Hume Ck goat habitat

Mountain goat monitoring in Canadian Mountain Holidays' Bobbie Burns summer operating area, East Kootenay, September 2003

Prepared for:

Dave Butler, Director
Land Resources, Canadian Mountain Holidays Inc.
816 30th Ave S., Cranbrook BC V1C 4Y9

Prepared by:

Kim Poole

Aurora Wildlife Research
2305 Annable Road, Nelson BC V1L 6K4
Tele. (250) 825-4063; e-mail: klpoole@shaw.ca

Aurora Wildlife Research

October 2003

ABSTRACT

In September 2002, an aerial survey for mountain goat (*Oreamnos americanus*) was conducted within Canadian Mountain Holiday's (CMH) Bobbie Burns and Bugaboo summer tenure areas of the Purcell Mountains in the East Kootenay of southeastern British Columbia. Evidence from research elsewhere suggests that the accuracy of individual helicopter surveys is questionable, results of single surveys should be interpreted with caution, and that aerial surveys of mountain goats appear to be useful only as trend indicators. Therefore, in order to measure and monitor long-term trends in goat population size and distribution across the landscape, a goat survey was conducted in September 2003 in the Bobbie Burns portion of the study area, approximately half of the area surveyed in 2002. The objectives of this study were to determine the number and distribution of mountain goats during late summer-early fall.

The September 2003 study area encompassed 650 km^2 and included primarily discrete mountain blocks. Within the study area a 395 km^2 census zone of potential goat habitat was surveyed, which generally included steep or cliff habitat above 6,000–6,500 feet elevation and below tree line down to about 5,500 feet. (Feet are provided as the unit of measure because the helicopter's altimeter was in feet). Survey methodology, timing, and 3 of 4 observers were identical to the 2002 survey. A Bell 206B helicopter was used following standard survey techniques; all goats were classified to kid or non-kid (adults and yearlings; hereafter adults). No sightability correction surveys were conducted. Survey conditions were poor on the first day of the survey (primarily due to patchy snow cover at higher elevations), but good for the remaining days.

The survey was conducted on 12, 13 and 15 September 2003. We spent 12.2 hours on survey within the census zone, for an average survey intensity of 1.9 minutes/km^2. We observed 183 goats in 59 groups, an average of 0.46 goats/km^2 within the census zone and 0.28 goats/km^2 within the study area. Group size ranged from 1 to 12. Elevations of goats ranged from 5,800 to 8,300 feet; 50% of censused goats occurred in the 7,000–7,700 foot band (mean 7,300 feet, median 7,400 feet). We counted 51 kids; a 28:100 kid to adult ratio. Assuming 60% sightability (as used in 2002) results in an estimate of roughly 305 goats in the study area (0.77 goats/km^2 within the census zone and 0.47 goats/km^2 within the study area).

The September 2003 survey documented 45% more adult goats within the same area compared to September 2002 (132 versus 91, respectively), and higher kid ratios (28% versus 16%, respectively). Group size did not differ between years, but goats were found on average 700 feet lower in elevation, and were less associated with glacial features in 2003, possibly related to cooler weather. Differences among years in number of adults observed may primarily be related to goat sightability.

I recommend that to establish long-term population trends for goat populations within the CMH tenure area, annual monitoring should be continued. Efforts should be made to continue to standardize survey timing, effort and observers/pilot among years.

TABLE OF CONTENTS

INTRODUCTION

Canadian Mountain Holidays (CMH) has tenure to conduct winter heli-skiing and summer heli-hiking operations in the Bugaboo and Bobbie Burns areas of the Purcell Mountains in the East Kootenay of southeastern British Columbia. Surveys conducted in 1998 found far fewer mountain goats (*Oreamnos americanus*) than previously estimated for the area (Davidson 2000, Teske and Forbes 2001). The Bugaboo and Bobbie Burns summer areas were also surveyed at a reconnaissance level in early September 2000 (Wilson and Shackleton 2001). Although more goats were observed than during the 1998 survey, Wilson and Shackleton (2001) suggested that goats here appeared to occur at relatively low densities, and that habitat quality for goats was lower than in surrounding regions such as the Rocky Mountains. However, surveys conducted in mid-September 2002 found significantly higher numbers of goats within the CMH summer tenure area compared to previous surveys (Poole and Adams 2002).

