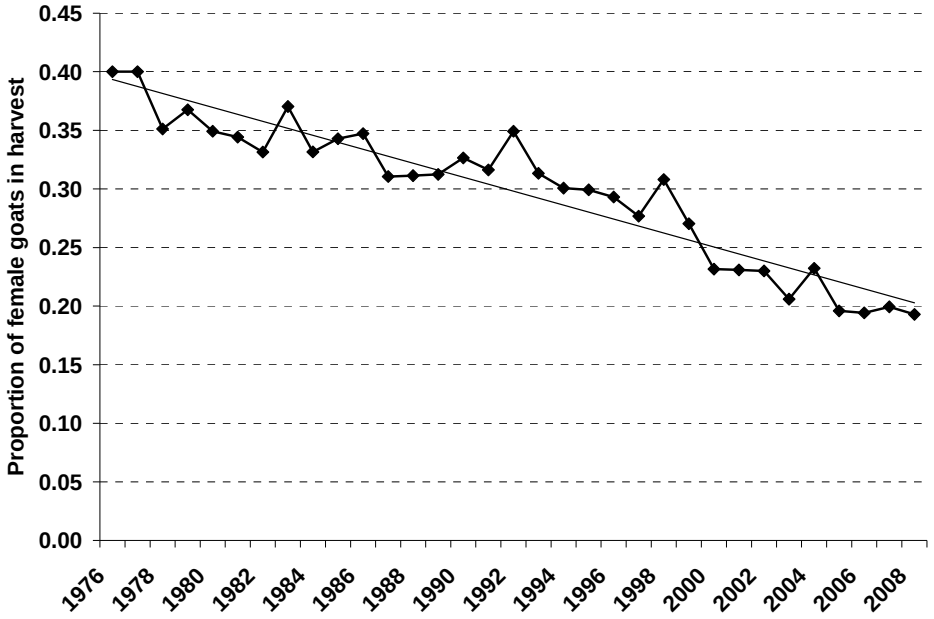

Figure 8. Proportion of female mountain goats in the total harvest in British Columbia from 1976 to 2008. Linear regression: $y = 12.172–0.006x$, $r^2 = 0.89$, $P < 0.001$.

Table 7. Proportion (%) of female mountain goats in resident and non-resident harvests averaged over 5-year periods, British Columbia, 1979 to 2008.

Time period	% female mountain goat harvest by residents	% female mountain goat harvest by non-residents	Total % female harvest
1979–1983	40	30	35
1984–1988	39	25	33
1989–1993	39	24	32
1994–1998	36	22	29
1999–2003	28	19	23
2004–2008	26	16	20

Since 1976 the mean age of male and female mountain goats harvested in British Columbia has averaged 5.3 and 5.7 years, respectively. Mean age has fluctuated over time, and for males has remained relatively stable over the past 10 years, while mean age of harvested females has fluctuated more widely since about 2000 (Figure 9). During the past 10 years, mean age of mountain goats harvested by non-residents was higher than mean age of animals harvested by residents for both females (5.9 and 5.6 years, respectively) and males (5.6 and 5.3 years, respectively). Declining harvests (Figure 6) coupled with declines in the proportion of females in the harvest (Figure 8) have lead to fewer females being killed, especially since the late 1990s.

Table 8. Proportion (%) of female mountain goats in regional harvests averaged over 5-year periods, British Columbia, 1979 to 2008.

	Region								
Time period	**1**	**2**	**3**	**4**	**5**	**6**	**7A**	**7B**	**8**
1979–1983	47%	54%	44%	34%	34%	36%	35%	33%	30%
1984–1988	0%	53%	41%	37%	34%	29%	29%	29%	39%
1989–1993	20%	42%	38%	37%	33%	30%	28%	23%	27%
1994–1998	43%	44%	36%	34%	31%	25%	28%	22%	40%
1999–2003	40%	40%	31%	25%	35%	22%	24%	18%	31%
2004–2008	-	38%	28%	20%	31%	17%	26%	19%	17%
Total	35%	50%	36%	33%	33%	27%	29%	25%	33%

Note that sample sizes were < 15 animals during 2004–2008 in regions 1 (0 goats), 2 (8), and 8 (12). MoE

Regions: 1 Vancouver Island; 2 Lower Mainland; 3 Thompson; 4 Kootenay; 5 Cariboo; 6 Skeena; 7A Omineca; 7B Peace; 8 Okanagan.

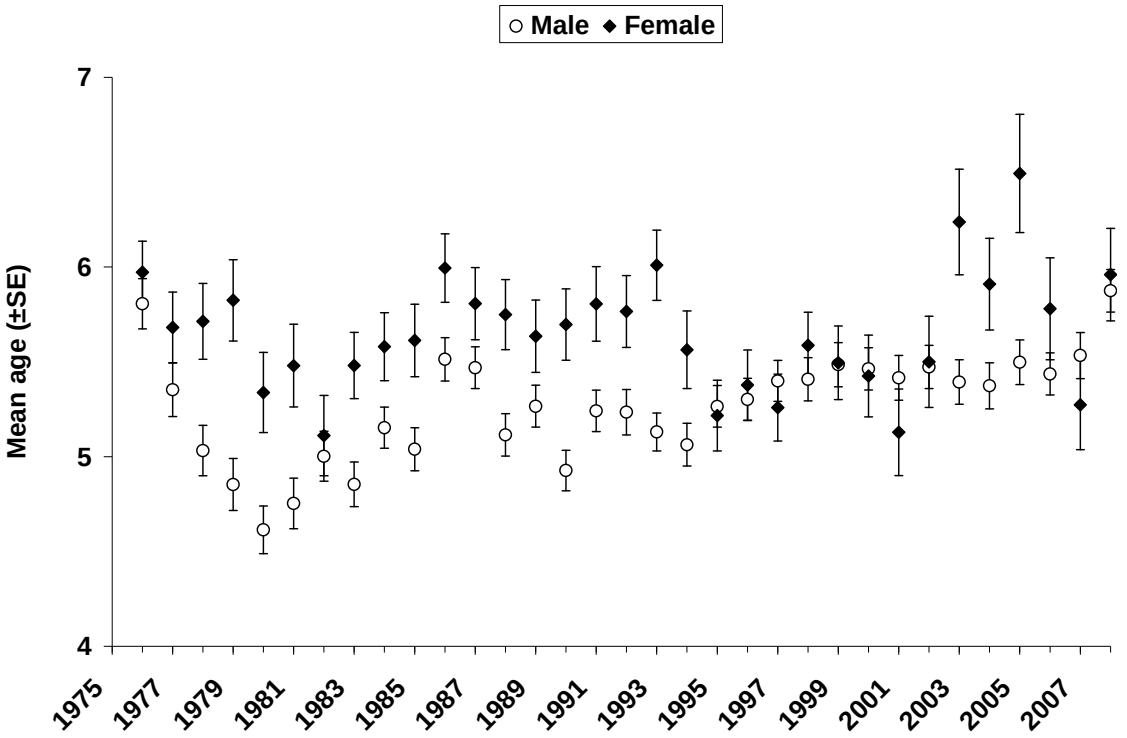

Figure 9. Mean age of female and male mountain goats harvested in British Columbia, 1976–2008.

The distribution of age of harvested mountain goats (based on counting annuli) between 1999 and 2008 was concentrated in the 3- to 6-year-old age categories, with an earlier peak for males than females (Figure 10). Mountain goats ≥ 8 years of age comprised 24% of the female harvest, and 21% of the male harvest.

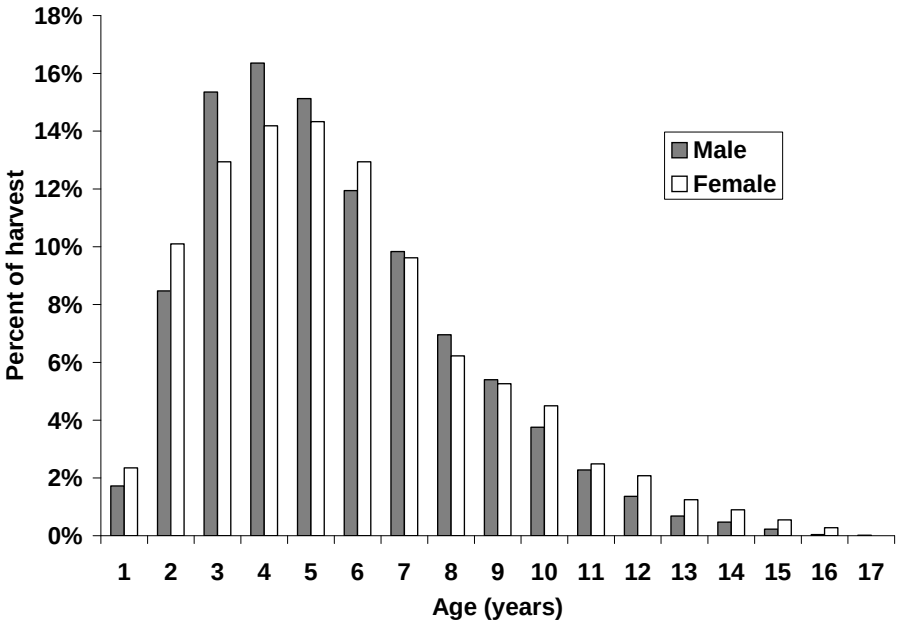

Figure 10. Distribution of age of harvested male (*n* = 5276) and female (*n* = 1445) mountain goats, British Columbia, 1999–2008. Note that aging from horn annuli beyond 8 years of age is not reliable (S. Côté, pers. comm. 2010).

Number of active hunters, hunter success

An active hunter is defined as someone who buys a licence and hunts mountain goats, whether successful or not, and is determined from hunter questionnaires and guide outfitter declarations. The number of active resident mountain goat hunters in the province peaked in the mid-1990s at about 1900 hunters, and declined to approximately 1100–1300 hunters in recent years (Figure 11). Note that this is far lower than the number of LEH authorizations available. For example, in the Kootenay region resident hunters actively hunted on 50–55% of LEH authorizations during the mid-1980s to mid-1990s, but only 25–35% since the late 1990s. The number of non-resident hunters within the province has remained relatively constant over time, generally in the 600–650 range, although this number was slightly lower in 2007 and 2008 (Figure 11). Non-resident hunter numbers would presumably closely mirror the number of mountain goat licences allocated to guide outfitters, but may be affected by the global economy (less discretionary income during hard times).

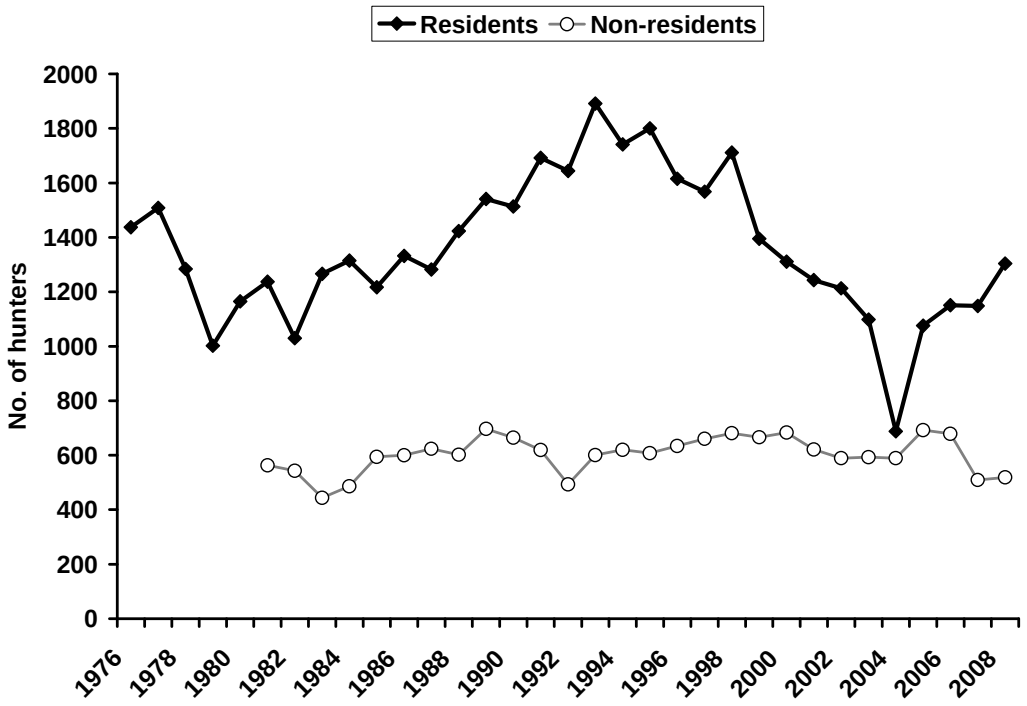

Figure 11. Number of active resident and non-resident mountain goat hunters in British Columbia, 1976–2008.

Mean number of days each active hunter actually hunted mountain goats has remained relatively stable for residents and non-residents since the mid-1970s and mid-1980s, respectively (Figure 12). Between 2004 and 2008, active resident and non-resident mountain goat hunters hunted an average of 5.0 and 5.4 days, respectively.

Resident hunter success (defined here as kills per active hunter) declined between the early 1980s and the late 1990s, and subsequently stabilized, averaging 23–28% for most of the past 10 years (Figure 13). Non-resident hunter success appears to have declined from the early 1990s to 2000, and averaged 63% between 2004 and 2008.

The mean number of kills per 100 days spent hunting for residents declined from the mid-1980s and tended to stabilize around the year 2000. For non-residents, number of kills per 100 days also decreased slowly from the mid-1990s through to year 2000, and has trended up in the past 5 years (Figure 14). Non-residents were more successful than residents at harvesting mountain goats; from 2004 to 2008, kills per 100 hunter days averaged 5.8 and 11.6 for residents and non-residents, respectively.

