Mountain goats on Bugaboo Pass

A population review of mountain goats in the Kootenay Region

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Introduction

Over half of the world's mountain goats (*Oreamnos americanus*) are found in British Columbia (Côté and Festa-Bianchet 2003), and the province is considered the geographic heart of North American goat range (Vogel et al. 1995). Thus, provincial responsibility for the conservation of this species is high. Mountain goats are widespread in the Kootenay Region (Region 4) of southeastern BC (Shackleton 1999), with roughly 12–13% of the provincial total (Hatter 2005b). Greater numbers (approximately 80%) of the estimated Kootenay Region goat population is found in the East Kootenay (EK) compared with the West Kootenay (WK). High-density populations are located throughout the Rocky and Purcell mountains.

At the request of the BC Ministry of Environment (MoE), Kootenay Region, I was tasked to review current and historic population information about mountain goats in the Kootenay Region, including analysis of what is know about population dynamics that can be used to set harvest and conservation objectives and identify knowledge gaps. This report has the following objectives:

1. Critically review all population data and summarize historic and current population size, population density, and population trajectory information, drawing on all available sources of information. Focus on data from the Kootenay Region but if nearby areas are relevant to our regional understanding then present these too.
2. Summarize information on vital rates such as reproduction and mortality and present these measures across time;
3. Summarize harvest rate data comparing harvest numbers and population estimates; and
4. Summarize data for the entire region, or for ecological units, as appropriate;

Relevant ecology of mountain goats

I present here a brief review of the relevant population ecology and dynamics of mountain goats. Much of this information is summarized in Côté and Festa-Bianchet (2003). A large portion of the recent insights into goat ecology is based on research conducted at Caw Ridge in west central Alberta, the continent's best known and best studied mountain goat population.

Habitat and competition

Mountain goats primarily inhabit alpine and subalpine areas in northwestern North America, often residing in areas with snow cover for more than half the year. Two distinct ecotypes of goats have been proposed for western Canada, a coastal ecotype that typically winters at lower elevations in forested habitats, and an interior ecotype that inhabits areas of generally drier and lower snowfalls (Hebert and Turnbull 1977). Interior populations in the Kootenay Region undergo seasonal movements tied to elevation, utilizing higher elevation at or above treeline during summer and fall, and lower elevations during spring and early summer (related to access to green-up vegetation and mineral licks). Interior 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. There appears to relatively low risk from logging on most winter range in the Kootenay (Poole and Heard 2003, Poole et al. 2006).

Declines in mule deer (*Odocoileus hemionus*) 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, resulting in changes to recruitment and survival.

Rocky mountain bighorn sheep (*Ovis canadensis*) is the only ungulate that has the potential to overlap mountain goat range for most of the year. In the Kootenay Region, sheep only occur in east of the

Columbia Valley trench. Laundré (1994) suggested that while substantial overlap in forage classes occur between species (less so during winter), there is little evidence of resource overlap and competition within sympatric populations, largely due to differences in selection of habitat.

Mineral licks

Interior populations of mountain goats 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 1971, Hopkins et al. 1992, Poole and Heard 2003, Poole and Bachmann 2006). 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 (Hebert and Cowan 1971). Goats generally use traditional trails to access licks. These trails often traverse extensive areas of forest, and goats may stage and rest at rocky bluffs within the timber as they make periodic excursions to the lick (Hebert and Cowan 1971).

Reproduction and growth

Mountain goats breed from late October to early December, normally peaking 15–20 November (Côté and Festa-Bianchet 2003; S. Côté, personal communication). Goats give birth between mid-May and early June. Data from Caw Ridge suggest females product 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 (Festa-Bianchet et al. 1994, Côté and Festa-Bianchet 2001). While 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 year of age (Côté et al. 1998a).

Productivity and survival

Kid production peaks at 4–6 year of age (6 years at Caw Ridge, 1–2 years earlier in other populations and with introduced herds), and at Caw Ridge increases slightly from ages 6 to 9 (Côté and Festa-Bianchet 2001). Productivity and reproductive senescence begin at 10 years of age. 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).

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 goats – wolves (*Canis lupus*), cougars (*Felis concolor*) and bears (*Ursus* spp.; Côté and Festa-Bianchet 2003) – may become more numerous within the forest matrix, resulting in higher levels of predators being supported by higher numbers of prey other than goats, and goats therefore being taken more often as secondary prey.

Disturbance

The potential effects of human disturbance on goats has been summarized and well-debated elsewhere (Hatler 2001, Wilson and Shackleton 2001, Hurley 2004, Goldstein et al. 2005). Studies to further examine this topic are reported to begin shortly in the Skeena Region of BC (S. Gordon, MoE, Smithers). Broad-scale declines in mountain goats in the Kootenay Region during the 1990s attributed to helicopter disturbance (B. Forbes, Section Head, BC Ministry of Water, Land and Air Protection [WLAP], Cranbrook, BC, letter of 5 June 2000) have been unproven, and also apparently occurred in the National

Parks, where helicopter disturbance is minimal. Although helicopter and human disturbance can undoubtedly affect goats at both the individual and population scales, the results of these potential impacts are unknown. Ground disturbance related to road access may be important.

Density dependence

Introduced herds 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, Williams 1999). 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. 2001, Gonzales Voyer et al. 2003, Hamel et al. 2006). 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 to harvest or natural declines have been reported for native populations (Côté et al. 2001, Gonzales Voyer et al. 2003). With a doubling of the Caw Ridge population over the past 15 years (Hamel et al. 2006), there has been no evidence of density dependence in kid production or survival, or recruitment (Côté and Festa-Bianchet 2003), or adult survival (Festa-Bianchet et al. 2003). However, nutrient availability may limited the reproductive performance of goats by retarding their growth (Festa-Bianchet et al. 1994), and litter size (twinning) may be related to resource availability (Houston and Stevens 1988), suggesting that some density-dependent response should occur. A density-dependent response should be most noticed near carrying capacity (*K*), and it is possible that most native populations are held at densities below *K* such that responses by the population are difficult to detect. An alternative hypothesis is that most populations are near *K* and the harvest does not decrease the population below *K* enough that density dependence is apparent; however, empirical data in support of this latter theory are limited (Côté et al. 2001).

Harvest rates

Native populations of mountain goats are sensitive to overharvest (Côté and Festa-Bianchet 2003). Data from Caw Ridge suggest a 1% harvest for small, native populations may be sustainable (Gonzales Voyer et al. 2003, Hamel et al. 2006). However, implicitly acknowledging that the ecology of goats at Caw Ridge (an isolated population of 100–150 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% yearly harvest with a strong encouragement to harvest adult males. Coupled with these suggestions, Côté and Festa-Bianchet (2003) recommend almost annual monitoring of population size, an approach that is not practical across much of the broad expanse of goat range in the Kootenays and elsewhere in BC.

