Mountain goat by Helmet Fall, KNP

Mountain goat survey in Management Units 4-35 and 4-16, Kootenay region, British Columbia, August-September 2006

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December 2006

ABSTRACT

Mountain goats (*Oreamnos americanus*) are managed as a big game species in British Columbia, and as such, aerial surveys are conducted periodically to document population trend and productivity, and to establish hunting quotas. To continue to update estimates for the Kootenay region of southeastern British Columbia, I conducted mountain goat surveys during August and September 2006 within portions of wildlife management unit (MU) 4-35 southeast of Golden in the East Kootenay, and MU 4-16 off the Slocan Valley in the West Kootenay. Portions of Kootenay National Park (KNP) and Yoho National Park (YNP) within MU 4-35 were surveyed. The objectives of these surveys were to determine the numbers and distribution of mountain goats during late summer.

MU 4-35 is within the Rocky Mountains, and MU 4-16 is within the Selkirk Mountains of the Columbia Mountains. Standard survey techniques were followed using a Bell 206B helicopter. All goats were classified to kid or non-kid (yearlings and older; hereafter adults).

Within MU 4-35 we used 23.8 hrs of helicopter time, including 19.5 hrs on survey, and surveyed a 562-km^2 census zone of potential goat habitat. Overall survey intensity averaged 2.1 min/km^2. We observed 633 goats in 182 groups, and counted 124 kids (20% of total goats), a 24 kids:100 adults ratio. Elevations of goat groups ranged from 5,600 to 9,600 feet ($\bar{x}$ = 7,390 feet; median = 7,400 feet), and 67% of observed goats occurred in the 7,100–7,800 foot band. Based on 60–65% sightability, I estimated 1,018 goats for the census zone (density of 1.81 goats/km^2). Corrected estimates for subzones 4-35A and 4-35 B and the portions of KNP and YNP surveyed were 169, 518, 267, and 65 goats, respectively.

Within subzones 4-16 A and C we used 5.6 hrs of helicopter time, including 4.3 hrs on survey, and surveyed a 114-km^2 census zone of potential goat habitat. Survey intensity averaged 2.3 min/km^2. We observed 42 goats in 16 groups, and counted 10 kids (24% of total goats), a 31 kids:100 adults ratio. Elevations of goat groups ranged from 4,200 to 7,200 feet ($\bar{x}$ = 6,090 feet; median = 6,000 feet), and 62% of observed goats occurred in the 5,500–6,700 foot band. Based on 50% sightability, I estimated 84 goats for the census zone (density of 0.74 goats/km^2).

Within subzones 4-35A and B we estimated 46% more goats than estimated during comparable counts conducted in 2000, and estimated likely twice as many goats within the KNP portion of MU 4-35 as recently thought. These results, along with survey data from other areas in the East Kootenay from 2002–2005, continue to suggest a reversal from perceived declines reported in the late 1990s and 2000 in mountain goat numbers in the region.

Suspected poor sightability of goats in MU 4-16 provided little confidence in the estimate of goats within the areas surveyed. In areas similar to MU 4-16, more effort may be required to explore the most optimum timing for surveys, or other techniques (e.g. DNA sampling) should be explored to more accurately track trends in goat numbers or estimate population size.

Estimated densities of goats obtained from surveys since 2002 continue to suggest an ecological basis for goat densities in southeastern British Columbia that could be used to estimate goat numbers in un-surveyed areas, and to track goat numbers across broad areas by sub-sampling a smaller area more frequently. I suggest this approach warrants further review.

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INTRODUCTION

Mountain goats (*Oreamnos americanus*) are a high profile species in British Columbia, valued by hunters and non-hunter alike. Within the Kootenay region of southeastern British Columbia, most goat hunting is through a limited entry permit system for residents and a quota system for non-residents based on estimated population size (Poole 2006). Periodic surveys are required to update population estimates to ensure that harvests are sustainable. Within national parks, estimates of population size of larger mega-fauna are used to broadly inventory species abundance, to track changes in population levels, and to contribute to a national program of ecological integrity monitoring.

Surveys conducted since 2002 have updated mountain goat estimates within significant portions of both the Purcell and Rocky mountains in southeastern British Columbia (Poole and Adams 2002, Poole and Mowat 2002, Poole 2003, Poole 2004, Poole and Klafki 2005), and in general found higher numbers than thought present in the late 1990s and 2000 (Halko and Hebert 2000, Teske and Forbes 2001). To continue to update estimates for the region, I conducted mountain goat surveys during August and September 2006 within 2 wildlife management units (MU; 4-35 and 4-16) within the Kootenay region. These units were chosen because they had dated population estimates that suggested unsustainably high harvest rates (Poole 2006). Large portions of MU 4-35 abut Yoho National Park (YNP) and Kootenay National Park (KNP); thus, these surveys provided an opportunity to efficiently survey entire mountain blocks split between provincial Crown and federal protected lands. The objectives of the surveys were to determine the number and distribution of mountain goats within these areas. Data obtained will be used to refine current harvest management strategies, habitat quality assessments, and land use designations and management.

STUDY AREA

Selected survey areas were portions of MUs 4-35 in the East Kootenay and 4-16 in the West Kootenay (Fig. 1). Surveys in MU 4-35 were divided into 2 main ranges of the Rocky Mountains; the Beaverfoot Range (the front range between the Columbia Valley and the Beaverfoot and Kootenay valleys; primarily in subzone 4-35B), and the Vermillion Range (primarily between the Kootenay and Vermilion valleys (subzone 4-35A of provincial lands), including adjacent areas in KNP and YNP. MU 4-16 is located off the Slocan Valley in the Selkirk Mountains of the Columbia Mountains, and subzones 4-16 A and C, south of Valhalla Provincial Park, were surveyed.