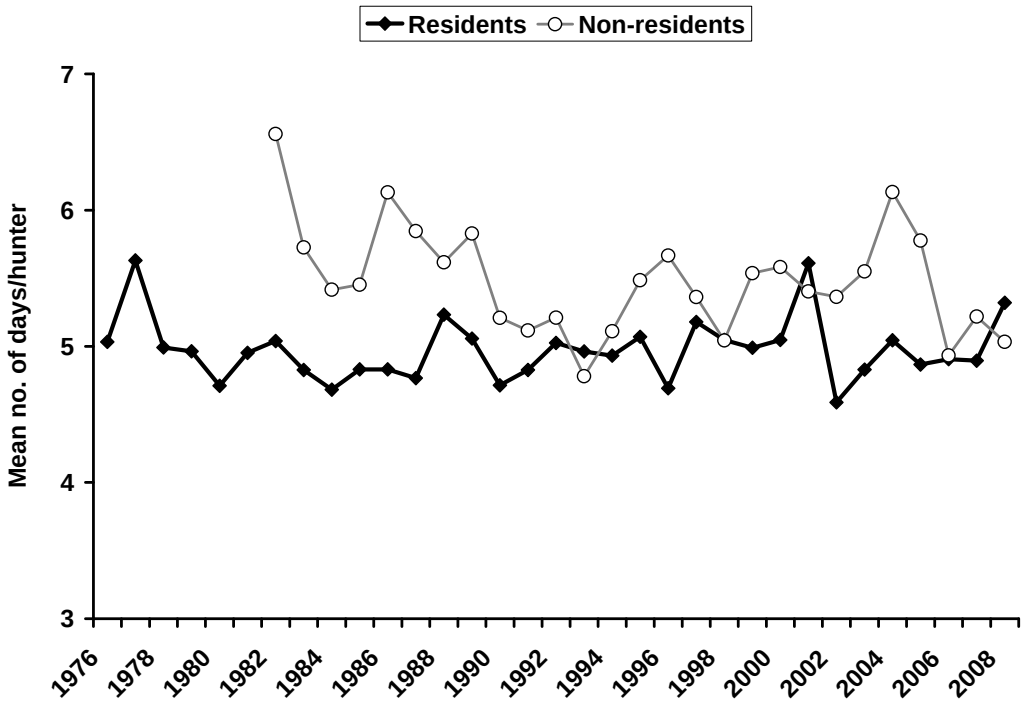

Figure 12. Mean number of days per active resident and non-resident mountain goat hunter in British Columbia, 1976–2008.

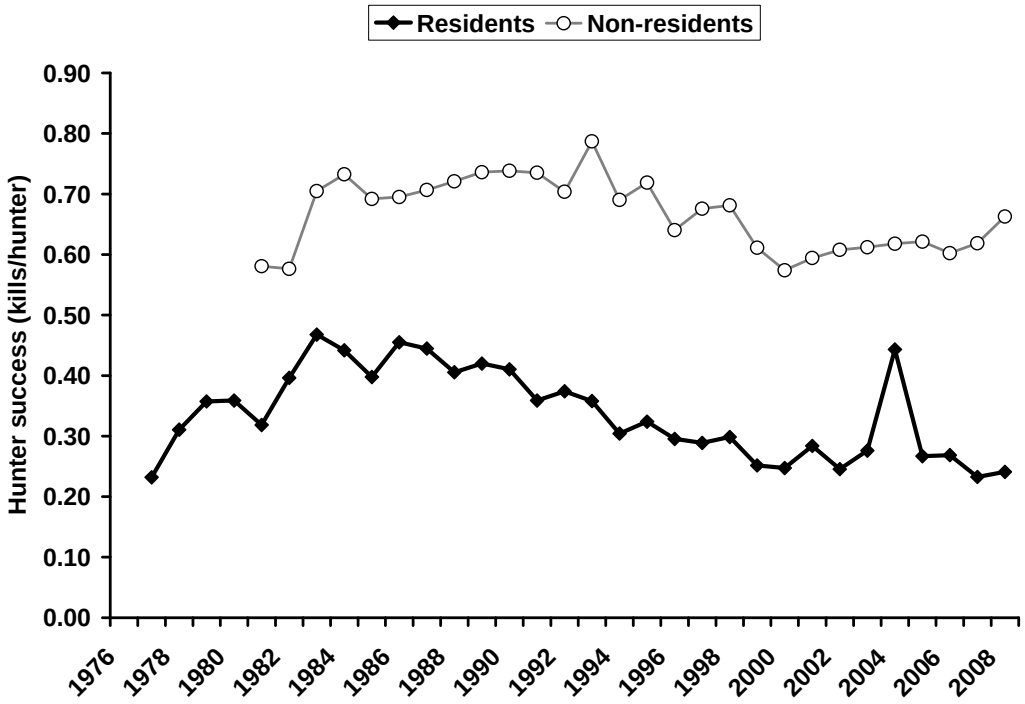

Figure 13. Resident and non-resident mountain goat hunter success (kills per active hunter) in British Columbia, 1976–2008.

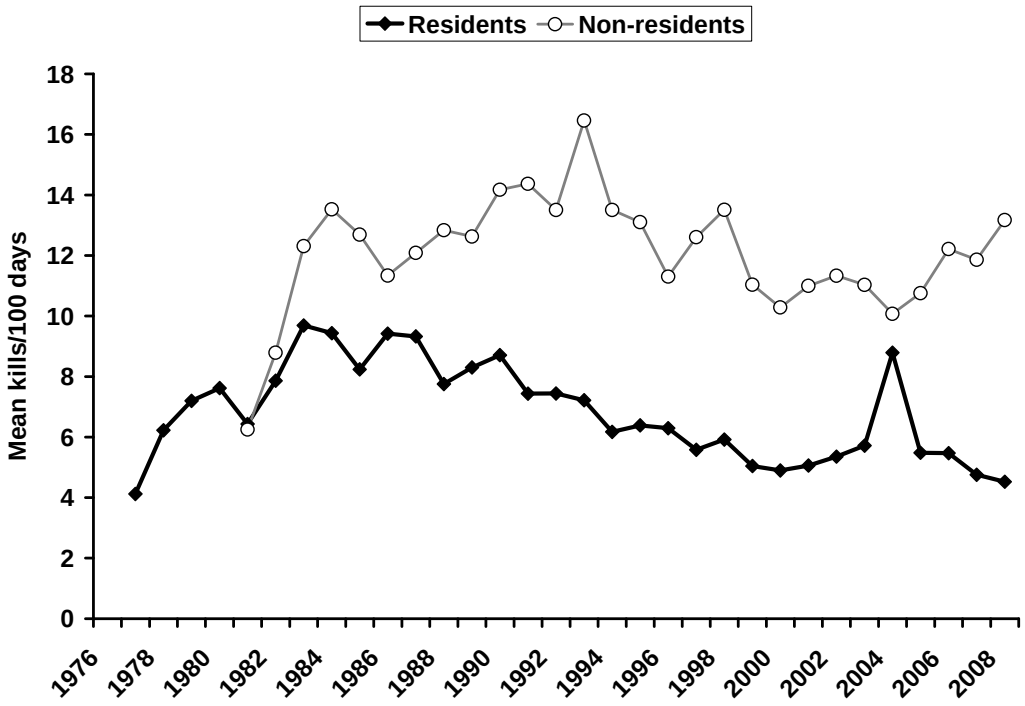

Figure 14. Mean number of kills per 100 days hunting effort for resident and non-resident mountain goat hunters in British Columbia, 1976–2008.

Harvest rate

Harvest rates can be calculated in different ways. In British Columbia, the harvest rate is defined as the harvest (estimated or known) divided by the population estimate for the area in question. All animals, including kids, are used to derive the population estimate. There is greater likelihood of inaccurate estimates of the denominator in this equation (poor population estimates), which may contribute to incorrect harvest rates. Tracking of the non-kid ("adult") portion in population trend analyses would likely reduce the inherent variance compared with total population numbers.[42]

Average annual harvest rates calculated for the 2001–2005 hunting seasons for the Kootenay and Thompson Regions were 2.2% and 1.0%, respectively.[43] Both areas showed a steady decline in harvest rate from the late 1980s (4.7% and 1.9%, respectively), although this may have been a result of both declining harvest and increasing population estimates. However, regional versus local scale issues may confound reporting of harvest rates, as local overharvest may not be identified in regional summaries. Most regions lack precise enough regional population estimates, resulting in actual harvest rates available only for local areas.

3.2.3 Population inventory

Large portions of British Columbia have been inventoried for mountain goats over the past three decades (Figure 15). However, many of the surveys have only occurred once and are dated,

[42] Poole, 2006.
[43] Poole, 2006, 2007a.

especially in the northern half of the province, resulting in a poor understanding of population trends and changes to distribution.

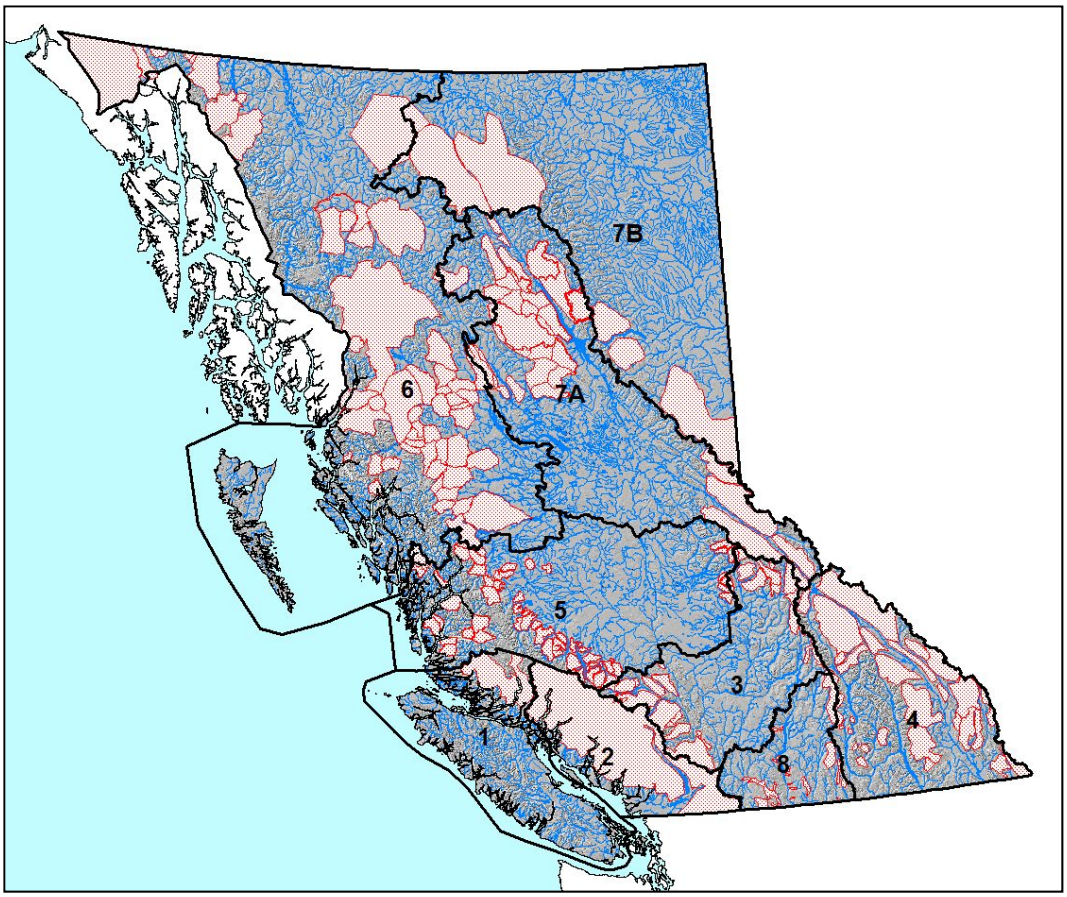

Figure 15. Areas surveyed for mountain goats in British Columbia since the early 1970s. Regions: 1 Vancouver Island; 2 Lower Mainland; 3 Thompson; 4 Kootenay; 5 Cariboo; 6 Skeena; 7A Omineca; 7B Peace; 8 Okanagan.

In most areas of British Columbia, aerial surveys are used to inventory mountain goats within selected study areas (RISC 2002; Poole 2007b). Although fixed-wing aircraft are used in Alaska, aerial surveys within British Columbia and other jurisdictions utilize helicopters. Total counts are generally used, as other techniques are less developed or provide wide confidence limits (Poole 2007b). Reliable mark-resight techniques have not been well tested and tend to produce wide confidence limits (Smith and Bovee 1984; Cichowski *et al.* 1994; Poole *et al.* 2000; Pauley and Crenshaw 2006; Schulze *et al.* 2008). Regression-based sightability models have only recently been developed for mountain goats (Poole 2007b; Rice *et al.* 2009), where group size, terrain obstructions, and vegetation cover are principal factors affecting sightability.

Surveys in most areas of British Columbia are conducted during mid-July to September, consistent with most other jurisdictions (Toweill *et al.* 2004). Surveys in the Vancouver Island and Okanagan Regions are often conducted during winter (B. Harris, pers. comm. 2009; K. Brunt, pers. comm. 2009). During mid-summer through early fall most mountain goat populations are at high elevation (above treeline), enhancing sightability. In interior populations,

variable portions of the population may use low-elevation mineral licks to a greater extent before mid-July, reducing visibility in forested habitats.

Survey techniques generally involve flying contours within potential mountain goat range, counting and recording all mountain goat locations using a Global Position System. Correction to account for animals presumed missed during the survey is generally applied afterward (see below), unless a study-specific correction is obtained or sightability model is used. Mountain goats are often classified only into kids and non-kid (yearlings and older) based on body size (B.L. Smith 1988) to reduce survey time, to minimize harassment (Côté 1996), and because researchers familiar with classification from aircraft agree more detailed age and sex classification is not reliable (Houston *et al.* 1986; Stevens and Houston 1989; Gonzalez-Voyer *et al.* 2001). Most other jurisdictions in North America obtain kid to non-kid ratios during aerial surveys, although a number use ground surveys for more detailed classification data (Toweill *et al.* 2004). Aerial counts of mountain goats have limited precision, but standardized surveys can be used as indicators of broad population trends over time (Gonzalez-Voyer *et al.* 2001; Poole 2007b). However, management agencies still require estimates of population size, which are typically based on infrequent surveys (every 5–10 yr).

The ratio of kids to adult females can be used as a rough index to reproductive success of a population. Differences in timing of the surveys and definition of an adult female can lead to variation in this index. Also, due to the difficulty of accurately identifying sex and age classes of mountain goats during aerial surveys, managers often use the ratio of kids to older animals (≥ 1 year of age) as an index to reproductive success (Glasgow *et al.* 2003). Regardless of ratio used, sex/age ratios are poor predictors of recruitment or of population change (McCullough 1994), because of errors in classification, overwinter survival of juveniles is highly variable (Gaillard *et al.* 2000), and true recruitment into the reproductive, adult population may not occur until age 3 or 4.

Ground counts can be more precise than aerial surveys, but are logistically difficult to conduct in large, remote areas (B.L. Smith 1988). From the ground and with an experienced observer, kids, yearlings, 2-year-old males and females, and adult males and females can be classified.