Mountain goats are sensitive to adult female mortality because of comparatively late age at first reproduction and poor production of kids (Festa-Bianchet et al. 1994, Côté and Festa-Bianchet 2001, Hamel et al. 2006). Harvested females often end up being the dominant animals of the most productive age group (Côté and Festa-Bianchet 2001), thus having a significant impact on recruitment (Festa-Bianchet et al. 1994, Côté and Festa-Bianchet 2001). Female social rank is strongly related to age and does not decrease in the oldest females (Côté 2001). Females aged ≥7 years, those of the highest social rank, and females of the highest body mass account for most of the recruitment (Côté and Festa-Bianchet 2001). Population modeling of small to medium size 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).

Current provincial goat harvest management

The following explanation of the current goat harvest management in BC was obtained from 2 presentations by Ian Hatter, BC MoE, Victoria, at the March 2005 mountain goat workshop in Prince George (Hatter 2005a, b). I was unable to obtain further written information or clarification on this management process.

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 goats with ≤25% females in the harvest). These allocations were based on a review of the literature and modelling in the program RISKMAN (Taylor et al. 2002), in large part using data from Caw Ridge in the foothills of east-central Alberta. The EK has generally used a 5% allocation in recent years (I. Teske MoE, Cranbrook, personal communication). The status of goats over larger areas (such as aGame Management Zone [GMZ]) is evaluated with a simple model comparing average harvest with the "potential biological removal" (PBR).

$PBR = N_{MIN} \bullet \beta_{MSY} \bullet RF$; where:

- PBR = potential biological removal
- N_{MIN} = minimum population estimate (set at ~70% of the best estimate)
- β_{MSY} = harvest rate at maximum sustained yield (MSY) (set at 5.7%)
- RF = risk factor (scaled from 0–1, and apparently based on environmental variation and harvest composition, with lower RF number with higher proportion of females in the harvest)

Where the average annual harvest over a 5-year period exceeds the PBR, the GMZ is assessed in greater detail at the management zone or population level.

Kootenay region

Phelps et al. (1983) reviewed the history of mountain goat management in the Kootenay Region up until 1973. Estimates of the numbers and harvests of mountain goat in the Kootenay region have fluctuated over the past 4–5 decades. Many populations were believed to have declined in the 1960s to early 1970s, primarily as a result of "massive overharvest" of goat populations due to liberal harvesting regulations combined with increased access (Phelps et al. 1983). This overharvest occurred as a result of 1) a philosophy of maximum harvest, 2) a lack of sufficient management input, 3) a lack of understanding of the vulnerability of the species, and 4) the proliferation of uncontrolled access (Phelps et al. 1983). Road density in the Kootenay increased rapidly from the 1950s (see McLellan 1990 for an example from the Flathead Valley).

Beginning in 1966, mountain goat season length in the Kootenay generally declined, and the bag limit was lowered from 2 to 1 goats. Partial hunting closures were initiated in 1969 and 1970, and full closures were in place in 1971 (mid and southern West Kootenay) and 1972 (mid and southern East Kootenay) through to 1975. Closures were not implemented in the northern portions of the region during this period. Beginning in 1976 in the East Kootenay and 1977 in the West Kootenay, goat hunting was re-instated under a Limited Entry Hunting (LEH) system. Compulsory inspection for mountain goats in the Kootenay was initiated in 1976. LEH subzones within management units were used more regularly starting in 1987 (data from BC MoE files, Cranbrook).

With the implementation of stricter quotas, reductions in season length, and periods of hunting closures (Phelps et al. 1983), populations were thought to have recovered and stabilized through to the early 1990s (BC MoE files). Further declines were perceived to have occurred through the mid to late 1990s (Halko

and Hebert 2000), although very few surveys were conducted between 1991 and 1998. Causes for this recent decline were poorly understood and untested (Wilson and Shackleton 2001, Hatler 2001, Poole and Adams 2002), and potentially included over-harvest (again related to access), increased predation, adverse weather (primarily severe winters in 1995–1996 and 1996–1997), habitat change (from fire suppression, logging, or natural cycles), and increased disturbance from human activity, including helicopters, snowmobiles, hydroelectric development, and logging activities. Recent surveys in the EK indicate an increase in estimated goat numbers relative to the late 1990s and 2000 (Poole and Adams 2002, Poole 2003, 2004, Poole and Klafki 2005). This trend is supported by an increase in catch per unit effort by resident hunters at the provincial level since 2000 (Hatter 2005b).

Outside of the national parks (~3.6% of the land base in the Kootenay), about 94% of goat populations can be hunted within designated LEH goat hunting zones, and in open seasons in 3 Management Units (MUs) in the northern portion of the region (MU 4-37 north and west of Windy Creek, MU 4-39 north of Bourne Creek, and MU 4-40) (Figs. 1, 2). The remaining ~6% of the goats reside in areas outside of designated goat hunting zones. These proportions can change if, for example, new LEH zones are created. For a broader assessment, MUs can be further amalgamated into 3 game management zones (GMZs) in the EK and 2 zones in the WK (Fig. 3).