Potential goat habitat in the study areas primarily is made up of 2 biogeoclimatic zones: the Engelmann Spruce-Subalpine Fir (ESSF) zone and the Alpine Tundra (AT) zone above tree line. Tree line is generally located between 1,900–2,150 m (6,250–7,050 ft). July and January mean temperatures for Golden are 17.2ºC and –10.1ºC, respectively, and for Castlegar, 19.9ºC and –3.2ºC, respectively (Environment Canada climate normals, unpublished data). Golden receives an average of 491 mm of precipitation including 184 cm of snowfall annually. Castlegar receives an average of 533 mm of precipitation including 225 cm of snowfall annually. Climate varies within the study areas, with cooler temperatures and deeper snowfalls at higher elevations and on north and east-facing slopes. The Selkirk Mountains generally have deeper and wetter snow, and the Rocky Mountains have shallow and drier snow. 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 alpine larch (*Larix lyallii*) and whitebark pine (*Pinus albicaulis*) at the highest elevations (Parish et al. 1996). In the AT zone, conifers are present only in stunted krummholz forms. Glaciers with associated moraine deposits are found in portions of the study areas. We surveyed census zones of potential goat habitat, which generally included steep or cliff habitat above 6,000–6,500 feet (1,850–2,000 m) elevation and below tree line down to about 5,500 feet (1,675 m). (Feet will be provided as the unit of

measure because the helicopter's altimeter was in feet). Some areas of MU 4-16 were surveyed to lower elevations (4,000 feet).

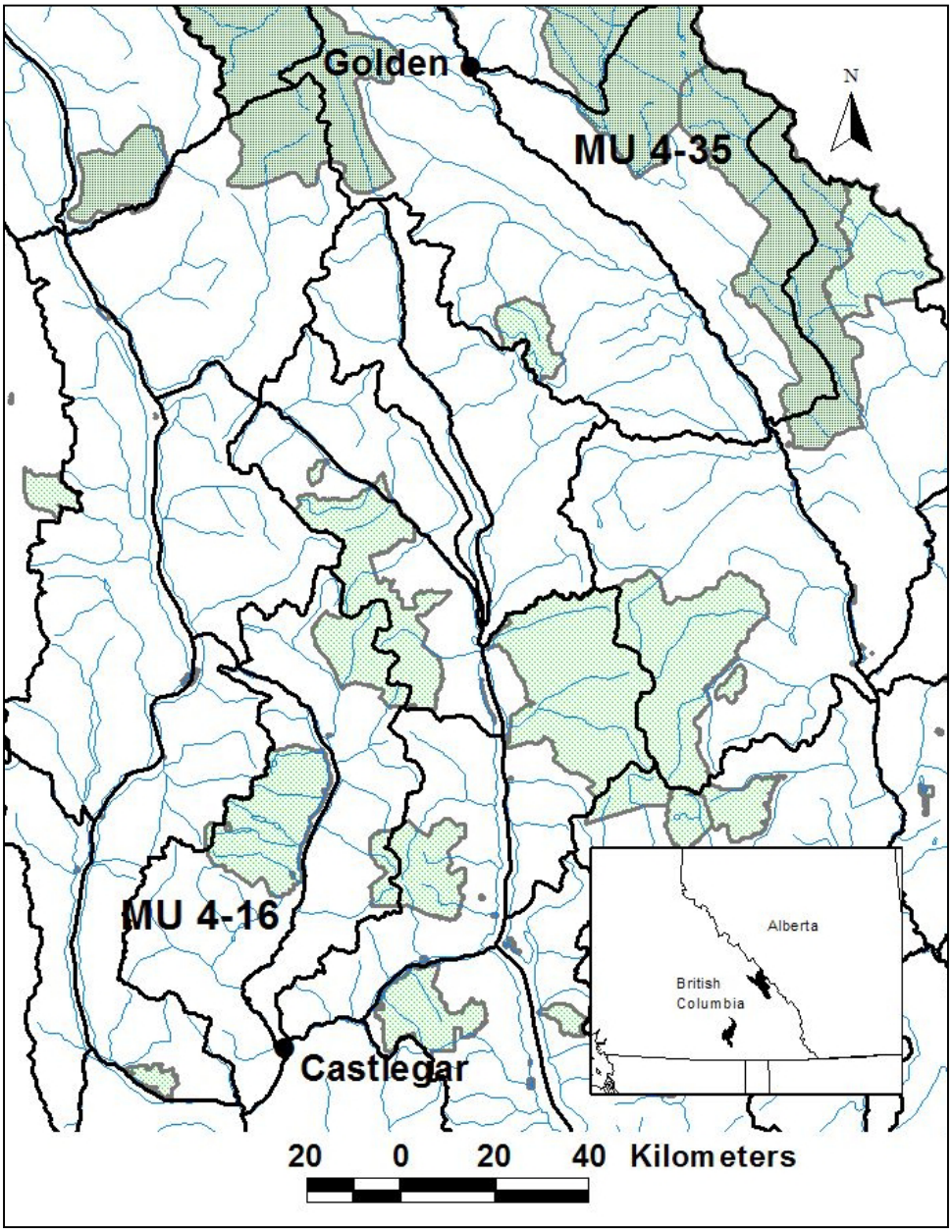

Figure 1. Wildlife management units (MU) 4-35 and 4-16 (black outlines), Kootenay region, portions of which were surveyed for mountain goats during August – September 2006. National parks are shown in dark green shading, provincial parks in light green shading.