Research is being conducted in the province to determine the feasibility of population estimates derived from identification of individuals using DNA obtained from collected scat and hair samples (Poole and Reynolds, in prep.). Such methodology may be appropriate where mountain goats are difficult to observe and aerial sightability is low, where populations are small, or as a comparison with aerial survey-derived estimates.

Reliable trend data over time can also be provided by hunters with long familiarity with a given area or population. Scandinavian research suggests that hunter observations can be a useful tool for estimating long-term population trends in moose (Solberg and Sæther 1999; Sylvén 2000; Rönnegård *et al.* 2008).

Sightability

Portions of the animals in an area are not observed during aerial surveys. For example, out of 100 mountain goats in a surveyed area, perhaps only 65 will be seen. To provide a more accurate

estimate of the number of animals present, an adjustment for sightability is often applied to the number seen. The average sightability during mountain goat surveys for interior populations are 60–70% (Gonzalez-Voyer *et al.* 2001; Poole 2007b). Rice *et al.* (2009) modeled 85% sightability for an interior population in Washington, but lower sightability is assumed for most coastal populations (46%: Smith and Bovee 1984; Alaska 45–65%: K. White, pers. comm. 2008). For south coastal British Columbia, aerial sightability values of 15–25% were estimated based on mark-recapture techniques using radio-collared animals (K. Brunt, pers. comm. 2009).

Calculation of density within the census zone of potential mountain goat habitat
Density of mountain goats observed on summer range may be a useful metric of population health or ecosystem capacity. Demarchi *et al.* (2000) used this to calculate the density in the census zones in west-central British Columbia (~70 goats/100 km^2; no correction for sightability). For south-coastal British Columbia, densities of 30–65 goats/100 km^2 of potential mountain goat habitat were estimated based on mark-recapture techniques using radio-collared animals (K. Brunt, pers. comm. 2009). Recent surveys within adjacent areas of the Rocky Mountains (~170 goats/100 km^2) and Purcell Mountains (~70 goats/100 km^2) (all corrected for sightability) have generated similar mountain goat densities within broad areas.[44] These consistencies lend support for an ecological basis for mountain goat densities, possibly related to broad habitat carrying capacity or similar density-independent factors in operation (e.g., weather), and could lead to the ability to model and extrapolate density estimates to other areas.

Survey reporting
Reports on mountain goat surveys conducted within British Columbia should provide sufficient detail to allow others to compare data among areas and over time. These details include time on survey (to calculate survey effort), area of potential mountain goat habitat surveyed (to calculate survey effort and density), and age/sex breakdown of sightings (as appropriate).

4.0 MANAGEMENT

4.1 Management Goal

The management goal for mountain goats is to maintain viable, healthy and productive populations of mountain goats throughout their native range in British Columbia.

4.2 Rationale for the Management Goal

This management goal has been set to prevent mountain goats from becoming at risk in British Columbia (Goal 2 of the Conservation Framework; B.C. Ministry of Environment 2009).

4.3 Management Objectives

1. To effectively maintain suitable, connected mountain goat habitat.
2. To mitigate threats to mountain goats.

[44] Poole 2006.

3. To ensure opportunities for non-consumptive and consumptive use of mountain goats are sustainable.

4.4 Recommended Management Actions

Our approach to mountain goat management in British Columbia is to provide recommendations that were developed from empirical data based in science. The purpose of this section is to provide scientific recommendations on a provincial scale that could be used by government and stakeholders for policy development and implementation of management actions for mountain goats. However, in areas where the science is unclear or lacking, we followed a precautionary approach to recommendations, including consideration of recommendations from other jurisdictions.

A summary table of recommended actions for mountain goat management in British Columbia can be found in Appendix C. This table groups actions by the management objective they help to achieve and indicates within which Conservation Framework Action Group each of the actions belongs. The table also notes what threats or concerns each action helps to address. Details about these recommended actions on habitat, population/harvest, disturbance and access management is found in the following text.

Please note that specific recommendations apply consistently to all industries within the province and all recommended actions are not listed in any order of priority.

4.4.1 Habitat management recommendations

Issues and information relevant to mountain goat habitat management are summarized here:

- Escape terrain is the key habitat feature required by mountain goats to avoid predators; escape terrain usually means cliffs or cliff complexes, but can include forest cover, particularly when associated with cliff habitat or in mountain goats associated with river/canyon situations;
- Winter is the most critical season for mountain goats, generally characterized by restricted movements and habitat availability;
- The importance of snow interception habitat to mountain goats during winter differs among areas of the province, with the greatest requirement in coastal and interior wet-belt areas;
- Mineral lick use is high in interior populations, but appears less important to coastal populations;
- The influence of habitat change (i.e., succession, forest encroachment, wildfires, human development) on habitat productivity and carrying capacity is poorly known;
- Connectivity of habitat is important, especially among river goat populations, and between important habitats such as cliff complexes and mineral licks; and
- Climate change may have a direct impact on habitats occupied by mountain goats (and hence mountain goats) through increased temperatures, changes in precipitation—both with influences on forage quality and quantity and parasite life cycles, and greater

variability in extreme weather events, and indirectly through changes in alpine and other mesic south-facing cliff habitat.

Specific recommendations:

1. **Review, update, and validate/refine habitat suitability modelling:** Habitat capability and suitability models have been developed for some mountain goat populations in British Columbia (e.g., Heinemeyer *et al.* 2003; Keim 2004; Turney 2004; McNay *et al.* 2006; Taylor *et al.* 2006; Poole *et al.* 2009). Many of these models use different techniques and methodologies, and most have limited field-testing and verification.
   - Current habitat models should be reviewed for utility to determine which are the most useful within a particular ecosystem, their feasibility, and the most suitable approach to modelling within an area and on a province-wide scale to encompass all mountain goat range. Inventories should be conducted to validate models and confirm mountain goat occupation. Models should be standardized within an area, but may need adapting to fit certain regions.
   - Innovative GIS techniques such as use of solar incidence modelling (Kumar *et al.* 1997), or terrain ruggedness (Poole *et al.* 2009) should be considered to update regional habitat capability and suitability models for mountain goats within all regions of the province.
   - Suitability modelling should include a measure of connectivity.
   - Site-specific habitat assessments should be conducted where appropriate (e.g., where modelling results prove to be inaccurate, in localized areas).

2. **Inventory habitat used by mountain goats:** Inventory of important mountain goat habitats across the province is incomplete. These important habitats include kidding/early rearing and winter ranges (Keim 2004; Turney 2004; McNay *et al.* 2006; Poole *et al.* 2009, 2010), as well as key habitat components such as mineral licks and trails (Ayotte *et al*. 2008.).[45] Traditional trails often lead into lick complexes, or are used to connect suitable habitat and sub-populations of goats.
   - Important mountain goat habitat should be identified, especially for kidding/early rearing and winter ranges, and for mineral licks and trails. This should ensure an adequate level of habitat inventory across the province, and may take the form of habitat inventories (as opposed to population inventories), such as modelling, aerial inventory, and radio-telemetry. Once identified, important habitat for mountain goats must be more formally included in resource use decisions.
   - Local knowledge should be used to assist in the identification of mountain goat habitat. Consider partnering with First Nations, guide outfitters or others to identify licks or trails in poorly-known areas.
   - Focus should be on important habitats where the disturbance risk is relatively greater (e.g., merchantable forest, oil and gas areas, mineral tenures, recreation tenures, and areas with developed access).
   - Important, non-sensitive goat habitat information should be readily available to First Nations, stakeholders, project proponents, and the general public.

[45] Rice, 2009; Corbould *et al.*, 2010.

3. **Identify habitat connectivity:** Most populations of mountain goat undertake seasonal movements (Côté and Festa-Bianchet 2003).[46] Other populations of goats use forest trails to maintain connectivity among groups and among discrete habitat patches.
   - At the landscape level, connectivity of forest cover between occupied habitats should be identified and maintained.

4. **Initiate and apply consistent habitat guidelines for mountain goats:** There is a need for consistent guidelines for management of mountain goat Ungulate Winter Range (UWR), Wildlife Habitat Areas (WHA), and Wildlife Habitat Features (WHF) and for goats as Regionally Important Wildlife (RIW). However, guidelines will likely differ across broad regions. For example, winter range may be more critical in coastal and wet interior areas (e.g., Gordon and Reynolds 2000; Taylor *et al.* 2006; Taylor and Brunt 2007). Mountain goats are usually reluctant to venture more than 400–500 m from escape terrain, often staying even closer to escape terrain during winter (Chadwick 1983; Fox *et al.* 1989; Haynes 1992; Gross *et al.* 2002; Poole and Heard 2003; Taylor *et al.* 2006; Taylor and Brunt 2007)

The following recommendations in Table 9 were developed through expert opinion from Ministry of Environment biologists, technical reports, and peer-reviewed literature. Table 9 is a risk matrix related to physical disturbance of habitat (i.e., vegetation removal) in proximity to important mountain goat habitat. The table relates to areas measured from the edge of important mountain goat habitat where the removal of a significant amount of the vegetation will lead to increased levels of risk to maintaining the effectiveness of these habitats. For example, removing over 25% of the vegetation cover within 350 m of escape terrain may result in a moderate risk that the escape terrain will no longer be effective. The intent is to maintain the effectiveness of these important habitats by preventing blowdown, reducing predation risk, and minimizing edge effects.

Two size classes of UWRs have been included in this table, because the relative risk to habitat effectiveness is considered to be related to the size of the habitat polygon. Larger polygons are considered to be more able to remain effective with adjacent vegetation removal, whereas the effectiveness of smaller habitat polygons is considered to be more sensitive to such alterations.

This table is not meant to conflict with any legal objectives or measures established through orders; legal requirements supersede this management plan.

[46] Rice, 2009.

Table 9. Risk matrix related to physical disturbance of habitat (i.e., vegetation removal) in proximity to important mountain goat habitat.

	Risk of removal of > 25% vegetation cover		
Important habitat	**High risk**	**Moderate risk**	**Low risk**
UWR > 500 ha	< 100 m	100–200 m	> 200 m
UWR < 500 ha	< 200 m	200–500 m	> 500 m
WHA	< 300 m	300–500 m	> 500 m
Escape terrain[a]	< 300 m	300–400 m	> 400 m
WHF licks	< 300 m	300–500 m	> 500 m
Travel corridors[b]	< 100 m	100–300 m	> 300 m

[a] Chadwick 1983; Fox 1983; Schoen and Kirchhoff 1982; Fox *et al.* 1989; Haynes 1992; Gross *et al.* 2002; Poole and Heard 2003; Taylor *et al.* 2006; Taylor and Brunt 2007.
[b] Corbould *et al.* 2010.

The levels of assumed risk predicted here do not reflect impacts that may result from the timing of habitat alteration or the implications of access as a result of the habitat alteration, as described in the relevant sections of this plan.

The relative impact of vegetation removal will also depend on the spatial distribution of such removal. Concentrated vegetation removal adjacent to important habitats may have a disproportionate impact on habitat effectiveness. It is recommended that professional judgment be used in determining the relative impact on mountain goat habitats on a case by case basis when undertaking any vegetation removal adjacent to these areas. Decisions related to development activities should also include landscape-level considerations (e.g., connectivity, disturbance) and the cumulative effects of different land use activities on mountain goat habitat effectiveness.

5. **Apply management tools and mitigation techniques consistently to all development:** Management of important mountain goat habitat and mitigation of potential impacts to this habitat is governed through different legislation for different industries; as a result, management is not consistently applied throughout the province or among development industries. Important habitat that is identified should remain sufficiently effective to maintain function for goats. Mitigation techniques, guidelines, and other management intended to achieve this should be consistently applied to all sources of disturbance.
    - All designations made under the *Forest and Range Practices Act* and the associated General Wildlife Measures should be applied consistently to other activities that might impact mountain goat habitat.
    - Existing habitat management tools should be used to ensure that habitat effectiveness is maintained (e.g., *Forest and Range Practices Act* and *Land Act* tools). Tools should be chosen to address the most likely threat to disturbance.
    - Guidelines to mitigate impacts of development on mountain goats should be based on available information and science, and applied consistently to sources of disturbance.
    - Ministry of Environment should prioritize the review and comment on development proposals in mountain goat habitat, and mitigation of impacts to important mountain goat habitat should be more formally included in resource use decisions.

4.4.2 Population / harvest management recommendations

Issues and information relevant to mountain goat population/harvest management are summarized here:

- Harvest of adult females has a large negative influence on population trend and sustainable harvest;
- Because of less obvious differences in mass and horn size, it is more difficult to identify males and females in the field than other ungulates;
- Hunter education, primarily methods to identify sex in the field and the importance of females to the population, is important in reducing female harvest;
- Resident hunter effort towards mountain goats has declined over the past 10 years, apparently because of fewer hunters, while the number of non-resident hunters has remained relatively constant over time;
- Compulsory inspection reporting and the Big Game Harvest Questionnaire appear to effectively track the harvest and hunter effort;
- Inventory across the broad range of mountain goat distribution in British Columbia is costly and difficult to conduct;
- Distribution of mountain goats may be declining along portions of the southern distribution in the province;
- There is weak evidence of density dependence in native mountain goat populations, but it appears to occur in introduced populations; and
- Sustainable harvest rates of native populations of mountain goats are low, likely in the 0–4% range, and are influenced by population size and proportion of females in the harvest.

Specific recommendations

1. **Do not harvest populations with less than 50 adults:** Modelling by Hamel *et al.* (2006) concluded that even without hunting, mountain goat populations in Alberta comprised of 25 individuals have, on average, a 50% chance of extirpation within 40 years; the risk of extirpation for 50 animals is two-thirds lower. This has led to a recommendation that mountain goat populations with fewer than 50 animals should not be hunted (Glasgow *et al.* 2003; Hamel *et al.* 2006; McDonough and Selinger 2008), a conclusion supported by modelling by Hatter (2005). Washington recently increased this minimum from 50 to 100 (Washington Department of Fish and Wildlife 2008; Rice and Gay 2010). Toweill *et al.* (2004) recommended hunting only populations with > 50 adults (not individuals), but provided no basis for this recommendation. However, removal of kids from the calculation of population size for harvest would add a measure of conservatism to the figure and reduce among-year variance in population size, since kid survival is lower and more variable than adult survival (Festa-Bianchet and Côté 2008).
    - Unless new research, monitoring, or other information suggests otherwise, populations in British Columbia of less than an estimated 50 adult (non-kid) mountain goats should not be hunted.
    - All hunted populations of an estimated 50–100 adults should be monitored at least every 3 years to ensure sustainable harvest.
    - Small, accessible herds should be monitored for signs of overharvest using site-specific compulsory inspection harvest data and more frequent surveys.