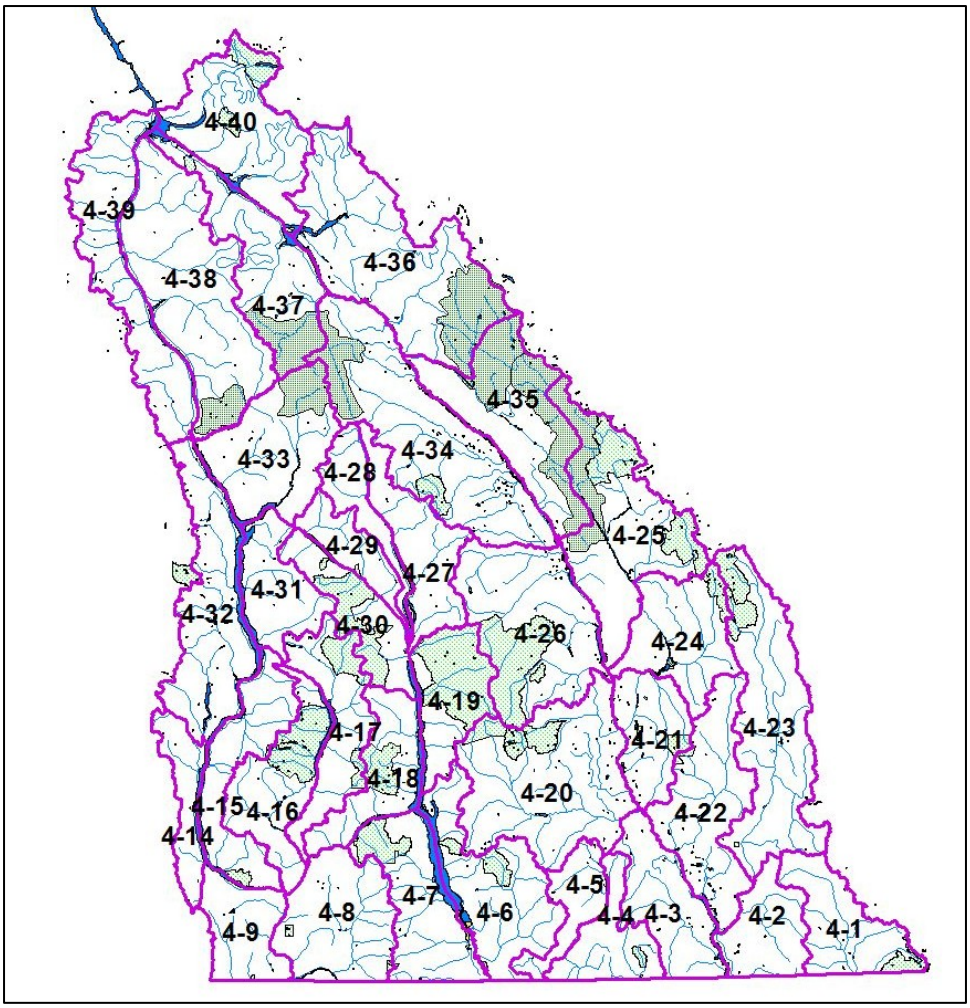

Figure 1. Location of management units (MUs) in the East and West Kootenay, southeastern British Columbia. National parks shown in darker green, provincial in lighter green.

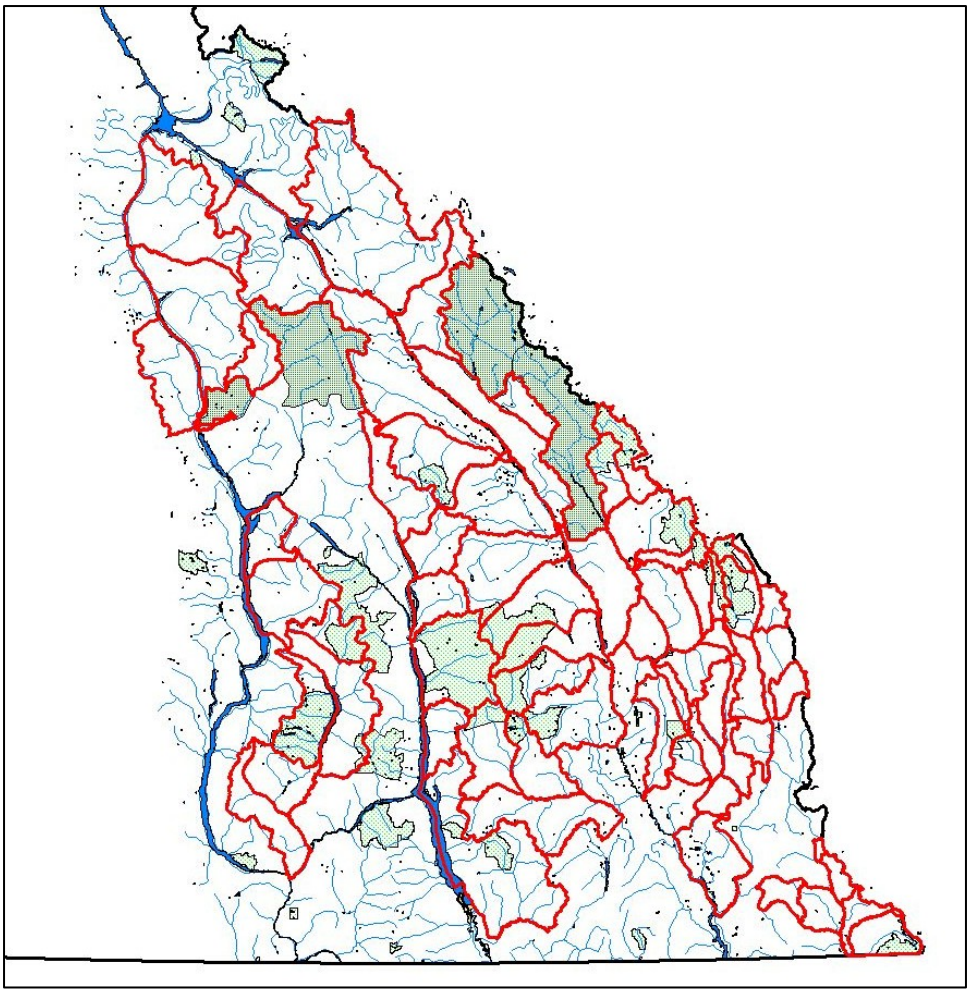

Figure 2. Location of Limited Entry Hunting (LEH) subzones (outlined in red) in the East and West Kootenay, southeastern British Columbia. National parks shown in darker green, provincial in lighter green.