Evidence from on-going studies in western Alberta suggests that the accuracy of individual helicopter surveys is questionable, results of single surveys should be interpreted with caution, and that aerial surveys of mountain goats appear to be useful only as trend indicators (Gonzalez Voyer et al. 2001). These authors concluded that yearly surveys are required to monitor populations. Given these caveats, Poole and Adams (2002:11) recommended that to establish long-term trends for goat populations within the tenure area, a sample of the study area be re-surveyed on an annual basis. The goal of this study was to determine trends in mountain goat population numbers and distribution within the Bobbie Burns and Bugaboo study areas. Study objectives were to determine the numbers and distribution of mountain goats during late summer/early fall within CMH's Bobbie Burns summer operating area.

STUDY AREA

The 2002 survey covered a 797-km^2 census area of potential goat habitat within the 1,410-km^2 study area (Bobbie Burns and Bugaboo summer tenure areas; Poole and Adams 2002). Within approximately half of this area (650 km^2 study area, 395 km^2 census zone), I chose a discrete set of mountain blocks to maximize the likelihood of sampling discrete goat populations (c.f. Gonzalez Voyer et al. 2003:214) and to minimize the potential for movement out of the census zone among years (Fig.1). The monitoring study area is bounded by McMurdo Creek to the north, Duncan River to the west, Conrad Icefield to the south, and Vowell Creek to the east (blocks 4–10 and the northern quarter of block 3 [3N]; Poole and Adams 2002). This study area aligns with much of zone B and the southern edge of zone A of Management Unit (MU) 4-34, and the north-eastern half of zone C of MU 4-27.

The study area is within the northern Purcell Mountains of the Columbia Mountains, west of the Rocky Mountain Trench (Fig. 1). The area is made up of 2 biogeoclimatic zones: Engelmann Spruce-Subalpine Fir (ESSF) zone and the Alpine Tundra (AT) zone above tree line (located roughly between 1900 and 2150 m [6,250–7,050 ft]). July and January mean temperatures for Golden, 20 km north of the study area, are 17.2ºC and –10.1ºC, respectively (Environment Canada climate normals, unpublished data). Golden receives an average of 490 mm of precipitation including 184 cm of snowfall annually. Climate varies within the study area, with cooler temperatures and deeper snowfalls at higher elevations and on north and east-facing slopes. High on the valley sides, hybrid white-Engelmann spruce (*Picea glauca* x *engelmannii*), subalpine fir (*Abies lasiocarpa*), and lodgepole pine (*Pinus contorta*) dominate, with scattered stands of whitebark pine (*Pinus albicaulis*) at the highest elevations (Parish et al. 1996). In the AT zone conifers are present only in stunted krummholz forms. Extensive areas of glacier with associated moraine deposits are found throughout the study area, some of them many square kilometres in extent.