- Before implementing or re-opening a hunting season within a managed unit, the population estimate for that unit should be > 50 adults, and should be based on inventory data.

2. **Set harvest rate based on estimated population size:** Evidence, primarily from western Alberta, suggests that native populations of mountain goats cannot sustain more than 1–3% harvest rate (based on total estimated population size and assuming a harvest focussed on adult males) (Côté and Festa-Bianchet 2003; Glasgow *et al.* 2003; Gonzalez-Voyer *et al.* 2003). Modelling conducted by Hatter (2005) suggested a sliding scale of higher sustainable harvest rates with larger population size. While most jurisdictions attain a harvest rate of < 2%, many aim for a higher harvest rate (up to 4–5%), in large part because of built-in conservative estimates of population size (often total count, not estimates, are used; McDonough and Selinger 2008), a mandated focus on avoiding female harvest, and frequent monitoring (Toweill *et al.* 2004). Ideal information to monitor population health and to ensure sustainable harvest management of a population of mountain goats would include regular inventories with sightability correction, accurate harvest data that include sex and age, hunter effort and success information, detailed composition data, and indications of trends in potential predators. Less data available should result in more conservative objectives for harvest. At a minimum, harvest data and hunter effort and success need to be monitored population by population to identify populations where the harvest may not be sustainable.
   - The British Columbia harvest rate should be a maximum of 3% of total estimated population size, following current recommendations to allow for reduced harvest rates (< 1–2%) for smaller populations, those with more accessible, disturbed, and/or heavily harvested segments of the population, or those with a greater proportion of females in the harvest (Table 4).
   - Following the precautionary principle harvest rates should be reduced by 1–2% to a more conservative rate if inventory data are dated if it is not possible to conduct inventories every 5–6 years, if hunter data suggest reduced hunter success, if increased females are in the harvest, or if there is uncertainty with the estimate (Table 4; Hatter 2005).
   - Isolated populations should be managed more conservatively than those that have good connectivity with adjacent populations.

3. **Base harvest rate on the managed unit:** Management of mountain goats must occur at a scale that is appropriate. Identification of distinct mountain goat populations is essential, otherwise overharvest may occur on easily accessible herds within a management unit (Festa-Bianchet and Côté 2008). It is often difficult to identify discrete populations in areas of continuous, high-elevation habitat. Current examination of mountain goat genetics (A. Shafer *et al.*, University of Alberta, unpublished data 2009) may assist population determination at broader scales and identify genetic variability of populations, but may not be useful at the finer scales required for management. Managers may need to manage on a herd-specific basis using precise geographical boundaries where access is easy (Côté and Festa-Bianchet 2003).
   - In areas of isolated populations with relatively little exchange with adjacent populations, then the isolated population should be considered as the unit of management (mountain goat population unit). By default, if regular (e.g., seasonal) exchange of individuals with adjacent populations is not verified by documented use of trails or marked animals, then

the population should be considered as discrete, with implications to minimum population size and harvest management (see above).
- In areas of more continuous distribution, the unit of management can be set in a manner that gives primary consideration to access (i.e., herd vulnerability), and population estimates.
- Where harvest is concentrated on an accessible herd or area within a larger population, the area should be considered as a management unit and managed accordingly.
- Some managed units with no harvest should be considered, which can be used to encourage viewing and public education, and as benchmark populations for conservation and scientific interest.

4. **Minimize female harvest:** Evidence suggests that a high proportion of females in the harvest can have implications to population viability and sustained yields, which becomes more acute with smaller populations (K.G. Smith 1988; Hatter 2005; Hamel *et al.* 2006; Festa-Bianchet and Côté 2008). Modelling suggests sustainable harvest rates decline when females comprise > 30% of the harvest for large populations, or > 25% for smaller populations (Hatter 2005). Although the female harvest in British Columbia has declined in the past three decades (Figure 8), there are still areas of high female harvest. Alberta used a double-quota system where if more than one-third of the harvest within a management unit is females, the season may be closed for one or more years to allow the population to recover (Glasgow *et al.* 2003). Alaska uses a point system of mountain goat management that essentially restricts (penalizes) harvest within a management unit if females are harvested (McDonough and Selinger 2008; K. White, pers. comm. 2008). Other jurisdictions do not permit harvest from larger groups or adults accompanied by kids (Toweill *et al.* 2004).
   - Effort should be directed towards reducing and eliminating the female harvest to the extent possible. The Ministry of Environment should consider increasing efforts to provide hunter education on sex identification in the field, by providing mandatory training for all hunters and guide outfitters that hunt mountain goats. This might include use of a brochure on sex identification in the field, free distribution of the mountain goat identification DVD currently in place (Duncan Gilchrist Productions), and use of web-based resources for sex identification.
   - British Columbia should consider implementing a weighted harvest system where the allowable harvest is influenced by the sex of animal being harvested. In this system, the harvest would be reduced for that managed unit if > 20% of the annual allowable harvest or > 30% of the actual harvest is female. In essence, females in the harvest would be assigned a higher weight than males, and under circumstances of excessive female harvest methods to reduce the female harvest should be adopted. Smaller populations with high female harvest should be treated with more aggressive management.
   - Ministry of Environment should consider the following regulation: it is unlawful to kill a female mountain goat accompanied by a kid or a female mountain goat in a group that contains one or more kids.
   - Ministry of Environment should consider consulting with stakeholders on possible ways to minimise harvest of females.

5. **Improve the accuracy of sex identification during compulsory inspections:** Compulsory inspections in British Columbia are primarily conducted by contractors. Currently, only the horns of harvested mountain goats are required for inspection. Determination of sex from the horns of younger animals can occasionally be problematic (B.L. Smith 1988).
   - Ministry of Environment should consider amending the parts required for compulsory inspection of mountain goats to include a positive identification of sex of the harvest animal. These might include a portion of the hide with evidence of sex attached.
   - Ministry of Environment should ensure that compulsory inspection contractors receive adequate training to identify sex of harvested mountain goats.

6. **Conduct adequate inventory to base harvest management decisions:** Parts of British Columbia have dated, poor, or no inventory on mountain goats, especially in some northern and many coastal areas. With the current level of inventory in these areas, the probability of detecting localized loss of mountain goats is low and local goat censuses are needed unless harvest is deemed to have little impact on population numbers. Aerial inventory data are best used as an indicator of population trend (Gonzalez-Voyer *et al.* 2001; Poole 2007b), and as such ideally require repeated surveys to provide meaningful data. Although aerial helicopter surveys are the standard in most areas of the province, they may not be applicable to all areas, especially those where mountain goats spend much of their time in more forested habitats. Ideal survey intensity would vary with the degree of risk managers are willing to accept that a decline (or increase – lost hunting opportunity) would not be detected. A 1- to 3-year survey interval is recommended in Alberta (Glasgow *et al.* 2003), and a 3- to 4-year interval appears to be used in Alaska, with a focus on areas of higher hunting pressure (McDonough and Selinger 2008).
   - Survey methodology should be rigorous and consistent within broad areas of the province. Standardized methodology would enable density calculations within census zones that may be applicable across wide geographic areas.
   - Survey effort should be calculated and survey details well documented, to allow wider temporal and spatial trends to be determined.
   - Ground-based composition surveys may provide more accurate classification data if all components of the population are sampled equally.
   - If resources are not available to provide monitoring at least at 5- to 6-year intervals, then harvest rates should be adjusted to be more conservative.

7. **Caution use of transplants where appropriate:** Transplants of mountain goats have been moderately successful within British Columbia (Table 3), and can be considered as an appropriate tool to be used. The Ministry of Environment has draft transplant (translocation) policy and procedures in place that function as a risk assessment and must be done to reduce the risk to donor and recipient herds (Teixeira *et al.* 2007). Primary considerations include:
   - The cause of the initial decline in numbers needs to be identified and addressed.
   - Where appropriate, transplant should be considered in the following priority: (1) vacant historical ranges that are still capable of supporting mountain goats, (2) augment existing imperilled herds, and (3) supplementation of existing herds that are below their range capacities.
   - Before transplant, a detailed and thorough site selection process is needed that would include historical use, initial reason for decline, forage quality and quantity, escape

terrain, expected population size, interspecific competition, winter conditions, access and connectivity with other populations/ranges (Glasgow *et al.* 2003). A list of potential transplant sites could be developed.
- If possible, health assessments of both donor and recipient (if appropriate) herds, including genetics, should be completed prior to animal movement.
- The potential effects of stress on translocated animals should be fully addressed, as stress (subclinical or the additive or accumulative effect of successive stressors) can cause high levels of mortality in such situations (Teixeira *et al.* 2007).
- Transplanted goats should be monitored post release for at least several years using VHF or GPS collars to determine the short- and long-term survival, causes of mortality, and the relative success of the operation.

4.4.3 Disturbance management recommendations

Issues and information relevant to mountain goat disturbance management are summarized here:
- Mountain goats appear to react to human disturbance, especially helicopters, to a higher degree than most ungulates; and
- There is conflicting data whether mountain goats can habituate to predictable, continuous, non-threatening stimuli; much human disturbance to mountain goats is unpredictable and discontinuous. Intense single disturbances and chronic stress from repeated disturbances can be expected to produce short- and long-term health effects on populations.

Specific recommendations:

1. **Use helicopter disturbance setbacks based on science:** Mountain goats appear to react to human disturbance to a higher degree than most ungulates, and appear to react strongly to helicopters. Recommended distances that helicopters should not approach mountain goats vary. Côté (1996) and Festa-Bianchet and Côté (2008) recommended a 2000-m buffer zone around alpine areas and cliffs known to support mountain goat populations, and that during any infringement on this zone, helicopters should maintain > 300 m above ground level. U.S. Forest Service requires aircraft maintain a 500-m minimum vertical distance from all observed goats (Goldstein *et al.* 2005). Observations in northern British Columbia support the 2000-m buffer with a 600 m height over ground level maintained (Foster and Rahs 1983), or, in Alberta, a 1000-m buffer and restrictions to overflights of > 460 m (Harrison 1999). A literature-based analysis in the Yukon also suggested a 2000-m buffer (Frid 1997). In southern British Columbia, Gordon and Wilson (2004) recommended that helicopter activity < 1500 m from occupied mountain goat habitat be managed to reduce behavioural disruptions. The Northern Wild Sheep and Goat Council (NWSGC) indicated in a position statement that helicopter activity should not occur within 1500 m of occupied/suspected nursery group or crucial winter range habitats during critical periods (Hurley 2004). Critical periods are generally considered to be winter – November 1 to April 30 – and during kidding/early rearing – May 1 to July 15.

In several jurisdictions, straight-line buffer distances from winter range, pre-kidding, kidding, and post-kidding areas are recommended or required for helicopters.[47] Alberta has developed guidelines that only permit industrial activity, ground or air based, within 800 m of identified critical mountain goat (and sheep) ranges between July 1 and August 22 (Alberta Fish and Wildlife Division 2001). This is designed to avoid disturbance during the spring parturition season, land use conflicts with hunters in alpine areas, and stresses on animals during winter. Overflights by both helicopters and fixed-wing aircraft must be > 400 m above alpine terrain within mountain goat and sheep range. No legislation regulates commercial/recreational heli-tourism activity in Alberta, although seasonal and minimum flight distance (1300–2000 m) guidelines are negotiated with local companies (J. Jorgenson, pers. comm. 2009). The Alaska Department of Fish and Game recommends following the NWSGC buffer distance of 1500 m, and federal agencies (U.S. Forest Service and Bureau of Land Management) recommend 1500 ft. (~460 m) (K. White, pers. comm. 2008). Guidelines for backcountry tourism and recreation in British Columbia recommend a minimum 1500 m distance to prevent changes to the behaviour of animals unless an alternate strategy is proposed and some sort of monitoring is conducted (B.C. Ministry of Environment 2006). Recommendations for heli-logging operations near designated mountain goat winter range within British Columbia vary among areas and are often negotiated outcomes (e.g., the Kispiox, Kalum, and Nass Timber Supply Areas specify 2000 m for heli-logging operations during winter; the Fraser Timber Supply Area specifies 500 m for heli-logging and restricts operations to non-winter periods).

In summary, many authors recommend a 2000-m buffer zone around mountain goat habitat (Foster and Rahs 1983; Côté 1996; Frid 1997; Wilson and Shackleton 2001; Festa-Bianchet and Côté 2008), while others recommend a 1500-m buffer (Gordon and Wilson 2004; Hurley 2004; B.C. Ministry of Environment 2006). These buffers are often assigned to occupied/suspected nursery group or crucial winter range habitats during critical periods (Hurley 2004), but are also recommended "around alpine areas and cliffs known to support mountain goat populations" (Côté 1996) and "for all mountain goat habitat" (Festa-Bianchet and Côté 2008). Côté (1996) further suggested that during any infringement on this zone, helicopters should maintain > 300 m above ground level. Other recommendations for vertical separation range from 400 to 600 m (Foster and Rahs 1983; Harrison 1999; Alberta Fish and Wildlife Division 2001; Goldstein *et al.* 2005). The timing of helicopter logging operations (winter versus summer/fall), method (conventional vs. helicopter), or distance (within 2000 m) can also affect disturbance of seasonal mountain goat habitats (Gordon and Wilson 2004).

These specific recommendations[48] apply consistently to all forms of helicopter activity within the province:

- For all areas of British Columbia, 2000 m horizontal distance[49] setback and 400 m vertical separation are recommended from all mountain goat habitat (Foster and Rahs

[47] Wilson and Shackleton, 2001.

[48] These "recommendations" should not be confused with "legal requirements" made under various regulations. In all situations, when proposing activities in or adjacent to mountain goat habitat, people operating in the area must exercise due diligence to understand management objectives.

[49] The horizontal distance recommendation may be reduced where topographic features (e.g., mountains) prevent "line of sight" viewing to the area of mountain goat habitat (e.g., Frid 2003). Reductions may be accomplished through development of mitigation strategies.

1983; Côté 1996; Frid 1997; Wilson and Shackleton 2001; Festa-Bianchet and Côté 2008) and to be applied year round.