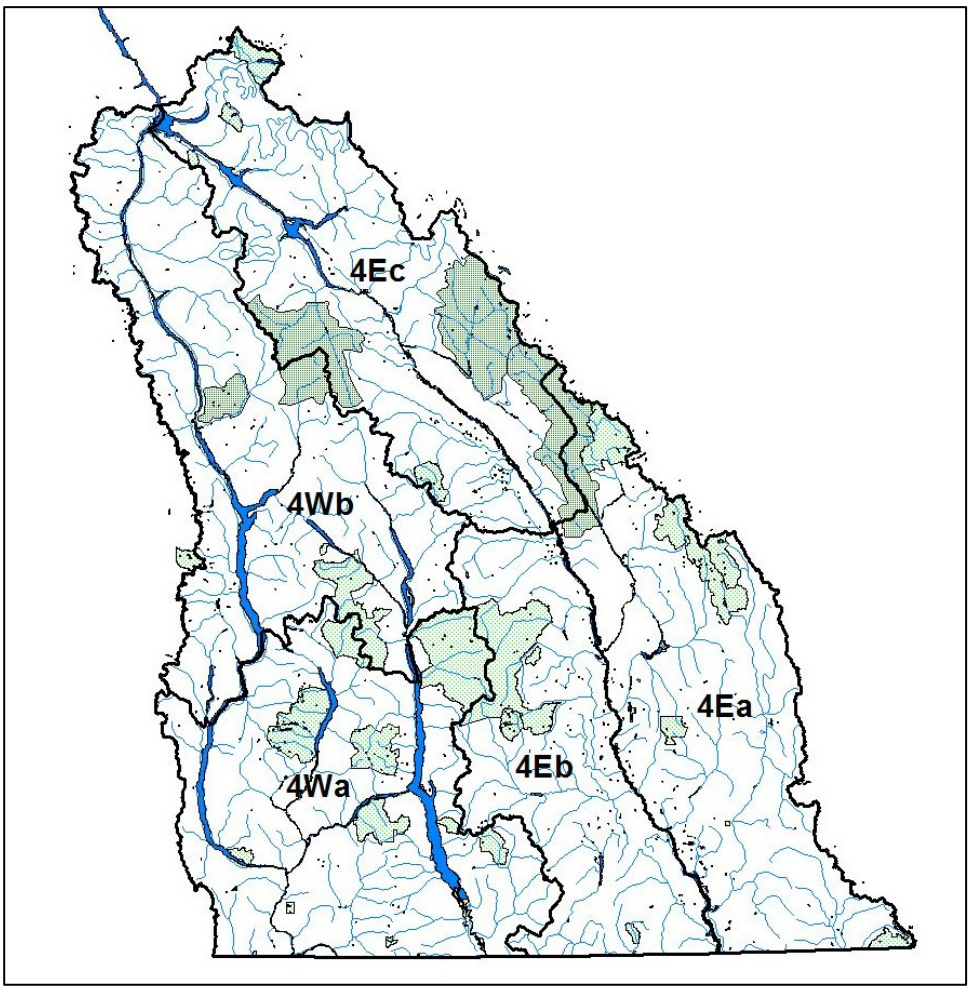

Figure 3. Location of game management zones (GMZs) in the East and West Kootenay, southeastern British Columbia. National parks shown in darker green, provincial in lighter green. GMZ 4Ea: MUs 4-01. 4-02, 4-21, 4-22, 4-23, 4-24, and 4-25; GMZ 4Eb: 4-03, 4-04, 4-05, 4-20, and 4-26; GMZ 4Ec: 4-34, 4-35, 4-36, 4-37, and 4-40; GMZ 4Wa: 4-06, 4-07, 4-08, 4-09, 4-14, 4-16, 4-17, 4-18, and 4-19; GMZ 4Wb: 4-27, 4-28, 4-29, 4-30, 4-31, 4-32, 4-33, 4-38, and 4-39.

Outfitting for mountain goats is provided by most guide/outfitters (G/O) operating within goat hunting areas, currently with a 75% resident: 25% G/O split on allocations (I. Teske, MoE, Cranbrook, personal communication). All goat hunting seasons in the Kootenay currently run from 1 September (archery) or 10 September (firearms) to 30 November, with hunters encouraged (but not required) to select males.

Methods

Population estimates

Goat population surveys are conducted using total counts with accuracy confirmed by mark-resight (Resource Information Standards Committee 2002) or applied sightability correction factor (Poole 2007). Goat population estimates by MU were obtained from MoE files for 1975, 1986, 1992, and 2000. These estimates were likely based on survey data in combination with local knowledge ("best guesses"), but I did not attempt to research the background or critically review surveys and estimates derived prior to the late 1990s. Estimates current to 2005 were obtained by examining all digital data and relevant reports to derive the most recent estimates for each goat LEH zone and MU (Appendix 1). Spatial analysis was conducted in ArcView 3.2a (Environmental Systems Research Institute [ESRI], Redlands California, U.S.A.). Estimates for the national parks were obtained from Alan Dibb (Parks Canada, Radium, personal communication, October 2005). Numbers of goats observed during summer and fall surveys were summed for each LEH zone and MU, with all goats observed within 1 km of a boundary summed and assigned equally between adjacent units. A number of MUs were suspected to have population estimates that were biased low or were derived from outdated surveys (e.g., 4-21, 4-25, 4-27, 4-34, and most WK MUs; Appendix 1), but in all but a few areas were not adjusted.

I obtained kid ratios (number of kids: 100 non-kids) from surveys dating back to 1978 from published reports (listed in literature cited and Appendix 1) and historic digital databases obtained from MoE, Cranbrook.

Since goat surveys do not observe all goats present in an area (e.g., Gonzalez-Voyer et al. 2001, Poole 2007), a sightability correction factor was applied to the number of goats observed during surveys. Sightability was assumed to be 60–65% for surveys conduced in the EK since 2002 (reviewed in Poole 2007), but was set as low as 40–50% for some surveys conducted in the late 1990s and 2000 (Teske and Forbes 2001). Note that sightability correction is applied by dividing the total count by the sightability correction factor (100 goats/0.65 = 154 goats), not by multiplying the total count by a variation of the correction factor (100 goats*1.65 = 165 goats).

Data on trends in potential predators of goats were summarized from Ministry of Environment (Mowat 2006). Trend data were derived from hunter sample questionnaires, compulsory inspections, compulsory reporting, guide declarations, trapper kill data, and problem kill data.

Harvest data

Anne Thogersen (MoE, Victoria) provided compulsory inspection mountain goat harvest data for the Kootenay (Region 4) from 1976 to 2005 for residents and G/Os (including guide declarations). Only those data from goats shot as legal hunter kills were included in the analysis. Data included whether the animal was harvested under a resident or G/O tag, date of harvest, sex, MU, LEH zone, and UTM location, and kill description location. Age data were provided from horn annuli counts (horn age; Smith 1988, Stevens and Houston 1989) for 83% of the records, and sectioned teeth (tooth age; Matson 1981) for 68% of records. I used the tooth age where both ages were available, since this was assumed to be most reliable. Forty goats (0.5%) were not assigned sex in the database and were removed from analyses pertaining to sex. Since UTM location was provided to the nearest kilometre and 1.3% of reported kills had no location, the stated MU and LEH zones were assumed to be correct. Spatial analysis was restricted to plotting of kill locations from 1976 to 2005; of these, 117 locations had no associated UTM, and the UTM locations from about 1 dozen kill records were obvious incorrectly recorded.

Harvest data were summed by MU and GMZ. Summations included total harvest and proportion of females in the harvest. In most analyses, harvests were also averaged by 5-year intervals (starting in 1981) to examine smoothed trend over time.

Number of hunters, total hunter days, and harvest levels were obtained from the "BIG GAME HARVEST STATISTICS 1976-2004 - FINAL.xls" spreadsheet provided to MoE staff by John Thornton, MoE, Victoria. Harvest figures were derived from compulsory inspection (CI) reports for both residents and non-residents. Hunter numbers and days spent hunting were derived from the hunter sample (residents) and guide declarations (non-residents). These data were used to summarize hunter numbers, hunter effort (total number of days hunted), and 2 indices of hunter success (kills/hunter and number of hunter days/kill). Data were summarized for the entire region, and at the time of writing were only available up to the 2004 season.

Harvest rate

I made the following assumptions in calculation of harvest rates:

- Population estimates from national parks were removed from MU and GMZ totals;
- All areas outside of the national parks were included in estimates of population size by MU or GMZ. Approximately 94% of goats residing outside of national parks occur in areas open to goat hunting (although this proportion is likely biased low with suspected underestimates in a number of MUs). I (and Guy Woods, MoE retired, Nelson, personal communication) believe it is valid to include all goats outside of national parks in calculation of harvest rates, regardless of whether they are in areas open to hunting, given a broad-scale approach to management (Hatter 2005b), and the occurrence of broad seasonal movements of goats (Poole et al. 2006);
- Harvest rates were calculated based on the population estimate for each unit, not on the minimum count or 70% of the best estimate (as in Hatter 2005b).