STUDY DESIGN AND METHODOLOGY

Study design and methodology generally followed RISC standards (RISC 2002, Poole 2007), and consisted of a total count survey, with sightability correction subjectively applied afterwards. The census zones were divided into blocks (survey units), which usually consisted of discrete mountain blocks that we were able to survey within 1–2.5 hours to avoid observer fatigue, maximize helicopter refuelling efficiency, and minimize the risk of animal movement within and out of blocks during the survey period. To take advantage of cooler survey conditions (<10ºC) when goats may be more active and visible, we started surveys at first light (~06:30–07:00 hrs) and generally finished by mid-day (11:30–13:00 hrs).

We used a Bell 206B Jet Ranger helicopter with pilot, navigator, and 2 observers. All occupants participated in locating mountain goats, and all had some or extensive experience at aerial surveys. We surveyed all alpine and open subalpine habitat, as well as areas of broken or disjointed cliffs and avalanche chutes below tree line. Within WMU 4-16, greater emphasis was placed on forested habitats below tree line. Generally starting at the lowest elevation, we flew roughly 150–200 m (500–650 foot) contour lines at 80–120 km/hr, 75–100 m out from the hillsides. We mapped approximate flight lines and survey coverage on 1:50,000 scale topographical maps and calculated the census zone based on the area surveyed. We also recorded broad habitat type, elevation from the helicopter's altimeter (estimated to the nearest 100 feet), and behaviour of goat groups when first spotted. Goat locations and helicopter flight tracks were recorded with a hand-held global positioning system (GPS) unit, which was later downloaded to a computer. 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 agree 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, although inconsistent effort was given to age and sex classification of other ungulates.

RESULTS

Management unit 4-35 – Beaverfoot valley

The census of MU 4-35 was conducted between 13 and 16 August 2006. Survey conditions were generally good with clear skies or high overcast, and light winds. Temperatures within the census zone were 4–10ºC (average 6.2ºC) at survey time. We used 23.8 hrs of helicopter time, including 19.5 hrs on survey, and surveyed a census zone of 562 km^2. Overall survey intensity averaged 2.1 min/km^2 (range among blocks: 1.6–3.0 min/km^2; Table 1). Survey effort was higher in the Beaverfoot Range (2.4 min/km^2) compared with Vermillion Range (1.7 min/km^2), because of greater vegetation cover and more broken and complex cliff formations within potential goat habitat in the former.

We observed 633 goats in 182 groups (Fig. 2), an average density of 1.13 goats/km^2. Group size ranged from 1 to 24 and averaged 3.5 ± 0.29 ($\bar{x}$ ± SE). "Typical" group size, an animal-centred measure of the group size within which the average animal finds itself (Jarman 1974, Heard 1992), was 8.0 (± 0.26). Nearly two-thirds (65%) of goat groups consisted of 1–2 animals, but only 14 large groups (≥10 goats) accounted for nearly one-third of the total animals observed. Overall we counted 124 kids (20% of total goats), a 24 kids:100 adults ratio. Based on past experience and other research (summarized in Poole 2007), I applied a sightability correction factor of 0.60 to the Beaverfoot Range (subzone 4-35B), and 0.65 to the Vermillion Range (4-35A). This resulted in an estimate of 1,018 goats for the census zone (density of 1.81 goats/km^2), including 568 goats in the Beaverfoot Range (1.88 goats/km^2), and 449 goats in the Vermillion Range (1.73 goats/km^2). Comparing data between

Beaverfoot and Vermillion ranges, kids ratios were almost identical (25 versus 24 kids:100 adults, respectively), as was the uncorrected density within the census zone (1.13 versus 1.12 kids/km^2, respectively) (Table 1).

Table 1. Mountain goats observed by survey block, Kootenay region, August – September 2006. Block numbers correspond to map numbers in Figs. 2 and 3. "Adults" refers to non-kids (yearlings and older).

Date	Block no.	Name	Area	Total	Adults	Kids	Time on survey (min)	Census area (km^2)	Survey effort (min/km^2)	Density (goats/km^2)
13-Aug-06	1	Kapristo	Beaverfoot	82	65	17	98	41.0	2.4	2.00
13-Aug-06	2	Fraser	Beaverfoot	44	36	8	67	32.8	2.0	1.34
13-Aug-06	3	Tower	Beaverfoot	93	71	22	90	33.7	2.7	2.76
13-Aug-06	4	Castle	Beaverfoot	47	42	5	95	36.0	2.6	1.31
14-Aug-06	5	Quinn	Beaverfoot	33	24	9	106	51.8	2.0	0.64
14-Aug-06	6	Baptiste	Beaverfoot	7	7	0	76	31.6	2.4	0.22
14-Aug-06	7	Mt Crook	Beaverfoot	3	2	1	68	28.4	2.4	0.11
16-Aug-06	8	Kindersley	Beaverfoot	12	9	3	75	25.0	3.0	0.48
16-Aug-06	9	Berland	Beaverfoot	20	17	3	47	21.8	2.2	0.92
15-Aug-06	10	Mt Goodsir	Vermillion	59	50	9	86	54.7	1.6	1.08
15-Aug-06	11	Helmet Mt	Vermillion	81	61	20	98	51.6	1.9	1.57
15-Aug-06	12	Dainard S	Vermillion	32	25	7	69	44.0	1.6	0.73
15-Aug-06	13	Floe L	Vermillion	34	29	5	87	51.2	1.7	0.66
16-Aug-06	14	Mt Wardle	Vermillion	86	71	15	102	58.7	1.7	1.47
		Subtotal	Beaverfoot	341	273	68	722	302	2.4	1.13
		Subtotal	Vermillion	292	236	56	442	260	1.7	1.12
		Total	**4-35**	**633**	**509**	**124**	**1164**	**562**	**2.1**	**1.13**
24-Sep-06	1	Airy-Russel	4-16C	11	9	2	111	50.0	2.2	0.22
24-Sep-06	2	Hoder-Bannock	4-16A	15	12	3	95	43.0	2.2	0.35
24-Sep-06	3	Dago	4-16C	16	11	5	52	21.0	2.5	0.76
		Total	**4-16A, C**	**42**	**32**	**10**	**258**	**114**	**2.3**	**0.37**