- Where any form of helicopter disturbance to mountain goats is an issue and action plans are developed, proponents should include mitigation strategies to address: the timing of operations, intensity, type of helicopter, and duration of helicopter activity when operations may affect mountain goats (i.e., within 2000 m). These action plans should consider using the framework developed by the IUCN for assessing threats to determine conservation actions (B.C. Ministry of Environment 2010).
- If flights < 2000 m horizontal distance or < 400 m vertical separation are necessary within mountain goat habitat, the following mitigation strategies to minimize disturbance should be considered: use of topographic barriers to separate helicopters from mountain goats; keep helicopters below mountain goats if possible; avoid flying directly towards, hovering near, or landing near mountain goats; and minimize the number of flights and time spent within disturbance space (Wilson and Shackleton 2001).
- Although little empirical data are available about the effects of fixed-wing overflights on mountain goats, concerns exist about the amount of disturbance. Until better scientific data are available, as a precautionary approach the restrictions noted above for helicopters should apply equally to fixed-wing aircraft (2000-m horizontal distance setback and 400 m vertical separation; adopt mitigation strategies where appropriate).

2. **Minimize industrial disturbance:** Many types of ground-based resource extraction, including oil and gas activities, and timber and mineral extraction, have the potential to disturb mountain goats. Most of these activities are mechanized in nature and require heavy equipment for sustained periods of time. In most cases ground access to mountain goat habitat is limited, and mountain goats appear to react less strongly to ground-based disturbance compared with aerial disturbance (Côté 1996). Few concrete recommendations to reduce industrial disturbance (other than those directed at aircraft) are provided in the literature, in large part because of a lack of empirical data. Most recommendations pertain to buffer zones (400- to 1600-m range) adjacent to mountain goat habitat, especially during critical periods (winter, kidding/early rearing, and mineral lick use), or suspension of operations within critical mountain goat habitat during winter (1 Nov. – 30 Apr.), and kidding/early rearing and mineral lick use (1 May - 15 July; Haynes 1992; Lemke 1999).

These specific recommendations apply consistently to all forms of industrial activity within the province:

- Maintain a 500-m buffer zone adjacent to important mountain goat habitat (winter range, kidding/early rearing, mineral lick use areas, and connecting trails) during winter and the kidding/early rearing and mineral lick use periods (1 Nov. – 30 Apr., and 1 May – 15 July, respectively), where no logging, wells, pipelines, road building, trail development or other industrial activity takes place (Fox *et al.* 1989; Haynes 1992; Lemke 1999).
- Within canyon-dwelling populations, industrial developments and activities should occur > 2000 m from the canyon rim, or in low-use (marginal) habitats (Foster and Rahs 1985). Access corridors, noise and activity levels should be further controlled during critical winter (1 Nov. – 30 Apr.) and kidding/early rearing (1 May- 15 July) periods.

3. **Minimize recreational disturbance:** Backcountry tourism and recreation can result in disturbance or displacement of mountain goats. Recreation varies from highly mechanized transportation (e.g., snowmobiles, snowcats, and ATVs), to generally less threatening human-power pursuits (e.g., hiking, ski touring, ice-climbing; Varley 1998; Canfield *et al.* 1999). To minimize impacts, British Columbia adopted guidelines to restrict motorized ground-based activities in open areas in relation to large mammals within 500 m line-of-sight, and non-motorized ground-based activities in open areas in relation to large mammals within 100 m line-of-sight (B.C. Ministry of Environment 2006).

These specific recommendations apply consistently to all forms of recreational activity within the province:

- During the designated winter (1 Nov. – 30 Apr.) and kidding/early rearing periods (1 May – 15 July), ground access should be restricted within 500 m of mountain goat habitat by motorized activities (snowcats, snowmobiles, ATVs, etc.), and by 100 m by non-motorized activities (ski touring, ice climbing, etc.) (Lemke 1999; B.C. Ministry of Environment 2006).
- In their review of the effect of recreation on ungulates in Montana, Canfield *et al.* (1999) suggested ways of reducing human disturbance on winter and summer ranges:
    - Route facilities, trails, and/or roads away from mountain goat winter range, kidding/early rearing ranges, and mineral lick areas;
    - Establish and only use designated travel routes to make human use of areas as predictable as possible; and
    - Identify potential conflicts and develop mitigative strategies.

4.4.4 Access Management Recommendations

Issues and information relevant to mountain goat access management are summarized here:

- Progressive increases in access within unroaded drainages are thought partially responsible for historic and, in some cases, current declines in mountain goat populations.
- Resource road development is the main source for industrial and recreational access in the province.

Specific recommendations:

Managing access in and near mountain goat habitat is complex, largely because of the many diverse resource development industries with different government ministries responsible for managing their land use practices. Disturbance and risk to mountain goats can increase as a result of increased access. Issues and recommendations related to disturbance and risk have been previously discussed.

1. **Reduce the amount and persistence of roads in and near mountain goat habitat:** Changes to habitat that facilitate access and disturbance can displace mountain goats from preferred habitats (Pendergast and Bindernagel 1977). For example, forestry development near mountain goat habitat may increase human access, leading to frequent disturbance and subsequently lower use by mountain goats of otherwise suitable habitat (Hengeveld *et al.* 2004). Mountain goats are susceptible to overharvest (Côté and Festa-Bianchet 2003; Hamel

et al. 2006), which is facilitated by increased access. Effects of road-building are mostly indirect because increasing road density is correlated with other human-induced stressors, including disturbance (from the ground), hunting pressure and forest harvesting. Proximity of roads to mountain goat habitat is the most important determinant of hunting pressure; hunters are generally deterred from hunting > 2 km from roads (Hengeveld *et al.* 2004).

- When industrial activity is required within 500 m of mountain goat habitat, all structures including roads should be temporary in design. Roads should be strategically located to facilitate effective removal wherever possible.
- Within 2 years after completion of industrial development activities, all temporary roads or structures adjacent (< 500 m) to mountain goat habitat should be permanently decommissioned (made unusable to off-road vehicles) to restrict vehicular traffic (Haynes 1992; Lemke 1999).
- Where roads could remain in place for an extended period of time, access control measures should be considered.

2. **Consider changes in access in harvest management decisions:** Human access into mountain goat habitat can have implications to population abundance and persistence. Many interior populations and some coastal populations are believed to have declined through the 1960s and early 1970s, in large part due to overharvest resulting from increased access within previously unroaded drainages (Phelps *et al.* 1983). Even now, harvest of mountain goats is generally concentrated in areas of easiest access.
   - Hunting allocations and regulations must be responsive to changes in the degree/ease of access due to land development in a given management unit or population. Harvest management should be reviewed in any cases when access changes within 2 km of mountain goat habitat.
   - Where concerns exist, consider closing access to recreational motor vehicle use into or near mountain goat habitat through the *Wildlife Act*.

3. **Consider the cumulative effects associated with access and integrate access management for all resource and recreational activities:** The potential impact to mountain goats from the recent increase in access through new resource development activities, such as independent power projects, wind power, pipelines, and other large-scale developments, is not well documented. However, these projects almost always require increased primary road access, often with additional development of spur roads and transmission corridors. In combination with other impacts, these projects can be expected to incrementally increase human disturbance. The cumulative effects of such developments on mountain goat habitat viability and disturbance are unclear. In general, there is a relative lack of integrated access management for resource development and recreational activities. Access from both resource development and recreational activities can increase impacts to mountain goat populations.
   - Fully assess mitigation strategies to reduce the impacts of increases in and persistence of access into and near mountain goat habitat associated with resource development activities.
   - Access management should be integrated for all forms of resource development and recreational activities.

- Communication among resource ministries should be improved by early involvement of all affected ministries, to promote a common understanding of all new forms of access into mountain goat habitat (i.e., all resource development activities) and to develop coordinated opportunities for resource managers to recommend potential mitigative measures to decision-makers.
- New tools should be developed and implemented to reduce the amount of new access and recreational use when upgrading existing roads (including temporary forest roads).

5.0 REFERENCES

Adams, L.G. and J.A. Bailey. 1982. Population dynamics of mountain goats in the Sawatch Range, Colorado. Journal of Wildlife Management 46:1003–1009.

Alberta Fish and Wildlife Division. 2001. Recommended land use guidelines for mountain goat and bighorn sheep ranges in Alberta. Alberta Sustainable Resource Development, May 2001.

Ayotte, J.B., K.L. Parker, J.M. Arocena, and M.P. Gillingham. 2006. Chemical composition of lick soils: functions of soil ingestion by four ungulate species. Journal of Mammalogy 87:878–888.

Ayotte, J.B., K.L. Parker, and M.P. Gillingham. 2008. Use of natural licks by four species of ungulates in northern British Columbia. Journal of Mammalogy 89:1041–1050.

Bailey, J.A. 1991. Reproductive success in female mountain goats. Canadian Journal of Zoology 69:2956–2961.

Banfield, A.W.F. 1974. The mammals of Canada. Univ. Toronto Press, Toronto, ON.

Brandborg, S.M. 1955. Life history and management of the mountain goat in Idaho. Idaho Wildlife Bulletin 2:1–142.

B.C. Conservation Data Centre. 2010. BC Species and Ecosystems Explorer. B.C. Min. Environ. Victoria, B.C. <http://a100.gov.bc.ca/pub/eswp/> [Accessed Feb. 12, 2010]

B.C. Ministry of Energy, Mines and Petroleum Resources. 2008. Health, Safety and Reclamation Code for Mines in British Columbia. Mining and Minerals Division, Victoria, BC. <http://www.empr.gov.bc.ca/Mining/HealthandSafety/Pages/HSRC.aspx> [Accessed Feb. 24, 2010]

B.C. Ministry of Environment. 1979. Preliminary mountain goat management plan for British Columbia. Victoria, BC.

B.C. Ministry of Environment. 2006. Wildlife guidelines for backcountry tourism/commercial recreation in British Columbia. Victoria, B.C. <http://www.env.gov.bc.ca/wld/twg/index.html> [Accessed Mar. 25, 2009]

B.C. Ministry of Environment. 2009. Conservation framework. Victoria, B.C. Available: <http://www.env.gov.bc.ca/conservationframework/index.html> [Accessed May 1, 2009]

B.C. Ministry of Environment. 2010. Draft British Columbia recovery strategy template guidance 2009/10. Victoria, BC.

Bunnell, F.L., D.F. Fraser, and A.P. Harcombe. 2009. Increasing effectiveness of conservation decisions: a system and its application. Natural Areas Journal 29:79–90.

Cadsand, B. 2009. Mountain goat- heliskiing interactions in northwest British Columbia – examining the medium-term effects of heliskiing on mountain goats. Research proposal, Univ. Northern British Columbia, Prince George, BC.

Canfield, J.E., L.J. Lyon, J.M. Hillis, and M.J. Thompson. 1999. Ungulates. Pages 6.1–6.25 *in* G. Joslin and H. Youmans, coordinators. Effects of recreation on Rocky Mountain wildlife: a review for Montana. Committee on Effects of Recreation on Wildlife, Montana Chapter of The Wildlife Society.

Carlsen, T. and G. Erickson. 2008. Status of Rocky Mountain bighorn sheep and mountain goats in Montana. Biennial Symposium of the Northern Wild Sheep and Goat Council 16:7–18.

Caughley, G. 1977. Analysis of vertebrate populations. John Wiley & Sons, Chichester, UK.

Caughley, G. and A. Gunn. 1996. Conservation biology in theory and practice. Blackwell Science, Cambridge, MA.

Chadwick, D.H. 1973. Mountain goat ecology – logging relationships in the Bunker Creek drainage of western Montana. Final report, project W-120-R-3, 4. Montana Fish and Game Department, Helena, MT.

Chadwick, D.H. 1983. A beast the color of winter: the mountain goat observed. Univ. Nebraska Press, Lincoln, NE.

Cichowski, D.B., D. Haas, and G. Schultze. 1994. A method used for estimating mountain goat numbers in the Babine Mountains Recreation Area, British Columbia. Biennial Symposium of the Northern Wild Sheep and Goat Council 9:56–64.

Cole, D.N., A.E. Watson, T.E. Hall, and D.R. Spildie. 1997. High-use destinations in wilderness: social and biophysical impacts, visitor responses, and management options. U.S. Dep. Agric., For. Serv., Rocky Mountain Res. Stn., Ogden, Utah. Research Paper INT-RP-496.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2009. Committee on the Status of Endangered Wildlife in Canada <http://www.cosewic.gc.ca/eng/sct5/index_e.cfm> [Accessed Apr. 16, 2009]

Cowan, I.M. 1951. The diseases and parasites of big game mammals of western Canada. Proceedings of the Annual British Columbia Game Convention 5:37–64.

Cowan, I.M. and W. McCrory. 1970. Variation in the mountain goat, *Oreamnos americanus* (Blainville). Journal of Mammalogy 51:60–73.

Côté, S.D. 1996. Mountain goat responses to helicopter disturbance. Wildlife Society Bulletin 24:681–685.

Côté, S.D. 2000. Dominance hierarchies in female mountain goats: stability, aggressiveness and determinants of rank. Behaviour 137:1541–1566.

Côté, S.D. and C. Beaudoin. 1997. Grizzly bear (*Ursus arctos*) attacks and nanny-kid separation on mountain goats (*Oreamnos americanus*). Mammalia 61:614–617.

Côté, S.D. and M. Festa-Bianchet. 2001a. Birthdate, mass and survival in mountain goat kids: effects of maternal characteristics and forage quality. Oecologia 127:230–238.

Côté, S.D. and M. Festa-Bianchet. 2001b. Reproductive success in female mountain goats: the influence of maternal age and social rank. Animal Behaviour 62:173–181.

Côté, S.D. and M. Festa-Bianchet. 2003. Mountain goat. Pages 1061–1075 *in* G.A. Feldhamer, B. Thompson, and J. Chapman, eds. Wild mammals of North America: biology, management, and conservation. The John Hopkins Univ. Press, Baltimore, MD.

Côté, S.D., M. Festa-Bianchet, and K.G. Smith. 1998. Horn growth in mountain goats (*Oreamnos americanus*). Journal of Mammalogy 79:406–414.

Côté, S.D., M. Festa-Bianchet, and K.G. Smith. 2001. Compensatory reproduction in harvested mountain goat population: a word of caution. Wildlife Society Bulletin 29:726–730.

Dailey, T.V. and N.T. Hobbs. 1989. Travel in alpine terrain: energy expenditure for locomotion by mountain goats and bighorn sheep. Canadian Journal of Zoology 67:2368–2375.

Dailey, T.V., N.T. Hobbs, and T.N. Woodard. 1984. Experimental comparisons of diet selection by mountain goats and mountain sheep. Journal of Wildlife Management 48:799–806.