Results

Population estimates

The 2005 estimate of goats in the Kootenay region was 9,249 goats, of which 581 (6.3%) were estimated to reside in national parks. Estimated numbers of mountain goats within the Kootenays as calculated in 2005 were higher than estimated population size in 2000 (Tables 1, 2, Fig. 4). Estimated mountain goat numbers in the national parks were removed from calculations used as the basis for harvest rate calculations.

Table 1. Goat population estimates by game management zone (GMZ) in the Kootenay Region 4, British Columbia. Data from 1986 to 2000 obtained from MoE files. Data for 2005 calculated from reports and spatial data from recent surveys (K. Poole, unpublished data). All data shown with 2005 estimates for national parks removed.

GMZ	1986	1992	2000	2005
4Ea	4705	5385	3069	4175
4Eb	1055	1550	470	941
4Ec	1277	1277	932	1638
4Wa	535	605	650	650
4Wb	1117	1127	997	1264
Total	8689	9944	6118	8668

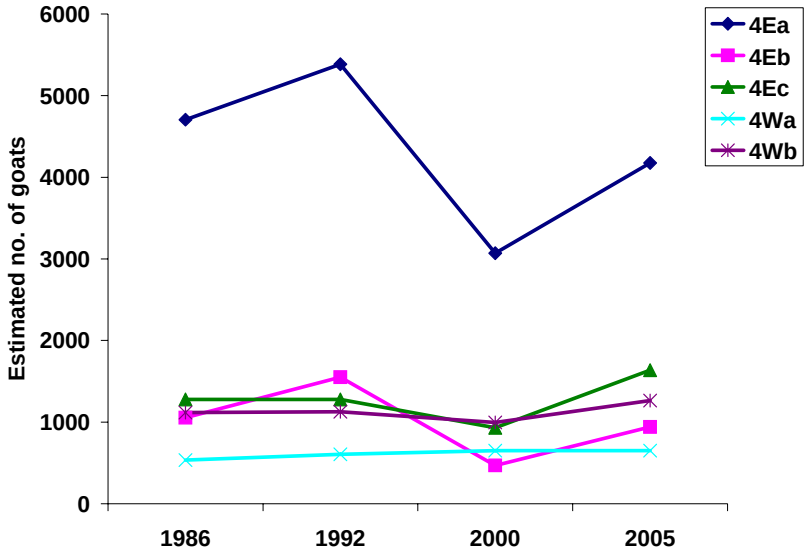

Figure 4. Goat population estimates by game management zone (GMZ) in the Kootenay Region 4, British Columbia (Table 1).

Table 2. Goat population estimates by management unit (MU) in the Kootenay Region 4, British Columbia. Game management zone (GMZ) shown brackets. Data from 1986 to 2000 obtained from MoE files. Data for 2005 calculated from reports and spatial data from recent surveys (K. Poole, unpublished data). "Ex NP" means estimates for national parks removed from MUs; these same estimates (derived in 2005) were removed from previous years to calculate the bottom line in the table.

MU (GMZ)	1986	1992	2000	2005	2005 ex NP
4-01 (4Ea)	535	545	312	436	
4-02 (4Ea)	125	175	50	58	
4-03 (4Eb)	0	0	0	0	
4-04 (4Eb)	0	0	0	0	
4-05 (4Eb)	25	25	25	25	
4-06 (4Wa)	45	60	45	45	
4-07 (4Wa)	20	20	20	20	
4-08 (4Wa)	20	20	20	20	
4-09 (4Wa)	100	100	100	100	
4-14 (4Wa)	20	30	30	30	
4-15 (4Wa)	15	20	20	20	
4-16 (4Wa)	60	80	140	140	
4-17 (4Wa)	100	100	100	100	
4-18 (4Wa)	30	45	45	45	
4-19 (4Wa)	125	130	130	130	
4-20 (4Eb)	270	435	150	430	
4-21 (4Ea)	220	210	95	135	
4-22 (4Ea)	1135	1150	685	883	
4-23 (4Ea)	1215	1290	1135	1266	
4-24 (4Ea)	860	1015	530	932	
4-25 (4Ea)	695	1080	342	545	465
4-26 (4Eb)	760	1090	295	486	
4-27 (4Wb)	150	150	150	300	
4-28 (4Wb)	80	80	80	80	
4-29 (4Wb)	60	60	60	60	
4-30 (4Wb)	80	80	50	50	
4-31 (4Wb)	80	90	90	90	
4-32 (4Wb)	50	50	50	50	
4-33 (4Wb)	100	100	100	100	
4-34 (4Ec)	370	370	215	362	344
4-35 (4Ec)	500	500	470	710	470
4-36 (4Ec)	425	425	345	444	364
4-37 (4Ec)	130	130	80	300	190
4-38 (4Wb)	350	350	350	467	414
4-39 (4Wb)	220	220	120	120	
4-40 (4Ec)	300	300	270	270	
Reg 4 total	**9270**	**10525**	**6699**	**9193**	
Total ex NP	**8689**	**9944**	**6118**	**8612**	

Density of estimated number of goats within potential goat habitat (census zone) is available for surveys conducted since 2002 (Poole and Adams 2002, Poole and Mowat 2002, Poole 2003, 2004, Poole and Klafki 2005), and shows a pattern of roughly similar densities among adjacent study areas (Table 3).

Table 3. Estimated density of mountain goats in the East Kootenay, 2002–2005.

Area	Date	Density (no./km^2)
Rocky Mountains		
Flathead	2005	1.26
Elk	2005	1.69
White	2005	1.66
Bull	2004	1.83
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

Kid ratios varied widely among surveys, with a possible trend of higher ratios since the late 1990s as compared with the 1980s (Figs. 5, 6). Few surveys appear to have been conducted during the mid-1990s. Although ratios do not differ when summed among time periods (PROC GLM; $F = 1.83$, 3 df, $P = 0.16$), the mean ratio during 1985–91 was significantly lower than ratios observed during 1998–2000 (LSD test, $P < 0.05$; Fig. 6).

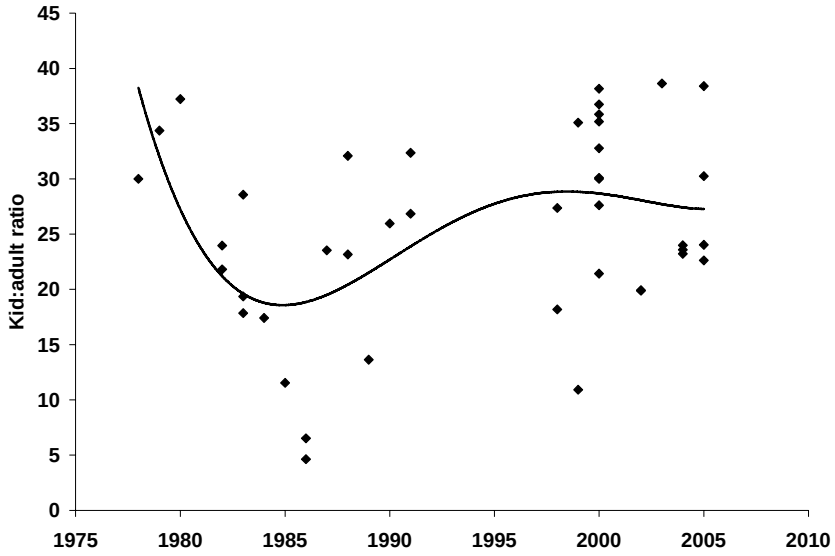

Figure 5. Kid ratios (no. kids: no. adults [non-kids]) derived from 42 mountain goat surveys conducted during summer (July–September) from 1977 to 2005, East Kootenay. Trend line is a 4th order polynomial fitted in Excel (r^2 = 0.27). Sources: published reports (listed in literature cited) and historic databases obtained from MoE.