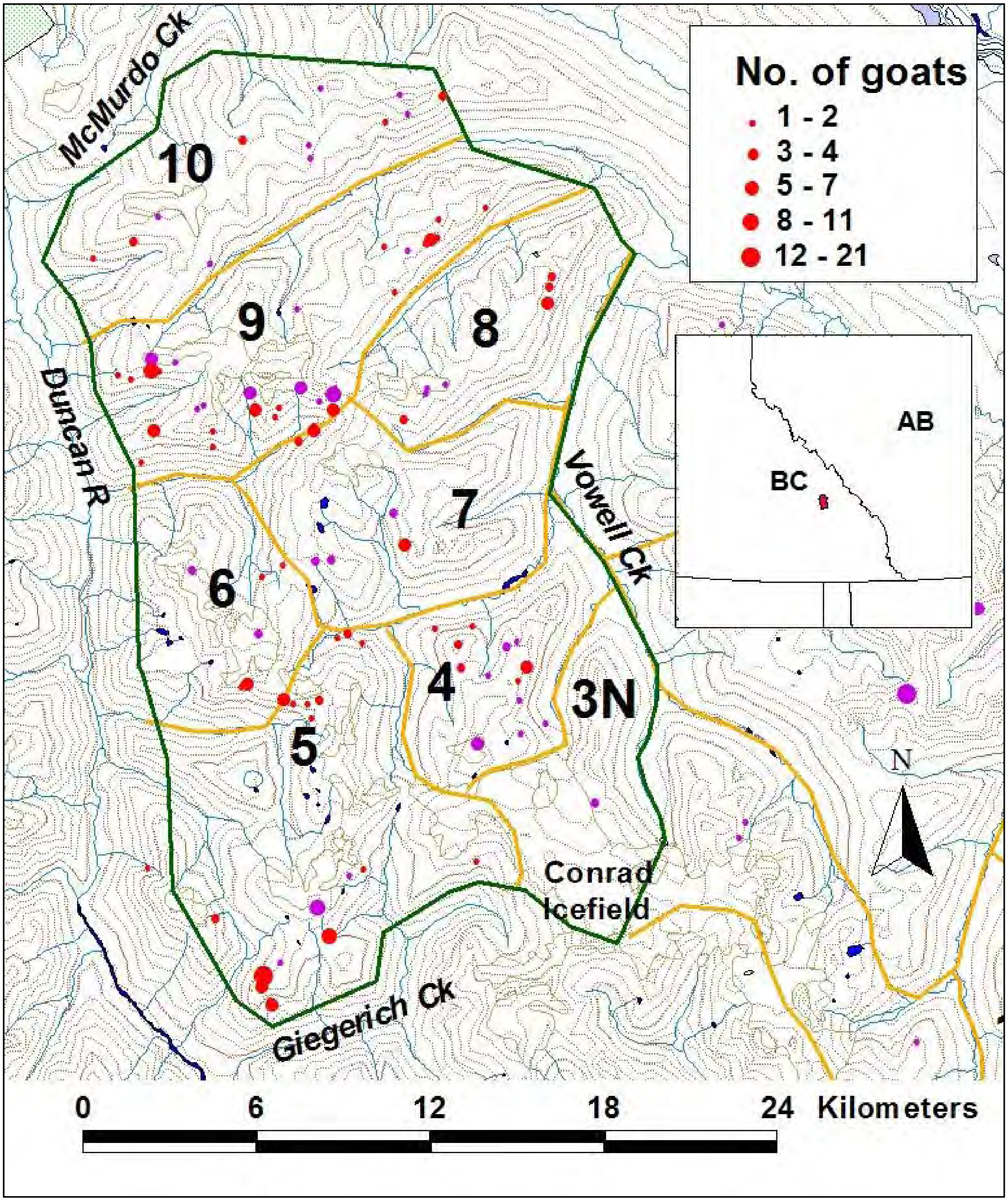

Figure 1. CMH Bobbie Burns mountain goat survey, 12–15 September 2003. Red dots symbolize goats observed in 2003, purple dots in 2002. Numbers of goats observed shown by dots scaled to number of animals observed in the group. Dark green outline depicts the approximate study area; orange outlines with black numbers refer to survey blocks (Table 1). The census zone covered potential goat habitat generally above 6,000–6,500 feet elevation.

STUDY DESIGN AND METHODOLOGY

Study design and methodology followed Poole and Adams (2002). To minimize potential variability and maximize repeatability in surveys among years, I attempted to ensure that timing, methodology, effort, and pilot and observers were consistent with the 2002 survey. To this end, survey timing, the helicopter pilot, and 2 of the 3 observers remained the same, and we attempted to conduct similar survey effort (approximately 1.5 min/km^2; see results and discussion).

A total count survey was conducted of the coverage area following RIC (2002) standards. We did not attempt to calibrate a sightability correction factor during the survey (see Discussion). The census zone was broken into survey blocks (survey units), which generally consisted of discrete mountain blocks that we were able to survey within approximately 1–2.5 hours to avoid observer fatigue and to minimize the risk of animal movement within and out of blocks during the survey period. The census zone generally included steep or cliff habitat above 6,000–6,500 feet elevation and below tree line down to about 5,500 feet. (Feet are provided as the unit of measure because the helicopter's altimeter was in feet). Glaciers >1 km^2 in size were removed from calculation of the census zone area.

The survey was conducted on 12, 13 and 15 September 2003. Following an unusually hot and dry summer, cooler weather and rain occurred during the week prior to the survey, with snow at elevations above 7,200–8,500 feet. Depending on aspect and the degree of snowmelt there was patchy snow at these higher elevations on the first day of the survey. Survey conditions on 12 September were overcast and windy, but on 13 September ranged from sunny to high overcast with light winds and excellent visibility. Conditions on 15 September were mainly overcast with high cloud. Temperatures in the census zone were seasonable (mostly 1–4 C).