Demarchi, M.W., S.R. Johnson, and G.F. Searing. 2000. Distribution and abundance of Mountain Goats, *Oreamnos americanus*, in westcentral British Columbia. Canadian Field-Naturalist 114:301–306.

Dormaar, J.F. and B.D. Walker. 1996. Elemental content of animal licks along the eastern slopes of the Rocky Mountains in southern Alberta, Canada. Canadian Journal of Soil Science 76:509–512.

EBA Engineering Consultants Ltd. 2004. Management of heliportable geophysical activities in mountain goat habitat in northeast British Columbia: recommendations & implications for petroleum exploration. Fort. St. John, BC. EBA Project No. 305-02580.003.

Festa-Bianchet, M. and S.D. Côté. 2008. Mountain goats: ecology, behaviour, and conservation of an alpine ungulate. Island Press, Washington, DC.

Festa-Bianchet, M., J.-M. Gaillard, and S.D. Côté. 2003. Variable age structure and apparent density dependence in survival of adult ungulates. Journal of Animal Ecology 72:640–649.

Festa-Bianchet, M., M. Urquhart, and K.G. Smith. 1994. Mountain goat recruitment: kid production and survival to breeding age. Canadian Journal of Zoology 72:22–27.

Fielder, P.C. 1986. Implications of selenium levels in Washington mountain goats, mule deer and Rocky mountain elk. Northwest Science 60:15–20.

Foster, B.R. 1982. Observability and habitat characteristics of the mountain goat (*Oreamnos americanus*, Blainville, 1816) in west-central British Columbia. M.Sc. thesis, Univ. B.C., Vancouver, BC.

Foster, B.R. and E.Y. Rahs. 1983. Mountain goat response to hydroelectric exploration in northwestern British Columbia. Environmental Management 7:189–197.

Foster, B.R. and E.Y. Rahs. 1985. A study of canyon-dwelling mountain goats in relation to proposed hydroelectric development in northwestern British Columbia, Canada. Biological Conservation 33:209–228.

Fox, J.L, C.A. Smith, and J.W. Schoen. 1989. Relation between mountain goats and their habitat in southeastern Alaska. U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. PNW-GTR-246.

Frid, A. 1997. Human disturbance of mountain goats and related ungulates: a literature-based analysis with applications to Goatherd Mountain. Prepared for Kluane National Park Reserve, Haines Junction, Yukon.

Frid, A. 2003. Dall's sheep responses to overflights by helicopters and fixed-wing aircraft. Biological Conservation 110:387–399.

Gaillard, J.-M., M. Festa-Bianchet, N.G. Yoccoz, A. Loison, and C. Toïgo. 2000. Temporal variation in fitness components and population dynamics of large herbivores. Annual Review of Ecology and Systematics 31:367–393.

Garde, E., S. Kutz, H. Schwantje, A. Veitch, E. Jenkins, and B. Elkin. 2005. Examining the risk of disease transmission between wild Dall's sheep and mountain goats, and introduced domestic sheep, goats, and llamas in the Northwest Territories. Environmental and Natural Resources, Government of the NWT, Yellowknife, NWT.

Gilbert, B.A. and K.J. Raedeke. 1992. Winter habitat selection of mountain goats in the North Tolt and Mine Creek drainages of the North Central Cascades. Biennial Symposium of the Northern Wild Sheep and Goat Council 8:305–324.

Glasgow, W.M., T.C. Sorensen, H.D. Carr, and K.G. Smith. 2003. Management plan for mountain goats in Alberta. Alberta Sustainable Resource Development, Fish and Wildlife Division, Edmonton, AB.

Goldstein, M.I., A.J. Poe, E. Cooper, D. Youkey, B.A. Brown, and T.L. McDonald. 2005. Mountain goat response to helicopter overflights in Alaska. Wildlife Society Bulletin 33:688–699.

Gonzalez-Voyer, A., K.G. Smith, and M. Festa-Bianchet. 2001. Efficiency of aerial surveys of mountain goats. Wildlife Society Bulletin 29:140–144.

Gonzalez-Voyer, A., K.G. Smith, and M. Festa-Bianchet. 2003. Dynamics of hunted and unhunted mountain goat *Oreamnos americanus* populations. Wildlife Biology 9:213–218.

Gordon, S.M. and D.M. Reynolds. 2000. The use of video for mountain goat winter range habitat inventory and assessment of overt helicopter disturbance. Biennial Symposium of the Northern Wild Sheep and Goat Council 12:26–37.

Gordon, S.M. and S.F. Wilson. 2004. Effect of helicopter logging on mountain goat behavior in coastal British Columbia. Biennial Symposium of the Northern Wild Sheep and Goat Council 14:49–63.

Gross, J.E. 2001. Evaluating effects of an expanding mountain goat population on native bighorn sheep: a simulation model of competition and disease. Biological Conservation 101:171–185.

Gross, J.E., M.C. Kneeland, D.F. Reed, and R.M. Reich. 2002. GIS-based habitat models for mountain goats. Journal of Mammalogy 83:218–228.

Hamel, S. and S.D. Côté. 2007. Habitat use patterns in relation to escape terrain: are alpine ungulate females trading off better foraging sites for safety. Canadian Journal of Zoology 85:933–943.

Hamel, S. and S.D. Côté. 2009. Maternal defensive behaviour of mountain goats against predation by golden eagles. Western North American Naturalist 69:115–118.

Hamel, S., S.D. Côté, and M. Festa-Bianchet. [2010]. Maternal characteristics and environment affect the costs of reproduction in female mountain goats. Ecology. In press.

Hamel, S., S.D. Côté, J.-M. Gaillard, and M. Festa-Bianchet. 2009. Individual variation in reproductive costs of reproduction: high quality females always do better. Journal of Animal Ecology 78:143–151.

Hamel, S., S.D. Côté, K.G. Smith, and M. Festa-Bianchet. 2006. Population dynamics and harvest potential of mountain goat herds in Alberta. Journal of Wildlife Management 70:1044–1053.

Harrison, D.G. 1999. Distribution and movements of canyon-dwelling mountain goats along Pinto Creek, Alberta. M.Sc. thesis, Univ. Northern B.C., Prince George, BC.

Harrison, D.G., M.P. Gillingham, and G.B. Stenhouse. 1998. Comparing methods to determine distribution and movement patterns of forest-dwelling mountain goats. Biennial Symposium of the Northern Wild Sheep and Goat Council 11:81–95.

Hatter, I. 2005. Guidelines for determining suitable harvest of mountain goats. Presentation to the 1st BC Mountain Goat Workshop, Prince George, March 2005.

Hatter, I.W. and D. Blower. 1996. History of transplanting mountain goats and mountain sheep - British Columbia. Biennial Symposium of the Northern Wild Sheep and Goat Council 10:158–163.

Hayden, J.A. 1984. Introduced mountain goats in the Snake River Range, Idaho: characteristics of vigorous population growth. Biennial Symposium of the Northern Wild Sheep and Goat Council 4:94–119.

Haynes, L.A. 1992. Mountain goat habitat of Wyoming's Beartooth Plateau: implications for management. Biennial Symposium of the Northern Wild Sheep and Goat Council 8:325–339.

Hebert, D. and I.M. Cowan. 1971a. Natural salt licks as a part of the ecology of the mountain goat. Canadian Journal of Zoology 49:605–610.

Hebert, D.M. and I.M. Cowan. 1971b. White muscle disease in the mountain goat. Journal of Wildlife Management 35:752–756.

Hebert, D.M. and H.D. Langin. 1982. Mountain goat inventory and harvest strategies: A reevaluation. Biennial Symposium of the Northern Wild Sheep and Goat Council 3:339–349.

Hebert, D.M. and W.G. Turnbull. 1977. A description of southern interior and coastal mountain goat ecotypes in British Columbia. Pages 126–146 *in* W. Samuel and W.G. Macgregor, eds. Proceedings of the First International Mountain Goat Symposium, Kalispell, Montana. BC Fish and Wildlife Branch, Victoria, BC.

Hebert, D. and R. Woods. 1984. A preliminary analysis of intensive, unreplicated survey data for mountain goat populations in British Columbia. Biennial Symposium of the Northern Wild Sheep and Goat Council 4:506–513.

Heinemeyer, K., T. Lind, and R. Tingey. 2003. Potential goat winter habitat model for the Central and North Coast Regions of British Columbia. Draft prepared for The Coast Information Team and Ecological Spatial Analysis Team.

Hengeveld, P.E., M.D. Wood, R. Ellis, R.S. McNay, and R. Lennox. 2004. Mountain goat habitat supply modeling in the Mackenzie Timber Supply Area, north-central British Columbia. Version 2 – March 2004. Peace-Williston Fish and Wildlife Compensation Program Report Number 290.

Hobbs, N.T., J.A. Bailey, D.F. Reed, and M.W. Miller. 1990. Biological criteria for introductions of large mammals: using simulation models to predict impacts of competition. Transactions of the 55th North American Wildlife and Natural Resources Council 55:620–632.

Hofmann, R.R. 1989. Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. Oecologia 78:443–457.

Holroyd, J.C. 1967. Observations of Rocky Mountain goats on Mount Wardle, Kootenay National Park, British Columbia. Canadian Field-Naturalist 81:1–22.

Hopkins, A., J.P. Fitzgerald, A. Chappell, and G. Byrne. 1992. Population dynamics and behavior of mountain goats using Elliot Ridge, Gore Range, Colorado. Biennial Symposium of the Northern Wild Sheep and Goat Council 8:340–356.

Horn, H. 2009. Part 3: Knowledge base for focal species and their habitats in coastal BC Ecosystem-Based Management Working Group Focal Species Project. <http://ilmbwww.gov.bc.ca/slrp/lrmp/nanaimo/cencoast/plan/project_results.html> [Accessed Sep. 8, 2009]

Houston, D.B., B.B. Moorhead, and R.W. Olson. 1986. An aerial census of mountain goats in the Olympic Mountain Range, Washington. Northwest Scientist 60:131–136.

Houston, D.B. and V. Stevens. 1988. Resource limitation in mountain goats: a test by experimental cropping. Canadian Journal of Zoology 66:228–238.

Hurley, K. 2004. Northern Wild Sheep and Goat Council position statement on helicopter-supported recreation and mountain goats, July 2004. Biennial Symposium of the Northern Wild Sheep and Goat Council 14:131–136.

International Panel on Climate Change (IPCC). 2007. Climate change 2007: synthesis report.

International Union for Conservation of Nature and Natural Resources (IUCN). 2008. 2008 IUCN red list of threatened species. <www.iucnredlist.org> [Accessed Mar. 10, 2009].

Jenkins, E., E. Hoberg, A. Veitch, H. Schwantje, M. Wood, D. Toweill, S. Kutz, and L. Polley. 2004. Parasite fauna of mountain goats (*Oreamnos americanus*) in the Northwest Territories, British Columbia, and Idaho. Biennial Symposium of the Northern Wild Sheep and Goat Council 14:141–158.

Jorgenson, J.T. and R. Quinlan. 1996. Preliminary results of using transplants to restock historically occupied mountain goat ranges. Biennial Symposium of the Northern Wild Sheep and Goat Council 10:94–108.

Joslin, G. 1986. Mountain goat population changes in relation to energy exploration along Montana's Rocky Mountain front. Biennial Symposium of the Northern Wild Sheep and Goat Council 5:253–269.

Keim, J. 2004. Modeling core winter habitat and spatial movements of collared mountain goats. Biennial Symposium of the Northern Wild Sheep and Goat Council 14:65–86.

Kraabel, B.J. and M.W. Miller. 1997. Effect of simulated stress on susceptibility of bighorn sheep neimtrophils to *Pasteunella haentolytica* leuukotoxin. Journal of Wildlife Diseases 33:558–566.

Kumar, L., A.K. Skidmore, and E. Knowles. 1997. Modelling topographic variation in solar radiation in a GIS environment. International Journal of Geographic Information Science 11:475–497.

Laundré, J.W. 1994. Resource overlap between mountain goats and bighorn sheep. Great Basin Naturalist 54:114–121.

Lele, S.R. and J.L. Keim. 2006. Weighted distributions and estimation of resource selection probability functions. Ecology 87:3021–3028.

Lemke, T.O. 2004. Origin, expansion, and status of mountain goats in Yellowstone National Park. Wildlife Society Bulletin 32:532–541.

Lentfer, J.W. 1955. A two-year study of the Rocky Mountain goat in the Crazy Mountains, Montana. Journal of Wildlife Management 19:417–429.

Macgregor, W.G. 1977. Status of mountain goats in British Columbia. Pages 24–28 *in* W. Samuel and W.G. Macgregor, eds. Proceedings of the first international mountain goat symposium. Kalispell, MT.

Mainguy, J. and S.D. Côté. 2008. Age- and state-dependent reproductive effort in male mountain goats, *Oreamnos americanus*. Behavioral Ecology and Sociobiology 62:935–943.

Mainguy, J., S.D. Côté, M. Festa-Bianchet, and D.W. Coltman. 2009. Father-offspring phenotypic correlations suggest intralocus sexual conflict for a fitness-linked trait in a wild sexually dimorphic mammal. Proceedings of the Royal Society B 276:4067–4075.

Master, L., D. Faber-Langendoen, R. Bittman, G. A. Hammerson, B. Heidel, J. Nichols, L. Ramsay, and A. Tomaino. 2009. NatureServe Conservation Status Assessments: factors for assessing extinction risk. NatureServe, Arlington, VA.

McCullough, D.R. 1994. What do herd composition counts tell us? Wildlife Society Bulletin 22:295–300.

McDonough, T.J. and J.S. Selinger. 2008. Mountain goat management on the Kenai Peninsula, Alaska: a new direction. Biennial Symposium of the Northern Wild Sheep and Goat Council 16:50–67.

McNay, R.S., R.M. McKinley, and L. Giguere. 2006. Identification of mountain goat winter range in the Fort St. James Forest District. Wildlife Infometrics Inc. Report No. 194.

Millspaugh, J.J., R.J. Woods, K.E. Hunt, K.J. Raedeke, G.C. Brundige, B.E. Washburn, and S.K. Wasser. 2001. Fecal glucocorticoid assays and the physiological stress response in elk. Wildlife Society Bulletin 29:899–907.

Moberg, G.P. 2000. Biological response to stress: implications for animal welfare. Pages 1–22 *in* G.P. Moberg and J.A. Mench, eds. The biology of animal stress: basic principles and implications for animal welfare CABI Publishing, New York, NY.