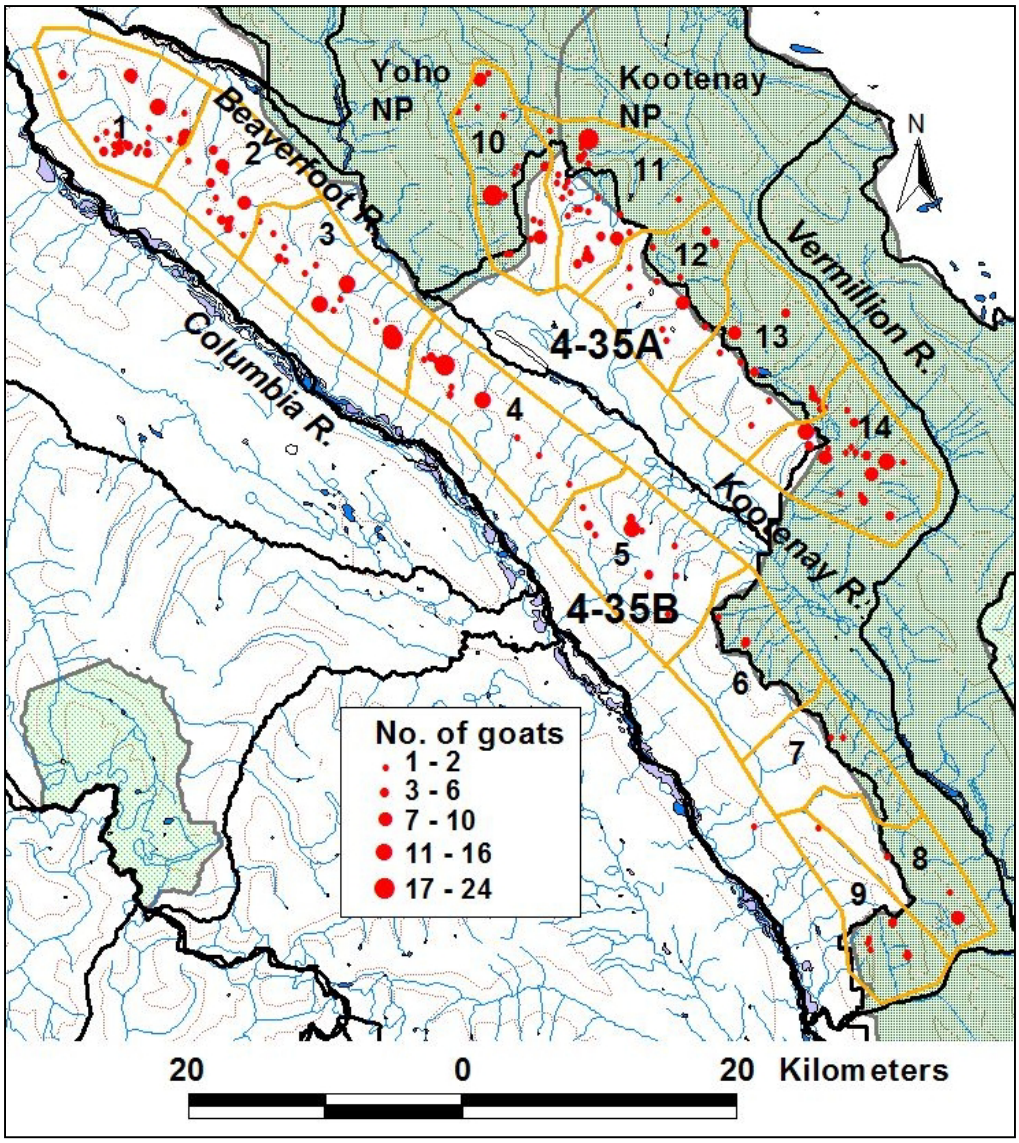

Figure 2. Location and number of mountain goats observed in Management Unit 4-35, 13–16 August 2006. Orange lines and black numbers refer to survey blocks (Table 1). Limited Entry Hunting subzone boundaries are in black (4-35A and 4-35B). The census zone covered potential goat habitat, generally above 6,000–6,500 feet elevation.

Elevations of goat groups generally ranged from 5,600 to 9,600 feet ($\bar{x}$ = 7,390 ± 45 feet; median = 7,400 feet); 67% of observed goats occurred in the 7,100–7,800 foot band. Two goats also were observed at a known mineral lick in a canyon in the Columbia Valley at 3,300 feet elevation.