We used a Bell 206B Jet Ranger helicopter with pilot, navigator, and 2 observers. Due to helicopter problems, we used a Bell 206L to survey blocks 4 and 3N on the last survey day. The pilot, navigator, and both observers remained the same throughout the census. All occupants participated in locating mountain goats. We surveyed all terrain above and including alpine and open subalpine habitat, as well as areas of broken or disjointed cliffs and avalanche chutes below tree line. Starting at the lowest elevation, we flew roughly 120–150 m (400–500 foot) contour lines at 80–100 km/hr, 75–100 m out from the hillsides. We mapped approximate flight lines, survey coverage and location of goats on 1:50,000 scale topographic maps and recorded broad habitat type and elevation (to the nearest 100 feet) of goat groups with the helicopter's altimeter. We also recorded goat locations and our helicopter flight track with a hand-held global positioning system (GPS) unit. We classified goats only into kids and non-kid (yearlings and older; hereafter called adults) based on body size (Smith 1988) to reduce survey time, to minimize harassment (Côté 1996), and because researchers familiar with classification from aircraft suggest more detailed age and sex classification is not reliable (Houston et al. 1986, Stevens and Houston 1989, Gonzalez Voyer et al. 2001, S. Côté, Université de Sherbrooke, personal communication). Incidental wildlife sightings were also recorded.

RESULTS

We spent 12.2 hours on survey within the census zone (survey area), an average survey intensity of 1.9 minutes/km^2 (range among blocks: 1.1–2.5 minutes/km^2; Table 1). We observed 183 goats in 59 groups (Fig. 1). Group size ranged from 1 to 12 and averaged 3.1 ± 0.31 (mean ± SE). "Typical" group size, an animal-centred measure of the group size within which the average animal finds itself (Jarman 1974, Heard 1992), was 4.9 (± 0.22). Over half (53%) of goats groups consisted of 1–2 animals. We counted 51 kids (28% of total goats); a 39:100 kid to adult ratio. Elevations of goats ranged from 5,800 to 8,300 feet, and 50% of observed goats occurred in the 7,000–7,700 foot band (mean 7,300 feet, median 7,400 feet). Elevation of goat groups did not differ between kid and non-kid groups (*t*-test, $t = 0.02$, 57 df, $P = 0.99$). We observed over half of the goats in alpine meadows or alpine barrens (59% of total goats). Other habitats used included cliff and broken cliffs (13%), avalanche tracks (10%), scree/talus (34%), krummholtz/timber (7%), and ridge tops (4%). Few goats were adjacent to or closely associated with features related to glaciers.

Table 1. CMH Bobbie Burns mountain goat survey results by block, 12–15 September 2003. Block numbers correspond to map numbers in Fig. 1. "Adults" refers to non-kids (yearlings and older).

Date	Block no.	Name	Time on survey (min)	Survey area (km^2)	Survey effort (min/km^2)	Adults	Kids	Total	Density (goats/km^2)
13-Sep-03	3N	Malloy Ck	25	17.4	1.4	0	0	0	0.00
13-Sep-03	4	Conrad Glacier, Vertigo	59	29.8	2.0	11	5	16	0.54
13-Sep-03	5	Giegerich, Crystalline	111	73.1	1.5	32	15	47	0.64
13-Sep-03	6	Hatteras	53	46.3	1.1	17	6	23	0.50
13-Sep-03	7	Syncline	82	52.0	1.6	13	8	21	0.40
13-Sep-03	8	Vermont, Malachite	64	30.6	2.1	10	4	14	0.46
12-13-Sep-03	9	Carbonate	177	71.8	2.5	40	9	49	0.68
12-Sep-03	10	Bobbie Burns	161	74.1	2.2	9	4	13	0.18
Total				**395**	**1.9**	**132**	**51**	**183**	

Mean density was 0.46 goats/km^2 within the census zone (range 0.00–0.68 goats/km^2 among blocks; Table 1) and 0.28 goats/km^2 within the study area. Goat densities were uniformly high among all blocks (0.40–0.68 goats/km^2) except for the Bobbie Burns (block 10) and the small portion of Malloy Creek (block 3N) surveyed. There was no correlation between survey effort and goat density among blocks (Spearman rank correlation, $P = 0.57$). Following rationale presented in Poole and Adams (2002), application of a 60% sightability factor results in an estimate of 305 goats in the study area (0.77 goats/km^2 within the census zone and 0.47 goats/km^2 within the study area).