Nagorsen, D.W. and G. Keddie. 2000. Late Pleistocene mountain goats (*Oreamnos americanus*) from Vancouver Island: biogeographic implications. Journal of Mammalogy 81:666–675.

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available <http://www.natureserve.org/explorer/servlet/NatureServe?searchName=Oreamnos+americanus>. [Accessed Sep. 10, 2009].

Nichols, L. 1985. Mountain goat fidelity to given areas by season and seasonal movements. Alaska Department of Fish and Game, Juneau, AK.

Pauley, G.R. and J.G. Crenshaw. 2006. Evaluation of paintball, mark-resight surveys for estimating mountain goat abundance. Wildlife Society Bulletin 34:1350–1355.

Pedevillano, C. and R.G. Wright. 1987. The influence of visitors on mountain goat activities in Glacier National Park, Montana. Biological Conservation 39:1–11.

Peek, J.M., B. Dennis, and T. Hershey. 2002. Predicting population trends of mule deer. Journal of Wildlife Management 66:729–736.

Peek, J.M., J.J. Korol, D. Gay, and T. Hershey. 2001. Overstory-understory biomass changes over a 35-year period in southcentral Oregon. Forest Ecology and Management 150:267–277.

Pendergast, B. and J. Bindernagel 1977. The impact of exploration for coal on mountain goats in northeastern British Columbia. Pages 64–68 *in* W. Samuel and W. Macgregor, eds. Proceedings of the first international mountain goat symposium. Kalispell, MT.

Penner, D.F. 1988. Behavioral response and habituation of mountain goats in relation to petroleum exploration at Pinto Creek, Alberta. Biennial Symposium of the Northern Wild Sheep and Goat Council 6:141–158.

Phelps, D.E., B. Jamieson, and R.A. Demarchi. 1983. The history of mountain goat management in the Kootenay Region of British Columbia. B.C. Fish and Wildlife Branch, Cranbrook, BC. Fish and Wildlife Bulletin No. B-20.

Pojar, J. 2009. Climate change and land use planning in the Atlin – Taku Area. Taku River Tlingit and B.C. Ministry of Agriculture, Integrated Land Management Bureau.

Poole, K.G. 2007b. Does survey effort influence sightability of mountain goats *Oreamnos americanus* during aerial surveys? Wildlife Biology 13:113–119.

Poole, K.G., K.D. Bachmann, and I.E. Teske. [2010]. Mineral lick use by GPS radio-collared mountain goats in southeastern British Columbia. Western North American Naturalist 70. In press.

Poole, K.G. and D.C. Heard. 1998. Habitat use and movements of mountain goats as determined by prototype GPS collars, Robson Valley, British Columbia. Biennial Symposium of the Northern Wild Sheep and Goat Council 11:22–35.

Poole, K.G. and D.C. Heard. 2003. Seasonal habitat use and movements of mountain goats, *Oreamnos americanus*, in east-central British Columbia. Canadian Field-Naturalist 117:565–576.

Poole, K.G., D.C. Heard, and G.S. Watts. 2000. Mountain goat inventory in the Robson Valley, British Columbia. Biennial Symposium Northern Wild Sheep and Goat Council 12:114–124.

Poole, K.G. and D.M. Reynolds. Mount Meager mountain goat aerial survey and DNA census, 2009. Prepared for B.C. Conservation Foundation, Surrey, BC. In preparation.

Poole, K.G., K. Stuart-Smith, and I.E. Teske. 2009. Wintering strategies by mountain goats in interior mountains. Canadian Journal of Zoology 87:273–283.

Province of British Columbia. 1996a. Land Act. RSBC1996, c.245. Queen's Printer, Victoria, BC.< http://www.bclaws.ca/Recon/document/freeside/--%20l%20--/land%20act%20%20rsbc%201996%20%20c.%20245/00_96245_01.xml> [Accessed Feb. 18, 2009]

Province of British Columbia. 1996b. Mines Act. RSBC1996, c.293. Queen's Printer, Victoria, BC. <http://www.bclaws.ca/Recon/document/freeside/--%20m%20--/mines%20act%20%20rsbc%201996%20%20c.%20293/00_96293_01.xml> [Accessed Feb. 18, 2009]

Province of British Columbia. 2002a. Forest and Range Practices Act. RSBC2002, c.69. Queen's Printer, Victoria, BC. <http://www.qp.gov.bc.ca/statreg/stat/F/02069_01.htm> [Accessed Feb. 18, 2009]

Province of British Columbia. 2002b. Wildlife Act. RSBC1996, c.488. Queen's Printer, Victoria, BC. <http://www.qp.gov.bc.ca/statreg/stat/W/96488_01.htm> [Accessed Feb. 18, 2009]

Province of British Columbia. 2004a. Government actions regulation. B.C.Reg.582/2004. Queen's Printer, Victoria, BC. <http://www.qp.gov.bc.ca/statreg/reg/F/ForRangPrac/582_2004.htm> [Accessed Mar. 25, 2009]

Province of British Columbia. 2004b. Identified wildlife management strategy. B.C. Ministry of Environment, Environmental Stewardship Division. <http://www.env.gov.bc.ca/wld/frpa/iwms/index.html> [Accessed Feb. 17, 2009]

Province of British Columbia. 2007. Sheep vegetation management guidelines. B.C. Ministry of Forests and Range. <http://www.for.gov.bc.ca/HFP/publications/00006/> [Accessed Mar. 25, 2009]

Province of British Columbia. 2008a. Application of FRPA to independent power producers, mineral interests and other occupiers of the land. B.C. Ministry of Forests and Range. Forest and Range Practices Act Bulletins, #16. <http://www.for.gov.bc.ca/hth/timten/FRPA_implementation/Bulletins.htm> [Accessed Mar. 25, 2009]

Province of British Columbia. 2008b. Land use operational policy. Reserves, designations and notations. B.C. Ministry of Agriculture and Lands. Amendment 3. <http://www.al.gov.bc.ca/clad/leg_policies/policies/reserves.pdf> [Accessed Feb. 18, 2009]

Reed, D.F. 2001. A conceptual interference competition model for introduced mountain goats. Journal of Wildlife Management 65:125–128.

Reimers, E., S. Eftestøl, and J.E. Colman. 2003. Behavior responses of wild reindeer to direct provocation by a snowmobile or skier. Journal of Wildlife Management 67:747–754.

Resources Information Standards Committee (RISC). 2002. Aerial-based inventory methods for selected ungulates: bison, mountain goat, mountain sheep, moose, elk, deer and caribou. Standards for components of British Columbia's biodiversity No. 32. Version 2.0. B.C. Min. Sustainable Resour. Manag., Victoria, BC.

Rice, C.G. 2008. Seasonal altitudinal movements of mountain goats. Journal of Wildlife Management 72:1706–1716.

Rice, C.G. and D. Gay. [2010]. Effects of mountain goat harvest on historic and contemporary populations. Northwestern Naturalist. In press.

Rice, C.G., K.J. Jenkins, and W. Chang. 2009. A sightability model for mountain goats. Journal of Wildlife Management 73:468–478.

Rideout, C.B. 1974. A radio telemetry study of the ecology and behavior of the mountain goat in western Montana. Ph.D dissertation, Univ. Kansas, Lawrence, KY.

Rideout, C.B. 1977. Mountain goat home ranges in the Sapphire Mountains of Montana. Pages 201–225 *in* W. Samuel and W.G. Macgregor, eds. Proceedings of the First International Mountain Goat Symposium, Kalispell, Montana. BC Fish and Wildlife Branch, Victoria, BC.

Rodenhuis, D., K.E. Bennett, A.T. Werner, T.Q., Murdock, and D. Bronaugh. 2007. Climate overview 2007: hydro-climatology and future climate impacts in British Columbia. Pacific Climate Impacts Consortium. Univ. Victoria, Victoria, BC.

Romeo, G. and S. Lovari. 1996. Summer activity rhythms of the mountain goat *Oreamnos americanus* (de Blainville, 1986). Mammalia 60:496–499.

Rönnegård, L., H. Sand, H. Andrén, J. Månsson, and Å. Pehrson. 2008. Evaluation of four methods used to estimate population density of moose *Alces alces*. Wildlife Biology 14:358–371.

Salafsky, N., D. Salzer, A.J. Stattersfield, C. Hilton-Taylor, R. Neugarten, S.H.M. Butchart, B. Collen, N. Cox, L.L. Master, S. O'Connor, and D. Wilkie. 2008. A standard lexicon for biodiversity conservation: unified classifications of threats and actions. Conservation Biology 22:897–911.

Schoen, J.W. and M.D. Kirchhoff. 1982. Habitat use by mountain goats in southeast Alaska. Final Report. Alaska Dep. Fish and Game, Juneau, AK.

Schommer, T.J. and M.M. Woolever. 2008. A review of disease related conflicts between domestic sheep and goats and bighorn sheep. U.S. Dep. Agric. For. Serv., Rocky Mountain Res. Stn., Fort Collins, CO. Gen. Tech. Rep. RMRS-GTR-209.

Schulze, C.R., R.F. Schulze, and S.I. Zeveloff. 2008. A ground-based paintball mark re-sight survey of mountain goats. Biennial Symposium of the Northern Wild Sheep and Goat Council 16:686–677.

Seip, D.R., C.J. Johnson, and G.S. Watts. 2007. Displacement of mountain caribou from winter habitat by snowmobiles. Journal of Wildlife Management 71:1539–1544.

Shackleton, D. 1999. Hoofed mammals of British Columbia. The mammals of British Columbia, Volume 3, Royal B.C. Museum. UBC Press, Vancouver, BC.

Shively, K.J., A.W. Alldredge, and G.E. Phillips. 2005. Elk reproductive response to removal of calving season disturbance by humans. Journal of Wildlife Management 69:1073–1080.

Sielecki, L.E. 2004. WARS 1983 – 2002: wildlife accident reporting and mitigation in British Columbia: special annual report. B.C. Min. Transport, Victoria, BC.

Singer, F.J. 1978. Behavior of mountain goats in relation to U.S. Highway 2, Glacier National Park, Montana. Journal of Wildlife Management 42:591–597.

Singer, F.J. and J.L. Doherty. 1985. Movements and habitat use in an unhunted population of mountain goats, *Oreamnos americanus*. Canadian Field-Naturalist 99:205–217.

Smith, B.L. 1976. Ecology of the Rocky Mountain goat in the Bitterroot Mountains, Montana. M.Sc. thesis, Univ. Montana, Missoula, MT.

Smith, B.L. 1988. Criteria for determining age and sex of American mountain goats in the field. Journal of Mammalogy 69:395–402.

Smith, C.A. 1984. Evaluation and management implications of long-term trends in coastal mountain goat populations in southeast Alaska. Biennial Symposium Northern Wild Sheep and Goat Council 4:395–424.

Smith, C.A. 1986. Rates and causes of mortality in mountain goats in southeast Alaska. Journal of Wildlife Management 50:743–746.

Smith, C.A. 1994. Evaluation of a multivariate model of mountain goat winter habitat selection. Biennial Symposium Northern Wild Sheep and Goat Council 9:159–165.

Smith, C.A. and K.T. Bovee. 1984. A mark-recapture census and density estimate for a coastal mountain goat population. Biennial Symposium of the Northern Wild Sheep and Goat Council 4:487–498.

Smith C.A. and K.J. Raedeke. 1982. Group size and movements of a dispersed, low density goat population with comments on inbreeding and human impact. Biennial Symposium of the Northern Wild Sheep and Goat Council 3:54–67.

Smith, K.G. 1988. Factors affecting the population dynamics of mountain goats in west-central Alberta. Biennial Symposium of the Northern Wild Sheep and Goat Council 6:308–329.

Smith, K.G. and D. Hobson. 2008. The status of mountain goats in Alberta, Canada. Biennial Symposium of the Northern Wild Sheep and Goat Council 16:37–41.

Solberg, E.J. and B-E. Sæther. 1999. Hunter observations of moose *Alces alces* as a management tool. Wildlife Biology 5:107–117.

Spittlehouse, D.L. 2008. Climate change, impacts and adaptation scenarios: change and forest and range management in British Columbia. B.C. Min. For. Range and Forest Science Program, Victoria, B.C. Technical Report 045.

Spraker, T.R. 1993. Stress and capture myopathy in artiodactylids. Pages 481–488 *in* M.E. Fowler, ed. Zoo and wild animal medicine, current therapy, 3rd ed. W.B. Saunders Co. Philadelphia, PA.

Spraker, T.R., C.P. Hibler, G.G. Schoonveld, and W.S. Adney. 1984. Pathologic changes and microorganisms found in bighorn sheep during a stress-related die-off. Journal of Wildlife Diseases 20:319–327.

Stevens, V. 1983. The dynamics of dispersal in an introduced mountain goat population. Ph.D. dissertation, Univ. Washington, Seattle, WA.

Stevens, V. and D.B. Houston. 1989. Reliability of age determination of mountain goats. Wildlife Society Bulletin 17:72–74.

Sumanik, K. 1970. Mountain goat harvests in west-central British Columbia, 1957–1968. B.C. Fish and Wildlife Branch Report, Victoria, BC.

Swenson, J.E. 1985. Compensatory reproduction in an introduced mountain goat population in the Absaroka Mountains, Montana. Journal of Wildlife Management 49:837–843.

Sylvén, S. 2000. Effects of scale on hunter moose *Alces alces* observation rate. Wildlife Biology 6:157–165.

Taylor, M., M. Obbard, B. Pond, M. Kuc, and D. Abraham. 2002. RISKMAN. Version 1.8.

Taylor, S. and K. Brunt. 2007. Winter habitat use by mountain goats in the Kingcome River drainage of coastal British Columbia. BC Journal of Ecosystems and Management 8:32–49.

Taylor, S., W. Wall, and Y. Kulis. 2006. Habitat selection by mountain goats in south coastal British Columbia. Biennial Symposium of the Northern Wild Sheep and Goat Council 15:141–157.

Teixeira, C.P., C. Schetini De Azevedo, M. Mendl, C.F. Cipreste, and R.J. Young. 2007. Revisiting translocation and reintroduction programmes: the importance of considering stress. Animal Behaviour 73:1–13.

Thompson, R.W. 1980. Population dynamics, habitat utilization, recreational impacts and trapping of introduced Rocky Mountain goats in the Eagles Nest Wilderness Area, Colorado. Biennial Symposium of the Northern Wild Sheep and Goat Council 2:459–462.

Toweill, D.E. 2008. Status of mountain goats and bighorn sheep and their management in Idaho. Biennial Symposium of the Northern Wild Sheep and Goat Council 16:4–6.