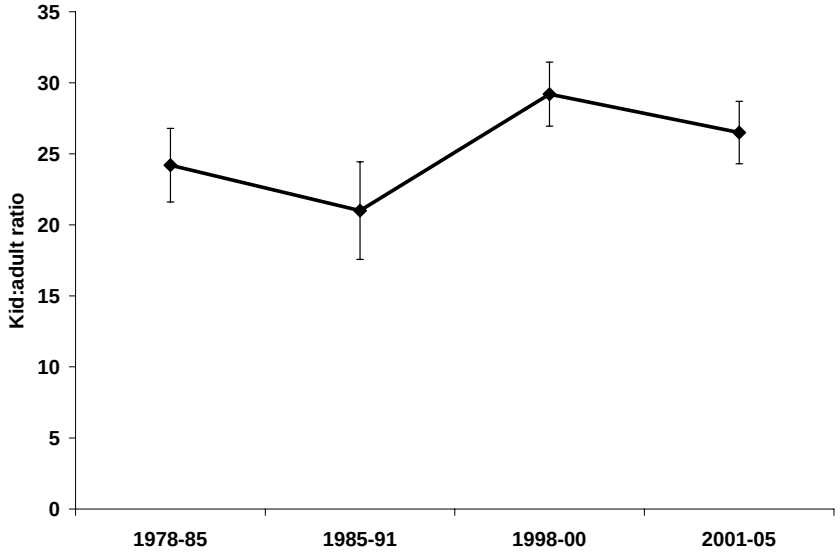

Figure 6. Kid ratios (no. kids: no. adults; mean ± SE) derived from 42 mountain goat surveys conducted during summer (July–September) from 1977 to 2005, East Kootenay, summarized among time periods. Sources: published reports (listed in literature cited) and historic databases obtained from MoE.

Predators

Cougar harvests and problems kills were relatively constant from 1976 to the early 1990, increased to peak in 1996–1998, and subsequently declined to lower levels by the early to mid-2000s (Fig. 7). Trends in numbers of problem cougars killed roughly mirror the harvest, suggesting both are a rough but reasonable index of population size. Wolf harvests were low through the 1980s, increased during the 1990s to peak in 1996 and 2002, and declined through to 2004 (Fig. 8); these statistics may reflect increased populations of wolves in the Kootenays beginning in the mid-1990s.

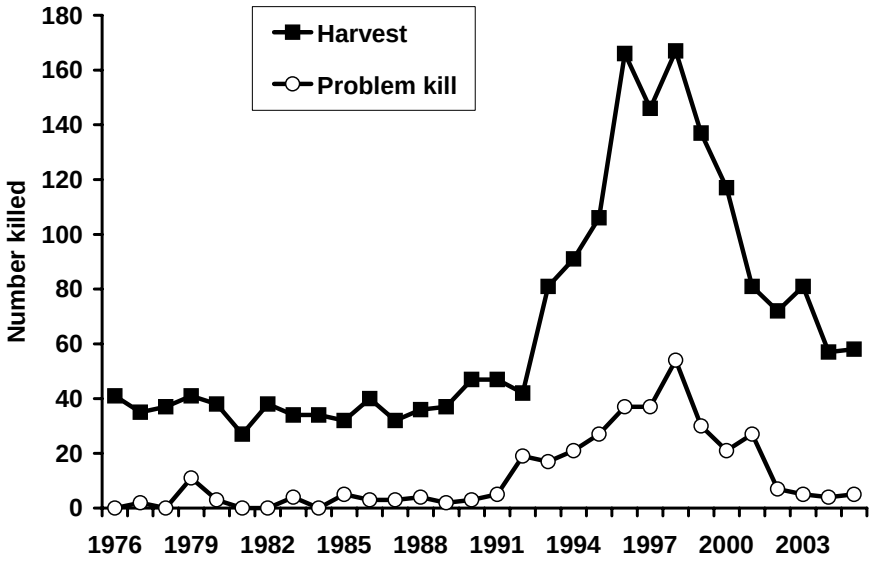

Figure 7. Cougar harvests and problem kills in the Kootenay Region, 1976–2005 (Mowat 2006).

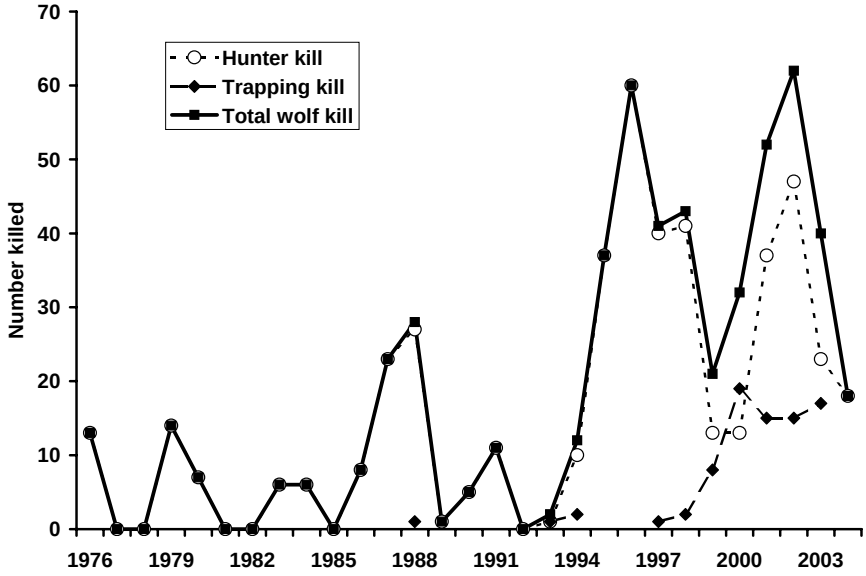

Figure 8. Wolf hunting and trapping harvests in the Kootenay Region, 1976–2004 (Mowat 2006).