Including all data from both ranges, mean elevation of goat groups with kids was similar to groups with no kids (7,360 feet versus 7,350 feet, respectively; *t*-test, $t = 0.06$, 180 df, $P = 0.95$). We observed 60% of goat groups in cliff/broken cliff complexes ($n = 182$ groups). Other habitats used included alpine meadows or alpine barrens (13%), scree/talus (9%), ridge tops (7%), and

krummholtz/subalpine (10%). Behaviour of goat groups when first observed included standing (31%), running (31%), walking (25%), and bedded (13%; n = 182 groups).

In a separate exercise for the BC Ministry of Environment, I updated current estimated goat numbers for the Kootenay for MU 4-35, including goat Limited Entry Hunting (LEH) zone, and guide/outfitter territory (K. Poole, unpublished data, November 2006). As standardized in that exercise, to assign goats located near boundaries I assigned half the total number of goats observed within a 1-km buffer on either side of boundaries along heights of land, and between national parks and provincial lands, to each side of the boundary.

The estimated number of goats in subzones 4-35B and 4-35A were 518 and 169 goats, respectively (Table 2). An estimated 267 goats occurred in the census zone within KNP, the bulk of which were in the Vermillion Range. Kid ratios did not appear to differ substantially between areas inside and outside of national parks, although subzone 4-35B had the highest overall ratio (as well as the largest sample size). Highest densities of goats were found in the northwestern end of the Beaverfoot Range, and the northwestern and southern ends of the Vermillion Range, and the southeastern end of the Beaverfoot Range had the lowest densities observed (Table 1, Fig. 2).

Table 2. Distribution of mountain goats observed during surveys in Management Unit 4-35, East Kootenay, August 2006. Kootenay and Yoho national park totals reflect only those portions of the parks surveyed.

Range	Area[1]	Goats in core	Goats in buffer	Obs. goats	Sightability	Corrected estimate	Kid ratio (in core)
Beaverfoot Range	**4-35B**	303	15 (8)[2]	311	0.60	518	26
	KNP	23	15 (8)	31	0.60	52	21
Vermillion Range	**4-35A**	59	101 (51)	110	0.65	169	23
	KNP	96	89 (44)	140	0.65	215	23
	YNP	36	12 (6)	42	0.65	65	
	KNP total	119	104 (52)	171	0.60/0.65	267	

[1] KNP = Kootenay National Park; YNP = Yoho National Park.
[2] Numbers in brackets are half of goats observed in 1-km buffer area.

Other wildlife observed during the survey included 84 mule deer (*Odocoileus hemionus*), 4 elk (*Cervus elaphus*), 80 bighorn sheep (*Ovis canadensis*), and 4 black bears (*Ursus americanus*). Age and sex classification for most ungulates were generally not attempted or consistent. Most mule deer were observed in blocks 4, 5, and 8 at 7,000–8,000 foot elevation in the Beaverfoot Range. All sheep were observed in 4 groups in the southeastern end of the Beaverfoot Range (blocks 7, 8, and 9). Nine lambs were present in the sheep groups.

Management unit 4-16 – Slocan Valley

An attempt to census MU 4-16 was conducted on 31 August 2006. Despite cool temperatures (1ºC), very few goats were observed, most were at low elevation (<6,800 feet), and most were extremely dirty in colour. Snow the previous couple of days made for difficult sightability, and likely contributed to the dirt on the goats. We used 4.0 hours of helicopter time, including 3.1 hours on survey within a census zone of 81 km^2 (2.3 min/km^2). Only 10 goats were observed (8 adults, 2 kids). Partway through this survey it was decided to attempt a re-survey at a later date when survey conditions and goat distribution may be more acceptable.

Portions of MU 4-16 were surveyed again on 24 September 2006, including all areas covered in the first survey attempt. Survey coverage was not continuous throughout the subzones of interest because of budget limitations; we attempted to survey areas historically known to harbour goats (see Discussion). Survey conditions were generally good with clear skies and light winds. Temperatures within the census zone were warm at survey time (10–17ºC; average 13.3ºC) because of an apparent inversion. We used 5.6 hrs of helicopter time, including 4.3 hrs on survey, and surveyed a census zone of 114 km^2. Overall survey intensity averaged 2.3 min/km^2 (range among 3 blocks: 2.2–2.5 min/km^2; Table 1).

We observed 42 goats in 16 groups (Fig. 3), an average density of 0.37 goats/km^2. Group size ranged from 1 to 7 and averaged 2.6 ± 0.46. Typical group size was 3.8 (± 0.30). We observed 10 kids (24% of total goats), a 31 kids:100 adults ratio. Based on past experience and other research (summarized in Poole 2007), I applied a likely conservative sightability correction factor of 0.50, which resulted in an estimate of 84 goats for the census zone (density of 0.74 goats/km^2), 30 goats for 4-16A and 54 goats for 4-16C. Because of few goats observed near boundaries and essentially no survey effort outside of the MU, I did not adjust for the few goats found within the 1-km buffer from MU boundaries.

Elevations of goat groups ranged from 4,200 to 7,200 feet ($\bar{x}$ = 6,090 ± 198 feet; median = 6,000 feet); 62% of observed goats occurred in the 5,500–6,700 foot band. Mean elevation of goat groups with kids was similar to groups with no kids (5,970 feet versus 6,170 feet, respectively; *t*-test, t = 0.48, 14 df, P = 0.64). We observed 69% of goat groups in cliff/broken cliff complexes (n = 16 groups). Other habitats used included avalanche tracks (13%), scree/talus (13%), and timber (6%). Behaviour of goat groups when first observed was not recorded.