During this survey we counted 183 goats (132 adults, 51 kids) within approximately 395 km^2. Within the same area during the September 2002 survey we observed 108 goats (91 adults, 17 kids; 16% kids, 19:100 kid to adult ratio) (Table 2). Therefore, we counted 45% more adult goats in 2003 compared with 2002. Adult numbers in all blocks except for 3N were similar to or up to 3 times higher in 2003 compared with 2002. Compared to the same area covered in the 2002 survey, goat group size ($t = 0.85$, 97 df, $P = 0.40$) and typical group size ($t = 1.01$, 289 df, $P = 0.31$) were similar, but goat groups were found at lower elevations in 2003 (7,300 versus 8,000 feet; $t = 5.55$, 97 df, $P < 0.0001$).

Table 2. Comparison of block data between mountain goat surveys conducted in September 2002 and September 2003. "Adults" refers to non-kids (yearlings and older).

		2003				2002			
Block no.	Survey area (km^2)	Adults	Kids	Total	Survey effort (min/km^2)	Adults	Kids	Total	Survey effort (min/km^2)
3N	17.4	0	0	0	1.4	2	1	3	1.4
4	29.8	11	5	16	2.0	12	4	16	1.8
5	73.1	32	15	47	1.5	13	1	14	1.1
6	46.3	17	6	23	1.1	6	2	8	1.1
7	52.0	13	8	21	1.6	8	2	10	1.4
8	30.6	10	4	14	2.1	3	2	5	2.0
9	71.8	40	9	49	2.5	39	5	44	1.8
10	74.1	9	4	13	2.2	5	0	8	1.3
Total	**395**	**132**	**51**	**183**	**1.9**	**91**	**17**	**108**	**1.5**

During the survey we observed 10 grizzly bears (*Ursus arctos*): a sow with 3 yearlings in the vicinity of the International Basin hut (block 10), 2 adult bears north of Giegerich Creek (south side of block 5), and single adult bears at the top of Fitch Creek (west end of block 5), south of Witch Lakes (block 3N), above Hatteras Creek (southwest corner of block 9), and west of Carbonate Lake (block 9). The grizzly bears were observed primarily in alpine meadows at 6,400–7,700 feet elevation. An adult (and likely very nervous) black bear (*U. americanus*) was observed about 400–500 m from the pair of adult grizzly bears north of Giegerich Creek. We also recorded 8 mule deer (*Odocoileus hemionus*) in 4 groups (3 singles and a group of 5), all at 7,200–7,500 feet elevation. We observed (but did not record) about a dozen golden eagles (*Aquila chrysaetos*), and observed a juvenile grey phase gyrfalcon (*Falco rusticolus*) in the Carbonate Range (initially perched at about 8,500 feet elevation).

DISCUSSION

The 2003 CMH Bobbie Burns survey was conducted under generally good survey conditions and visibility. Cool temperatures and survey commencement 24 hours after a storm event may have contributed to goats being more active and/or visible (Singer and Doherty 1985). Weather conditions on 12 September (survey of block 10 and the north side of block 9) were less than ideal, and higher elevation snow made surveying more challenging. Within areas of continuous snow cover we searched for and followed goat tracks to key in on some animals; the dirty, off-white goats tended to stand out against the clean snow background. In areas of patchy snow, we increased survey intensity in an effort to compensate for expected lower sightability. Snow cover was not a significant factor during flights on 13 and 15 September.

A host of factors can influence mountain goat survey results and sightability (Fox 1984); potentially the most important factors might be changes in behaviour and distribution (e.g., hiding in cliffs or below tree line), differential sightability by terrain and vegetation, survey effort, seasonal effects, and weather conditions (see Poole and Adams 2002 for more detailed discussion on sightability). Surveying the same area with the same aircraft and 3 of the 4 same observers reduced some factors contributing to variability in sightability (e.g., differences in terrain and vegetation, observer bias).

Differences between our counts may relate to slightly higher survey effort in 2003, but this occurred primarily on blocks with patchy snow cover (blocks 9 and 10), and blocks with far more goat sightings (resulting in more circling to verify sightings). A greater contribution to increased counts between years may have been a result of differences in goat behaviour. Temperatures during the 2002 survey were higher than average, and as a result goats may have spent more time hiding under cover in cool, shaded areas, possibly reducing sightability. Locations of goat groups observed in 2002 and 2003 suggest significant differences in distribution (Fig. 1). Anecdotal evidence from reconnaissance flights for goats (some collared) in the Cayoosh range in southern BC suggested significant changes in distribution and/or habitat use during summer-fall 1998, attributed in part to the hot, dry weather (Hatler et al. 1999). During the 2002 CMH survey, goats were found at higher elevations and were more closely associated with features related to glaciers (Poole and Adams 2002). Goats observed in the 2003 survey were at lower elevations, and were associated with alpine meadows and alpine barrens to a far greater extent than in 2002. Thus, even though survey timing was identical, seasonal phenology related to weather and vegetation may have contributed to different distribution, behaviour, and hence sightability between years.