Trends in populations of black bears (*Ursus americanus*) and grizzly bears (*U. arctos*) in the Kootenay region are less clear. Numbers of black bears killed have declined slowly from the early 1980s to present, but both hunter success and days per kill (catch per unit effort) have remained relatively stable since the mid-1980s (Mowat 2006), suggesting no clear trend to the population (the declining harvest may be a result of declining interest). Grizzly bears harvest numbers in the Kootenays have varied considerably since 1976, but general increasing hunter success and decreasing days per kill (Mowat 2006) suggest populations may have increased over this time period, with a possible levelling since the late 1990s.

Harvest data

A total of 7,764 harvested goats were recorded in Region 4 from 1976 to 2005 (Fig. 9), including 7,483 from 1981 to 2005 (Fig. 10). Although possibly an artefact of initiation of the inspection and recording system, goat harvests appeared to increase dramatically during the late 1970s to 1984. I did not further address harvests prior to 1981, in part to enable comparison among 5-year periods ending in 2005, as well as some suspicion on the quality of the earlier data. Goat harvests in GMZ 4Ea alone comprised an average of 57% of the Region 4 harvest since 1980.

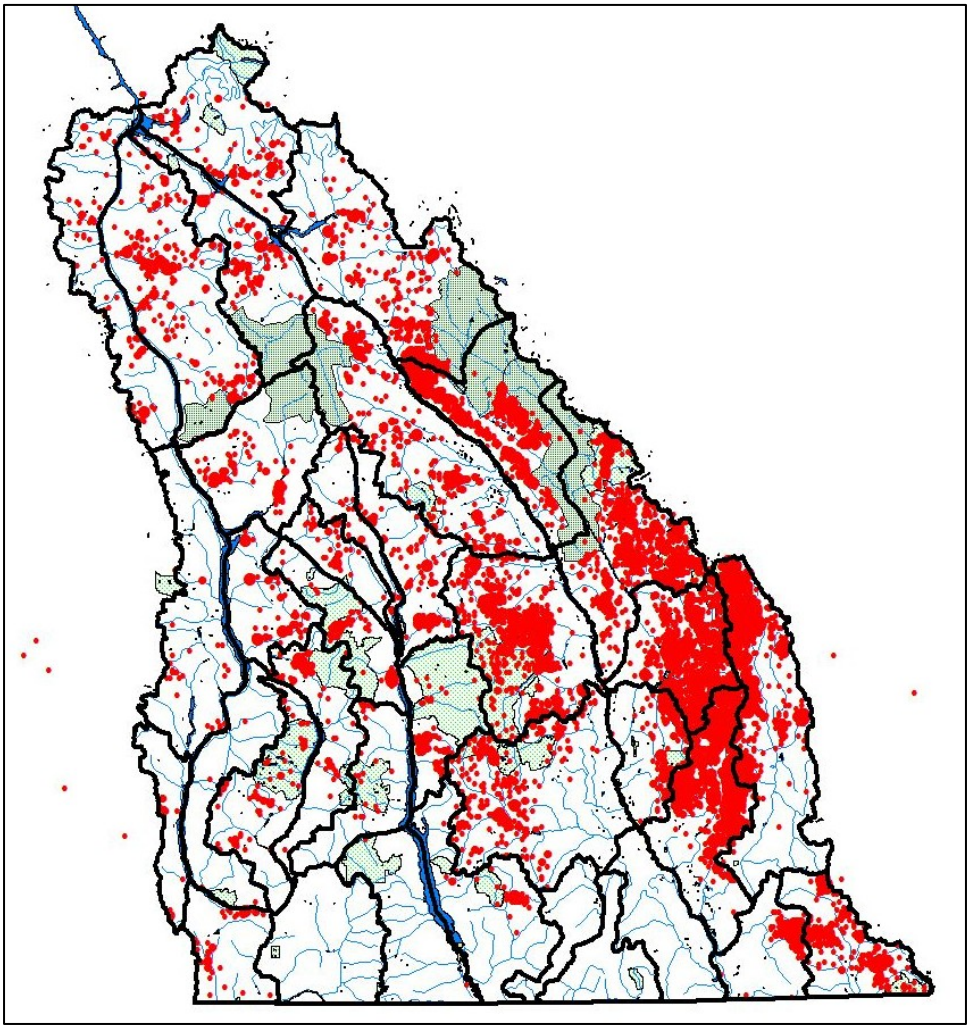

Figure 9. Mountain goat kill locations in the East and West Kootenay, southeastern British Columbia, 1975 to 2005. Red dots are scaled from 1 to 13 goats per location. Wildlife management units (MUs) are superimposed on the figure.

Harvest numbers in most GMZs decreased after peaking in the late 1980s and early 1990s, and appeared to have stabilized in most areas since 1999 (Fig. 10). Annual harvests by residents peaked in the late 1980s and early 1990s, and declined considerably through to the 2000s (Table 4). Guide-outfitter harvests peaked in the early 1990s. By proportions, the resident harvest has declined over the past 25 years to stabilize in the late 1990s at about two-thirds of the overall harvest, with a concomitant increase in the proportion of goats taken by G/Os (Table 4).

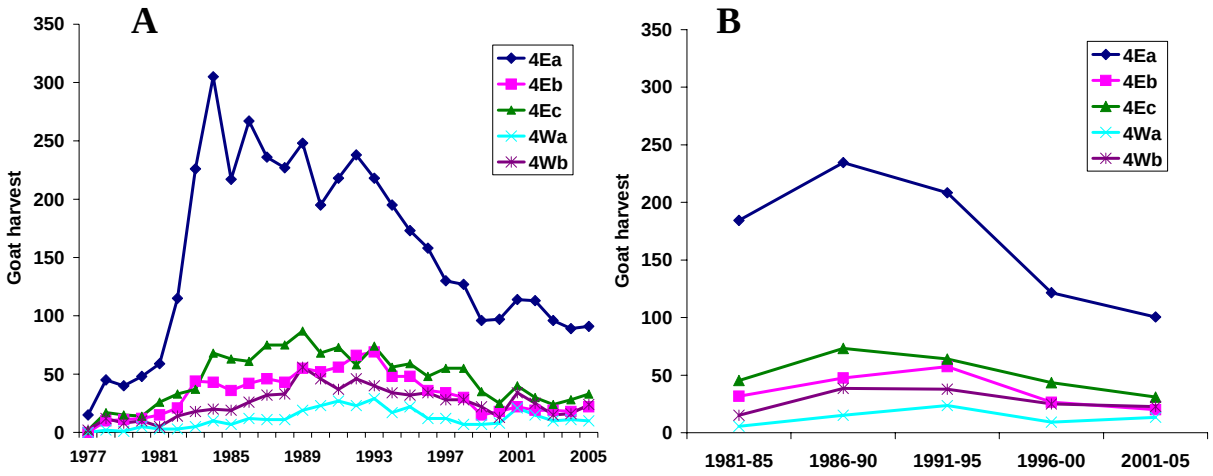

Figure 10. Mountain harvest by game management zone (GMZ) in the East Kootenay (GMZ 4Ea, 4Eb, 4Ec) and West Kootenay (GMZ 4Wa, 4Wb); A) annual (1977 to 2005), and B) average annual by 5-year period (1981 to 2005).