The only other species observed during surveys of MU 4-16 were 3 mule deer on 31 August.

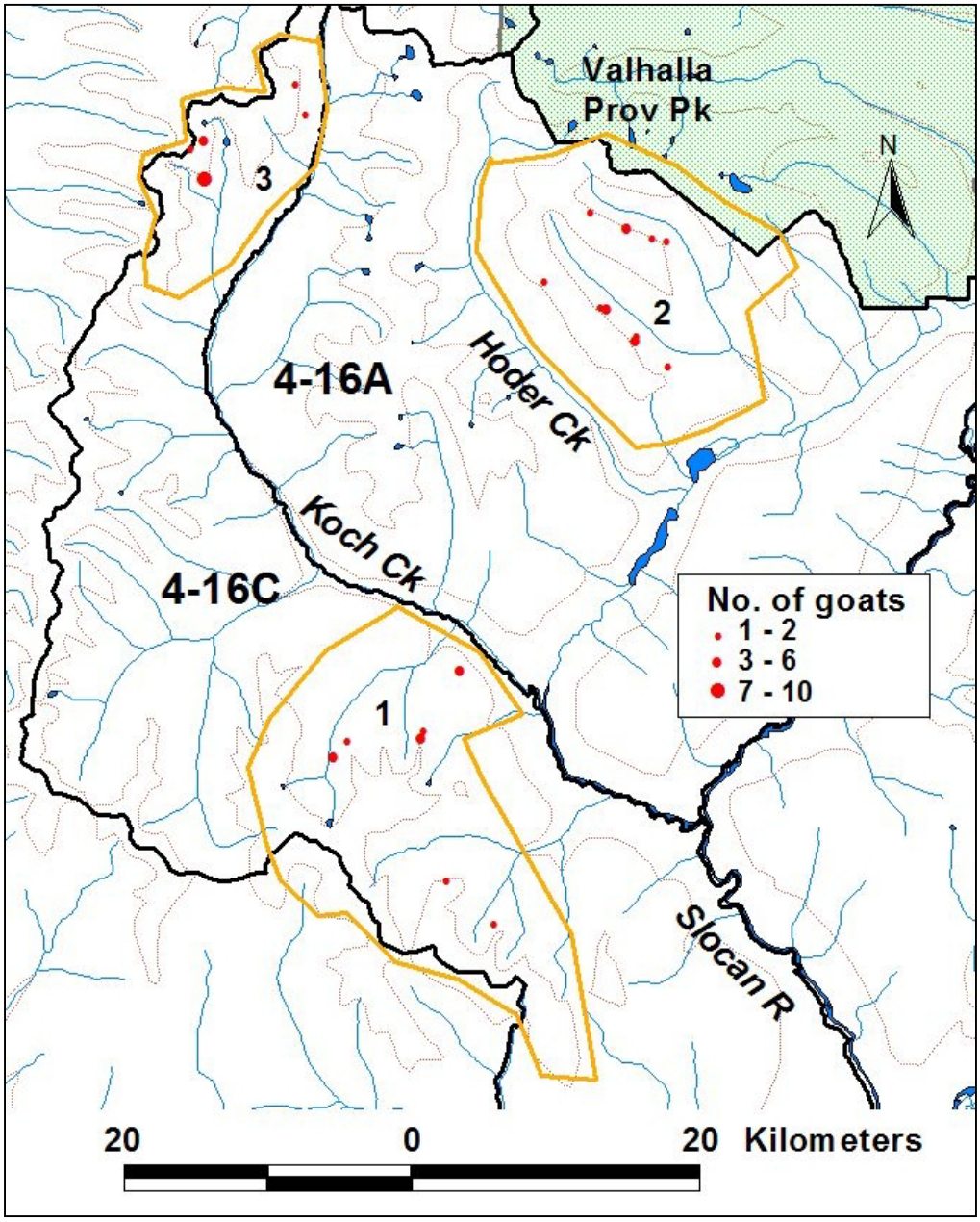

Figure 3. Location and number of mountain goats observed in portions of Management Unit 4-16, 24 September 2006. Orange lines and black numbers refer to survey blocks (Table 1). Limited Entry Hunting subzone boundaries are in black (4-16A and 4-16C). The census zone covered potential goat habitat.

DISCUSSION

Population estimates

Goat numbers in MU 4-35 appear to be higher than recent estimates. Surveys conducted within LEH subzone boundaries in August 2000 observed 18 goats in subzone 4-35A and estimated 36 goats (based on 50% sightability), while in 4-35B, 217 goats were observed and 434 were estimated (Teske and Forbes 2001). Using lower sightability corrections (60–65%), surveys from August 2006 observed 110 and 311 goats in subzones 4-35A and 4-35B, respectively, and estimated 169 and 518 goats, respectively. Direct comparison between surveys is difficult, in part because of a lack of detail from the 2000 survey about coverage and effort (minutes spent in the census zone of potential goat habitat). The 2000 count of subzone 4-35A seems particularly low, perhaps because of low survey effort or poor coverage; only 45 minutes separated the first and last goat groups observed during that survey, whereas roughly 170 minutes were used to survey the same area in 2006. Overall, the estimated goat numbers within subzones 4-35A and B are 46% higher than the 2000 estimates (19% increase for subzone 4-35B alone). Given different sightability corrections (in part to account for lower survey effort in 2000) and suspected lower survey coverage in 2000, it is difficult to conclude whether real changes in goat numbers occurred from 2000 to 2006, but goat populations in 2006 appear to be slightly higher than numbers present in 2000. Kid ratios from the 2000 survey (33 kids:100 adults) were higher than ratios observed in 2006 for both subzones (26:100).