Toweill, D.E., S. Gordon, E. Jenkins, T. Kreeger, and D. McWhirter. 2004. A working hypothesis for management of mountain goats. Biennial Symposium of the Northern Wild Sheep and Goat Council 14:5–45.

Turney, L. 2004. Modeling of ungulate winter range for mountain goat in the Nadina Forest District, British Columbia. Prepared for B.C. Ministry of Water, Land and Air Protection, Smithers, BC.

Varley, N. 1998. Winter recreation and human disturbance on mountain goats: a review. Biennial Symposium of the Northern Wild Sheep and Goat Council 11:7–10.

Varley, N.C. 1994. Summer-fall habitat use and fall diets of mountain goats and bighorn sheep in the Absaroka Range, Montana. Biennial Symposium of the Northern Wild Sheep and Goat Council 9:131–138.

Washington Department of Fish and Wildlife. 2008. 2009-2015 game management plan. Wildlife Program, Olympia, WA.

Williams, E.S. 2001. Paratuberculosis and other mycobacterial diseases. Pages 361–371 *in* E.S. Williams and I.K. Barker, eds. Infectious diseases of wild mammals, 3rd ed. Iowa State Univ. Press, Ames, Iowa.

Williams, J.S. 1999. Compensatory reproduction and dispersal in an introduced mountain goat population in central Montana. Wildlife Society Bulletin 27:1019–1024.

Wilson, S., M.P. Gillingham, D. Heard, G. Kuzyk, R. Marshall, S. Gordon, and D. Butler. 2007. Behavioural interactions between mountain goats and helicopters: status report and workplan 2007-11. Report prepared by the Mountain Goat Behaviour-Helicopter Activity Steering Committee for the Habitat Conservation Trust Fund.

Personal Communications

Addison, Chris. 2009. B.C. Ministry of Environment, Victoria, BC.

Brunt, Kim. 2009. B.C. Ministry of Environment, Nanaimo, BC.

Côté, Steeve. 2008, 2010. Université Laval, Sainte-Foy, PQ.

Dielman, Pat. 2009. B.C. Ministry of Environment, Williams Lake, BC.

Harris, Brian. 2009. B.C. Ministry of Environment, Penticton, BC.

Holley, Mona. 2009. B.C. Ministry of Environment, Victoria, BC.

Johnstone, Pierre, 2009. B.C. Ministry of Environment, Cranbrook, BC.

Jorgenson, Jon. 2009. Alberta Sustainable Resource Development, Canmore, AB.

Psyllakis, Jennifer. 2009. B.C. Ministry of Environment, Victoria, BC.

Reynolds, Darryl. 2008. B.C. Ministry of Environment, Sechelt, BC.

Schultze, George. 2009. B.C. Ministry of Environment, Smithers, BC.

Schwantje, Helen. 2009. B.C. Ministry of Environment, Victoria, BC.

White, Kevin. 2008. Alaska Department of Fish and Game, Douglas, AK.

Wickstrom, Dave. 2008. Darkwoods Forestry, Nelson, BC.

Woods, Guy. 2008. B.C. Ministry of Environment (retired), Nelson, BC.

Appendix A. International Union for the Conservation of Nature (IUCN) threat assessment for mountain goats in British Columbia (2009).

Condensed version of the IUCN Threats assessment (Salafsky *et al.* 2008) for mountain goats in British Columbia. A more detailed version has been provided to the B.C. Conservation Data Centre (http://www.elp.gov.bc.ca/cdc/index.html).

Threat[a]		Impact calculated	Scope	Severity	Timing
1	Residential & commercial development	Low	Small	Extreme	High
1.3	Tourism & recreation areas	Low	Small	Extreme	High
2	Agriculture & aquaculture	Low	Small	Slight	High
2.3	Livestock farming & ranching	Low	Small	Slight	High
3	Energy production & mining	Medium	Large	Moderate	High
3.1	Oil & gas drilling	Low	Small	Serious	High
3.2	Mining & quarrying	Low	Restricted	Moderate	High
3.3	Renewable energy	Medium	Restricted	Serious	High
4	Transportation & service corridors	Low	Restricted	Slight	High
4.1	Roads & railroads	Low	Restricted	Slight	High
4.2	Utility & service lines	Low	Restricted	Slight	High
4.4	Flight paths	Low	Small	Unknown	High
5	Biological resource use	Medium	Pervasive	Moderate	High
5.1	Hunting & collecting terrestrial animals	Low	Pervasive	Slight	High
5.3	Logging & wood harvesting	Low	Small	Serious	High
6	Human intrusions & disturbance	Medium	Pervasive	Moderate	High
6.1	Recreational activities	Medium	Pervasive	Moderate	High
6.3	Work & other activities	Low	Large	Slight	High
7	Natural system modifications	Low	Small	Slight	High
7.1	Fire & fire suppression	Low	Restricted	Slight	Negligible
7.2	Dams & water management/use	Low	Small	Slight	High
8	Invasive & other problematic species & genes	Medium	Large	Moderate	High
8.1	Invasive non-native/alien species	Low	Small	Moderate	Moderate
8.2	Problematic native species	Medium	Large	Moderate	High
10	Geological events	Low	Small	Slight	High
10.3	Avalanches/landslides	Low	Small	Slight	High
11	Climate change & severe weather	Low	Pervasive	Slight	Moderate - Low
11.1	Habitat shifting & alteration	Unknown	Unknown	Unknown	Unknown
11.3	Temperature extremes	Low	Pervasive	Slight	Moderate - Low

[a] Classification of Threats adopted from IUCN-CMP (Salafsky *et al.* 2008).

Appendix B. Discussion of boxes and linkages associated with the Conceptual Ecological Mountain Goat Model (Figure 4).

Habitat Features

Natal Range

- May be spatially associated with **winter range**
- **Predation risk** is influenced by location (i.e., typically remote and rugged terrain) and integrity of preferred habitat

Winter Range

- May be spatially associated with **natal range**
- Abundance, distribution and suitability influences **energetic condition** during a critical period (i.e., providing abundant preferred forage, snow conditions that minimize costs associated with mobility)
- **Predation risk** is influenced by location (e.g., elevation, availability of escape terrain), the integrity of preferred habitat, and the state of adjacent non-goat habitat

Early Spring Green-up Habitat

- Important for restoring **energetic condition** after winter
- **Predation risk** is influenced by the location (e.g., elevation, association with escape terrain) and integrity of preferred habitat

Summer-fall Habitat

- Forage availability affects **energetic condition**
- **Predation risk** in summer-fall is influenced by the location (e.g., high elevation, coincidence of suitable forage and escape terrain) and integrity of preferred habitat

Traditional Trails

- Trails allow movement among important habitat features: **natal range, winter range, early spring green-up habitat, summer-fall habitat,** and **mineral licks**
- Movement between habitat features expose mountain goats to **predation risk**, particularly at low elevations
- **Predation risk** along preferred trails is influenced by their location and integrity

Mineral Licks

- Influence **energetic condition** by providing essential minerals
- Location of licks influences the **predation risk** mountain goats are exposed to when in the area
-

Stressors

Fire Suppression

- Forest in-growth can reduce the suitability of **early spring green-up habitat** and **summer-fall habitat** by reducing forage abundance

Resource Extraction

- Industrial forestry and mineral exploration/development can reduce the suitability of **natal range, winter range, early spring green-up habitat, summer-fall habitat, traditional trails,** and **mineral licks**

Winter Severity

- A severe winter can reduce the availability of suitable **winter range**
- Severe winter conditions can affect **energetic condition** by increasing metabolic costs

- April-May snow conditions might be particularly important

Energetic Condition

- Influences vital rates: **adult female survival, kid production, recruitment** and **adult male survival,** and susceptible to **pathogens.**

Disturbance

- Disturbance of mountain goats resulting in displacement from preferred habitats can reduce the effectiveness of **natal ranges, winter range, early spring green-up habitat, summer-fall habitat, traditional trails,** and **mineral licks**
- Disturbance can also affect **energetic condition** by increasing metabolic costs through reduced feeding and ruminating efficiency and increased locomotion
- Disturbance can directly affect **predation risk** by reducing vigilance and increasing exposure to injury

Predation Risk

- Affects vital rates: **adult female survival, recruitment,** and **adult male survival**

Hunting Mortality

- Affects vital rates: **adult female survival** and **adult male survival**
- Includes sport hunting, subsistence hunting, and poaching

Pathogens

- Parasite loads and infectious diseases (viral and bacterial) affect **energetic condition**

Inbreeding Depression

- Created via feedback with vital rates (**adult female survival, kid production, recruitment,** and **adult male survival**) by reducing vigor in small populations

Vital Rates

Adult Female Survival

- Affects **kid production** and contributes to **population size**

Kid Production

- Affects **recruitment** and contributes to **population size**

Recruitment

- Contributes to **population size**

Adult Male Survival

- Adult male abundance can affect **kid production** and contributes to **population size**

Appendix C. Recommended management actions.

Recommended management action	Conservation Framework action group[a]	Threat or concern addressed[b]
Objective 1. To effectively maintain suitable, connected mountain goat habitat		
1. Review, update, and validate/refine habitat suitability modeling	Habitat Protection	Knowledge gap
2. Inventory habitat used by mountain goats	Habitat Protection	Knowledge gap
3. Identify habitat connectivity	Habitat Protection	Knowledge gap 11.2 and 11.3
4. Apply consistent habitat guidelines for mountain goats	Habitat Protection	1 thru 8
5. Apply mitigation techniques consistently to all development	Habitat Restoration	3, 5.3, 6.1, 6.3
Objective 2. To mitigate threats to mountain goats.		
Disturbance Management:		
1. Use helicopter disturbance setbacks based on science	Species & Population Management	3, 5.1, 5.3, 6.1, 6.3
2. Minimize industrial disturbance	Habitat Protection; Habitat Restoration	3, 5.3, 10.3
3. Minimize recreational disturbance	Habitat Protection; Habitat Restoration	6.1
Access Management:		
1. Reduce the amount and persistence of roads in and near mountain goat habitat	Species & Population Management	3, 5.1, 5.3, 6.1, 6.3, 8.2
2. Consider changes in access in harvest management decisions	Review Resource Use	5.1
3. Consider the cumulative effects associated with access and integrate access management for all resource and recreational activities	Habitat Protection; Species & Population Management	3, 5.1, 5.3, 6.1
Objective 3. To ensure opportunities for non-consumptive and consumptive use of mountain goats are sustainable		
1. Do not harvest populations with less than 50 adults	Review Resource Use	5.1
2. Set harvest rate based on estimated population size	Review Resource Use	5.1
3. Base harvest rate on the managed unit	Review Resource Use	5.1
4. Minimize female harvest	Review Resource Use	5.1
5. Improve the accuracy of sex identification during compulsory inspections	Review Resource Use	5.1
6. Conduct adequate inventory to base harvest management decisions	Species & Population Management	Knowledge Gap
7. Caution use of transplants where appropriate	Species & Population Management	5.1

[a] Data source: B.C. Ministry of Environment (2010).
[b] Data source: IUCN threats noted in Appendix A.

Appendix D. Glossary of terms.

Bachelor groups: include only adult males, mostly 3 years and older (Festa-Bianchet and Côté 2008).

Demographic stochasticity: the variability in population growth rates arising from random differences among individuals.

Dispersal: the movement an individual animal makes from its place of birth to the place where it reproduces.

Escape terrain: generally steep slopes usually ≥ 40º or ≥ 84% of shear or broken cliffs where most mammalian predators would be unable to access. Rock is the main substrate for escape terrain, but for populations living along river valleys, steep mud and clay banks often are used.

Extirpated: no longer exists in an area.

Habitat effectiveness: an area's actual ability to support mountain goats given the quality of the habitat and other factors, such as the extent of human disturbance.

Kidding/early rearing areas: the general area where kids are born and spend the first 4–6 weeks post-partum.

Identified mountain goat habitat: areas of mountain goat habitat established under the Government Actions Regulation, including areas described in wildlife habitat features or wildlife habitat areas.

Migration: movement back and forth between seasonal (often summer and winter) home ranges.

Mountain goat habitat: all habitat occupied by mountain goats during any portion of the year, including seasonal ranges (i.e., winter range, summer range, natal areas), traditional travel routes connecting these ranges, and seasonally important habitat features, including mineral licks and traditional trails to licks. Important mountain goat habitat is habitat occupied by mountain goats that has a higher functional importance for survival; includes (but is not limited to) winter range, kidding/early rearing areas, connectivity corridors, and mineral licks.

Natal area: areas used by parturient females to give birth and spend their first few days in isolation, generally between mid-May and mid-June. Natal area can also refer to a general area where a mountain goat was born (in the sense that an emigrant would go from its 'natal area' to somewhere else).

Nursery groups: include females of all ages, kids, and males up to 4 years of age (Festa-Bianchet and Côté 2008).

Parturition (birthing) site: where nannies give birth and spend their first few days in isolation with their young. Also generally known as the kidding area.

Population: a biological unit where it is meaningful to speak of a birth rate, a death rate, a sex ratio and an age structure in describing the properties of the unit (Caughley 1977); a discrete group of potentially interbreeding individuals in a given locality. Distinct populations of mountain goats can be surmised within individual mountain blocks or groups of mountain blocks where regular exchange is known or suspected can be considered to be relatively discrete. But because of difficulties accurately identifying distinct populations of mountain goats within often continuous habitat, we use the term "population" relatively loosely to refer to the managed unit of mountain goats for harvest (which can include no harvest). The term "herd" is generally used synonymously with "population" (Côté and Festa-Bianchet 2003; Festa-Bianchet and Côté 2008).

Precautionary principle: selection of actions that pose low risk to the current and future status of wildlife populations, and taking necessary action despite uncertainties around current conditions and/or outcome.

Sightability correction: acknowledging that animals are invariably missed during surveys, an adjustment for sightability is often applied to the number of mountain goats observed to estimate the total number within the census zone. These are often developed using marked animals to develop logistic regression models.

Summer range: areas used by mountain goats during summer (variable between areas and years, but generally from June to September).

Sustainable harvest rate: the level of harvest that will not compromise the viability of the mountain goat population, and that will benefit users now, while maintaining potential to meet needs of future generations.

Viable population: a population that maintains its genetic diversity and potential for evolutionary adaptation, and is at minimal risk of extinction from demographic fluctuations, environmental variations and potential catastrophe.

Winter range: areas used by mountain goats during winter (variable between areas and years, but generally from November to April). Summer and winter range extent and use may differ between bachelor and nursery groups and between coastal and interior goats.