Introduced goat populations have shown rates of increase (*r*) of 0.16–0.27 (summarized in Houston and Stevens 1988) and appear to be able to sustain high harvest levels (Swenson 1985, Williams 1999), but most established native populations appear to stabilize with limited capacity to increase or withstand elevated harvest levels (summarized in Côté et al. 2001, Gonzalez Voyer et al. 2003). It is obviously not possible that our 45% increase in observed adult goat numbers is related to recruitment over 1 year.

We cannot, of course, discount large movements of goats among mountain blocks as a major factor in the apparent increase in goat numbers. Given the general reluctance of goats to cross low-elevation, forested valleys, we attempted to geographically isolate our study area as much as possible, and may have accomplished this on the west (Duncan River valley) and east (Vowel Creek) sides of the 2003 study area. Although much of our northern boundary consisted of the Spillimacheen River valley, high-elevation habitat occurs through part of our northern boundary at Silent Pass. High-elevation habitat also occurs around the Conrad Glacier on the south side of the study area. Although goat subpopulations experience some immigration and emigration (Nichols 1985), no documentation exists of large-scale migrations or dispersals by mountain goats among discrete mountain blocks over time, and in general fidelity to summer and winter ranges is moderate to high (Nichols 1985, Houston et al. 1994, Lemke 1999**,** Côté and Festa-Bianchet 2003). No mountain goats studies with collared animals have been conducted in the Kootenays, but a 3-year study in the Robson Valley suggested generally high fidelity to seasonal ranges (Poole and Heard submitted). Large forest fires in portions of the Purcell Mountains (notably in upper Giegerich Creek) may have caused localized movement of some animals.

Studies point to the large variation in sightability obtained during goat surveys (Hebert and Langin 1982, Smith 1984, Smith and Bovee 1984, Cichowski et al. 1994, Poole et al. 2000, Gonzalez Voyer et al. 2001). Although pure conjecture, if sightability of goats increased from the 60% we surmised in 2002 to, for example 80% in 2003, then estimated adult goat numbers would be somewhat more similar between years (151 versus 165, respectively) and could almost be accounted for by recruitment. Since we had no collared goats, and no practical means of estimating survey sightability correction factors (Poole and Adams 2002), we are unable to reliably compare sightability between years.

Kid ratios were greater in 2003 (28%), suggesting higher productivity and kid survival compared with 2002 (16% within the 2003 study area; Poole and Adams 2002). The proportion of kids observed in 2003 was at the high end of the percent kids observed during summer/early fall surveys in southern interior B.C. (15–23%, McCrory 1979; and 10–31%, Hebert and Woods 1984), the Robson Valley (25%; Poole et al. 2000), and the adjacent Golden study area in 2002 (17%; Poole and Mowat 2002). The proportion of kids observed in 10 management units in the East Kootenay in 1998 and 2000 ranged from 0–28%, and averaged 20% (Teske and Forbes 2001). Observed kid ratios were also high (25%) during surveys conducted in the Robson Valley/Valemount area during late summer 2003 (L. Ingham, Columbia Basin Fish and Wildlife Compensation Program, Invermere, personal communication). Kid production appears to be negatively associated with winter severity during pregnancy (Smith 1977, Adams and Bailey 1982, Swenson 1985) and April–May snowfall and snow depth (Thompson 1980, Hopkins et al. 1992); thus, the low snowpack over most of the BC interior during winter 2002–2003 may have contributed to the higher kid ratios observed during summer 2003.

Management recommendations

Evidence from extensive studies in Caw Ridge, Alberta, suggest that the accuracy of individual helicopter surveys is questionable, results of single surveys should be interpreted with caution, and that aerial surveys of mountain goats appear to be useful only as trend indicators (Gonzalez Voyer et al. 2001). These authors concluded that yearly surveys are required to adequately monitor populations. Survey results from the Bobbie Burns study area in 2002 and 2003 tends to support the need for long-term monitoring to obtain trends in goat numbers. As noted in Poole and Adams (2002), results from 2002 and 2003 surveys support the need to develop empirically-based sightability corrections for use with goat surveys, using either models developed to account for sightability (as for moose [*Alces alces*] in British Columbia; Quayle et al. 2001), or a sample of collared goats within the survey area (Poole et al. 2000). At a minimum, there is a need to quantify sightability and goat counts among surveys flown at differing intensities.