Goats have not been surveyed on a consistent basis within Kootenay and Yoho national parks since the 1980s. Surveys in KNP in 1999 observed about 90 goats in areas that held about 230 goats in the 1980s (A. Dibb, personal communication, September 2005). In another area no animals were observed under good survey conditions and thorough coverage, where small numbers of goats were consistently seen in the 1980s (A. Dibb, personal communication, November 2006). Thus, all indications suggest lower numbers of goats were present in these parks during the late 1990s, with goat numbers down in prime ranges and absent from marginal ranges. Recent "back of the envelope" calculations for goat numbers in KNP (acknowledging that surveys are dated and background knowledge is limited) suggested about 200 goats for the entire park, with about 80 goats for the MU 4-25 portion and 120 goats for the MU 4-35 portion (A. Dibb, personal communication, September 2005). The current surveys covered the entire MU 4-35 portion of KNP, with the exception of ranges on either side of Tokumm Creek in the northern portion of the park near the continental divide. From an observed 171 goats, 267 animals were estimated, over twice the recent estimate for the MU 4-35 portion of the park. Additional goats likely occur in the northern portion of KNP within MU 4-35 to increase this estimate further. Whether this reflects an increase in goat numbers compared with recent times, or simply a more accurate and reliable count, is unclear, but it is likely a combination of these two factors. Regardless, it is likely that the mountain goat population in KNP is far higher than recently thought.

During the current survey only a small portion, perhaps 10%, of YNP was surveyed (all in MU 4-35); 42 goats were observed and 65 were estimated. Recent estimates for YNP are even more sparse than those for KNP (A. Dibb, personal communication, September 2005). McCrory et al. (1977) divided the park into 5 regions; their estimated total for the Ottertail Range (which encompasses the 2006 survey area) was 220 goats. With such low spatial and temporal coverage it is difficult to draw conclusions regarding trends in goat numbers in YNP.

The survey of MU 4-16 was difficult to conduct. On both attempts, goats occurred at low elevation and in highly treed and broken areas, rendering suspected sightability low. The second survey was more successful; over 2.5 times as many goats were observed in the same survey areas (blocks 1 and 2) using the same survey effort. A 50% sightability correction factor was applied to the observed number of goats, but I have little confidence whether this is realistic. I suspect that sightability is in fact

far lower in these habitats, but I am unable to quantify these differences. The healthy kid ratio (31:100) is encouraging, but is based on a relatively low sample size.

Little historic data on goat numbers are available for subzones 4-16 A and C. A survey in late September 1996 covering both subzones (7.2 hours on survey) observed 25 goats (Poole and Mowat 1997). During that survey, most animals were observed in blocks 1 and 2, no goats were observed in block 3 (and it is a little unclear whether this block was surveyed), and a few goats were observed west of block 1 in subzone 4-16C. These results suggest that goat numbers in the portions of subzones 4-16 A and C surveyed may have remained stable or increased slightly over the past 10 years, but there is little confidence in this pronouncement.

Although we did not survey all mountainous areas of subzones 4-16 A and C, we covered the 3 known main areas of goat concentration. Hunter kill locations and survey results (Poole and Mowat 1997) suggest that goats are absent or nearly absent from other areas in these subzones, with the exception of scattered animals west of Koch Creek between blocks 1 and 3 (Fig. 3). No goats have been observed during surveys or harvested from the mountain block between Koch and Hoder creeks in subzone 4-16A.

Kid ratios

Kid:adult ratios averaged 24 and 31:100 overall for MUs 4-35 and 4-16, respectively. Past summer/fall surveys in the Kootenay have reported a wide range of ratios since 2000 ($\bar{x}$ = 29:100 adults, range 20–39:100, n = 19; summarized in Poole 2006). Thus, the kid ratio observed in MU 4-35 was a bit lower than the recent average. 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). August kid ratios at Caw Ridge, Alberta, averaged 21:100 over the past 10 years (range 15–29:100), during a period when the population increased by approximately 50% (S. Côté, personal communication). Since much kid mortality can occur over winter and goats generally do not reproduce until 2–3 years of age, moderate to high kid ratios can provide an expectation of some recruitment, but are limited in their utility to predict population change (Côté and Festa-Bianchet 2003).

Sightability

Although standardized surveys have greater utility in being used as indicators of broad population trend over time, rather than absolute estimates of population size (Gonzalez-Voyer et al. 2001, Poole 2007), management agencies still require estimates of population size based on infrequent surveys. Studies show a wide variation in the sightability of mountain goats, affected by a host of factors. Very low survey effort likely will result in poor sightability, but differences in sightability at moderate to higher effort likely are masked by other factors (Poole 2007). Based on local and other studies (summarized in Poole 2007), I assumed that we observed an average of 65% of the goats in the Vermillion Range, and 60% of the goats in the Beaverfoot Range. The slightly lower sightability in the Beaverfoot Range was because of a higher tree line, greater association by goats with forested habitats, and more complex and broken cliff formations. Proportionately more cliff faces in the Vermillion Range could be easily scanned with little chance of missing goats. I suggest our sightability may err on the conservative side, but I am unable to verify the accuracy of these estimates. Different sightability corrections could be applied through different interpretation of past sightability studies or the degree of risk managers are willing to take (e.g., by managing for a larger goat population than actually exists).