ACKNOWLEDGEMENTS

I thank D. McTighe, Alpine Helicopters, Golden, for continued enthusiastic and skilled piloting, and T. Cardon, CMH, and R. Klafki, Golden, for their keen and competent assistance as observers. D. Butler, CMH, provided logistic and administrative support. The hospitality provided by CMH's Bobbie Burns lodge was greatly appreciated. R. Klafki and D. Butler reviewed an earlier draft of this manuscript.

LITERATURE CITED

Adams, L.A., and J.A. Bailey. 1982. Population dynamics of mountain goats in the Sawatch Range, Colorado. Journal of Wildlife Management 44:1003–1009.

Chichowski, 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.

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

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

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

Davidson, A. 2000. 1998 Purcell Range/White River mountain goat inventory. Unpublished report for Columbia Basin Fish and Wildlife Compensation Program, Athalmer, British Columbia.

Fox, J.L. 1984. Population density of mountain goats in southeast Alaska. Biennial Symposium of the Northern Wild Sheep and Goat Council 4:51–60.

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.

Hatler, D.F., G.F. Searing, S. Yasvenko, and M.W. Demarchi. 1999. Environmental impact assessment: Cayoosh Resort. Vol. 1, Part V. Wildlife, habitat and vegetation assessment. Unpublished report for NGR Resort Consultants Ltd., Sun Peaks, British Columbia.

Heard, D.C. 1992. The effect of wolf predation and snow cover on musk-ox group size. American Naturalist 139:190–204.

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 3:339–350.

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.

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

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

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., E.G. Schreiner, and B.B. Moorehead. 1994. Mountain goats in Olympic National Park: biology and management of an introduced species. Scientific Monograph NPS/NROLYM/NRSM-94-25. U.S. National Park Service, Washington, DC.

Jarman, P.J. 1974. The social organization of antelope in relation to their ecology. Behaviour 58:215–267.

Lemke, S.L. 1999. Cayoosh Range mountain goat study results and recommendations. Unpublished report for BC Ministry of Environment, Lands and Parks, Kamloops, B.C., Canada.

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, British Columbia.

Nichols, L. 1985. Mountain goat fidelity to given areas by season and seasonal movements. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration: Final Report Project W-21-1, W-21-2, W-22-1, W-22-2, and W-22-3, Job 12.5 R.

Parish, R., R. Coupé, and D. Lloyd (Editors). 1996. Plants of southern interior British Columbia. Lone Pine Publishing, Vancouver, B.C. Canada.

Poole, K.G., and I. Adams. 2002. Mountain goat monitoring in Canadian Mountain Holidays' Bugaboo and Bobbie Burns heli-hiking areas, East Kootenay, September 2002. Unpublished report for Canadian Mountain Holidays, Cranbrook British Columbia.

Poole, K.G., and G. Mowat. 2002. Mountain goat survey in management units 4-36 and 4-40, East Kootenay, August–September 2002. Unpublished report for Golden and District Rod and Gun Club, Golden, British Columbia.

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.C. Heard. Submitted. Seasonal habitat use and movements of mountain goats in east-central British Columbia. Canadian Field-Naturalist.

Quayle, J. F., A. G. MacHutchon, and D. N. Jury. 2001. Modeling moose sightability in south-central British Columbia. Alces 37:43–54.

RIC (Resources Inventory Committee). 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. Resources Inventory Committee, B.C. Ministry of Sustainable Resource Management, Victoria, British Columbia, Canada.

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. 1977. Influence of snow condition on winter distribution, habitat use, and group size of mountain goats. Pages 174–189 *in* W. Samuel and W.G. Macgregor, editors. Proceedings of the First International Mountain Goat Symposium, Kalispell, Montana. B.C. Fish and Wildlife Branch, Victoria, B.C., Canada.

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

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

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

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

Teske, I.E., and B. Forbes. 2001. Southern East Kootenay mountain goat aerial survey. Unpublished report. Wildlife Branch, British Columbia Ministry of Environment, Lands and Parks, Cranbrook, British Columbia.

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

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.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, British Columbia.