It is obvious that sightability of mountain goats in the portions of MU 4-16 surveyed was low, but I have limited experience to suggest a realistic sightability correction factor. Given the roughly doubling of goats observed between surveys in 2006, it is clear that sightability for this area can easily change by a factor of 2 or more, but it is less clear what the corrections might be. Few observed goats

were located in more typical, open rocky areas at higher elevation, and most animals were found at low elevations. During a survey of Valhalla Provincial Park (subzone 4-16B) on 18 July 1989, 83% of 18 goat groups were located at 7,500 foot and higher elevation (D. Heagy, British Columbia Parks, unpublished data). It is unclear whether goats south of the Park typically do not inhabit higher elevation areas where sightability may be higher, or whether this may occur during other periods of the year. I have suggested the 50% sightability correction as a conservative correction factor for the survey of MU 4-16, but I suspect our sightability was considerably lower.

Density

Recent surveys in adjacent areas of the Rocky Mountains and Purcell Mountains have generated fairly similar goat densities within census zones among areas (Table 3). Density estimates from the 2 areas surveyed here support these trends. These consistencies lend support for an ecological basis for goat densities in southeastern British Columbia, possibly related to broad habitat carrying capacity or similar density-independent factors in operation (e.g., weather, predation), and could lead to the ability to model and extrapolate density estimates to other areas. This pattern should be further explored.

Table 3. Estimated density of mountain goats in the Kootenay Region, 2002–2006 (data from Poole 2006).

Area	Date	Density (no./km^2)
Rocky Mountains		
Flathead	2005	1.26
Elk	2005	1.69
White	2005	1.66
Bull	2004	1.83
MU 4-35	2006	1.81
North of Golden	2002	0.28
Purcell Mountains		
St. Mary	2005	0.67
MU 4-26	2004	0.62
Bugaboos, Bobbie Burns	2002	0.43
Bobbie Burns	2003	0.77
Selkirk Mountains		
MU 4-16	2006	0.74

Management recommendations

The results of the MU 4-35 survey are consistent with increased numbers of goats observed and estimated on all surveys conducted in the East Kootenay since 2002, including portions of the northern and central Purcell Mountains (Poole and Adams 2002, Poole 2003, Poole 2004), and the central and southern Rocky Mountains (Poole 2004, Poole and Klafki 2005). A review of goat estimates for the East Kootenay suggests that there remains several areas where surveys are dated or non-existent, or

where harvest rates appear to be unsustainably high (Poole 2006). These areas should be surveyed if funding becomes available. In lieu of more intense monitoring in selected study areas (see below) all areas should be resurveyed roughly every 5 years to provide greater confidence in population trends.

Previous survey data from KNP were dated, followed inconsistent methodology, and were limited in coverage, thus, with the exception of the current survey, there is little basis for producing a reliable, current estimate of goat numbers for the entire park. Since it is efficient and effective to cover entire mountain blocks during surveys, the national parks may wish to take advantage of and supplement surveys of adjacent provincial lands to increase their knowledge of goat numbers within their boundaries.

Because of suspected poor sightability, surveys of habitats and areas similar to MU 4-16 may not result in reliable estimates of goat numbers. In these areas, more effort may be required to explore the most optimum timing for surveys, or other techniques (e.g. DNA sampling, or ground-based inventories) should be explored to more accurately track trends in goat numbers or estimate population size.

The close agreement in goat densities within potential goat habitat (the census zone) in adjacent areas (Table 3) suggests that it may be possible to both estimate goat densities in un-surveyed portions of these broader areas, as well as roughly track trends in goat numbers across large areas between surveys by sub-sampling a smaller area more frequently and extrapolating relative changes elsewhere. One requirement for using this method would be to calibrate relative differences in density among areas. For example, although densities appear similar from the Bull River north to MU 4-35, north of Golden in the Rocky Mountains estimated goat densities were considerably lower. Another requirement would be to determine the potential census zone within each MU, which could be completed with a GIS mapping project that identifies potential goat habitat (e.g., steep or cliff habitat above 6,000–6,500 feet (1,850–2,000 m) elevation and below tree line down to about 5,500 feet (1,675 m)). I feel that this method should be explored as more current mountain goat estimate data become available.

ACKNOWLEDGEMENTS

This survey was funded by British Columbia Ministry of Environment under the Recreational Stewardship Inventory Program, and by Parks Canada (Lake Louise, and Yoho and Kootenay National Park Field Unit). R. Klafki assisted with background research and study set-up, and I thank him for his efforts. D. McTighe, Alpine Helicopters, provided piloting for the MU 4-35 survey, and D. Damron and S. Lenarduzzi, High Terrain Helicopters, piloted the MU 4-16 surveys. I. Teske provided primary observer assistance. M. Anderson, L. DeGroot, G. Mowat, D. Goodwin, and T. Wolfenden provided additional observer assistance, and I thank all observers for their efforts. I. Teske provided logistic and administrative support. I thank members of the Southern Guides and Outfitters, the East Kootenay Wildlife Association, and local hunters for sharing their knowledge of mountain goat distribution, and members of the Southern Guides and Outfitters for assisting during the survey. I. Teske and A. Dibb reviewed an earlier draft of this report.

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