Table 4. Average annual harvest of mountain goats by residents and guide/outfitters (G/O), Kootenay Region, by 5-year period, 1981 to 2005. Percent of average annual harvest between residents and guide-outfitters shown in brackets.

Period	Residents (%)	G/O (%)	Total
1981–85	222 (79)	60 (21)	282
1986–90	310 (76)	99 (24)	409
1991–95	291 (74)	100 (26)	391
1996–00	148 (66)	78 (34)	226
2001–05	124 (66)	64 (34)	188

The number of resident goat hunters in the Kootenay peaked in early to mid-1990s at 850 hunters, and has declined steadily to date, with about 260 active resident goat hunters in 2004 (Fig. 11a). An active hunter is defined as someone who buys a tag and hunts for goats, whether successful or not, and is determined from hunter questionnaires, compulsory inspections, and guide declarations. Approximately 1,470 LEH tags were available for resident hunters in 2004 (BC Limited Entry Hunting regulations synopsis 2004–2005); thus, only 18.3% of tags appear to have utilized by resident hunters. Numbers of non-resident hunters remained steady through the 1990s at about 120–150 hunters, and dropped to an annual average of 91 hunters from 2000–2004 (Fig. 11a). Non-resident hunter numbers would presumably closely mirror the number of goat permits allocated to guide-outfitters. Mean number of days each active hunter used to hunt goats has remained relatively stable for residents, with the exceptions of an unusual increase in 2001 and a drop in 2004 (Fig. 11b). Mean numbers of days spent goat hunting by each non-resident hunter increased in the mid-1990s. Since 2000, active goat hunters have used an average of 5.1 and 5.6 days for residents and non-residents, respectively.

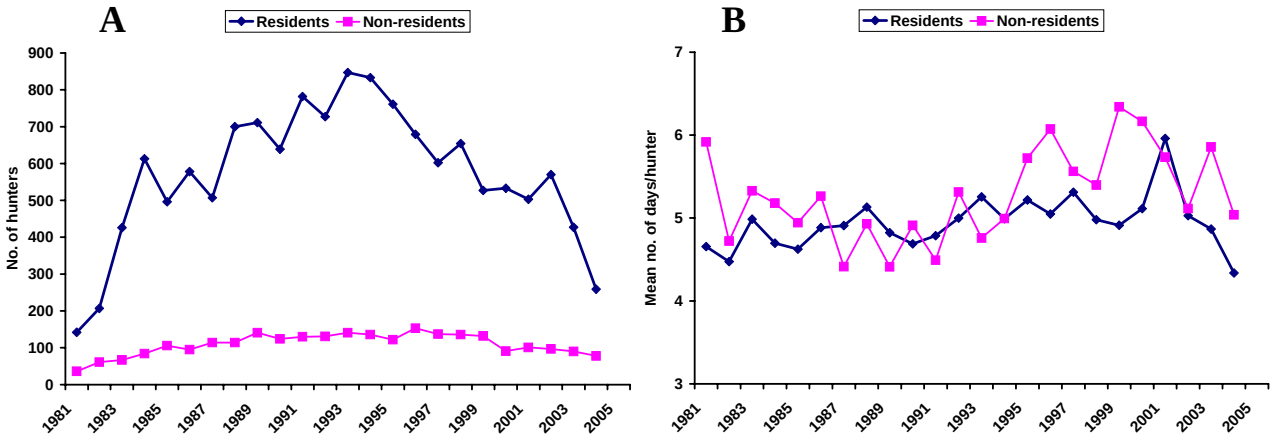

Figure 11. A) Number of active resident and non-resident goat hunters, and B) mean number of days per active hunter, for resident and non-resident hunters in the Kootenay Region, 1981–2004.

Hunter success (defined here as kills per active hunter) declined for both resident and non-resident hunters from the mid-1980s to about 1999–2000 (Fig. 12a). Hunter success subsequent to 1999–2000 appears to have increased for both groups. Resident and non-resident hunter success from 2000–2004 averaged 28% and 65%, respectively, considerably lower than hunter success experienced in the mid-1980s (mean of 1983–87: 58% and 79%, respectively). Average resident hunter success from 2000–2004 varied among GMZs: 4EA (32), 4EB, (29), 4EC (36%), 4WA (33), 4WB (17). Average non-resident hunter success from 2000–2004 also varied among GMZs: 4EA (72), 4EB, (50), 4EC (61%), 4WA and 4WB combined (60).

The mean number of days spent hunting per kill showed a trend that mirrored hunter success, with an increase in number of days up to about 1999–2000 (more pronounced for residents), and a subsequent decline (Fig. 12b). From 2000–2004, hunter days per kill averaged 19.0 and 8.7 for residents and non-residents, respectively.

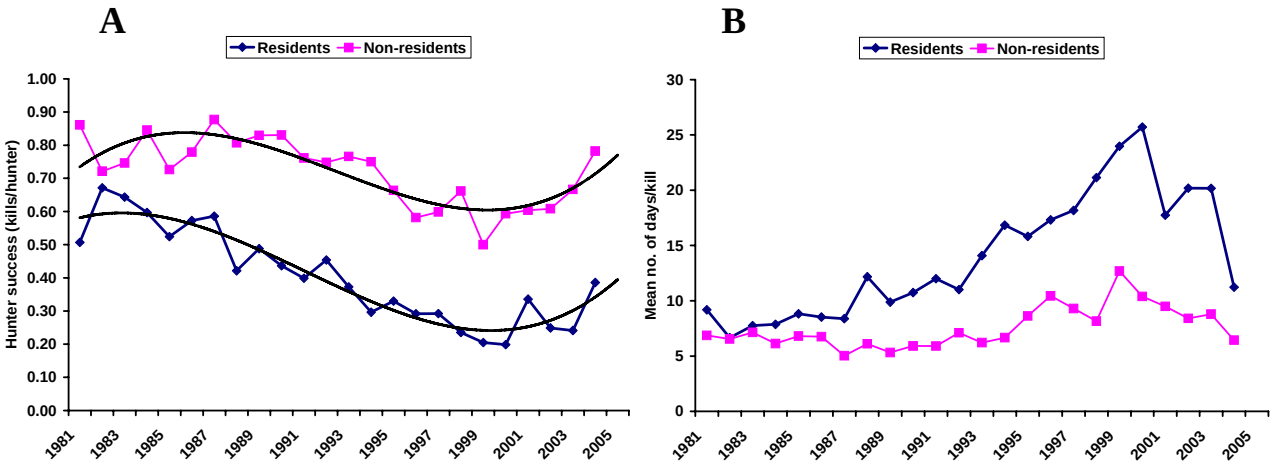

Figure 12. A) Mountain goat hunter success (kills per active hunter) and B) mean number of days per kill, for resident and non-resident hunters in the Kootenay Region, 1981–2004. The trend lines for hunter success are 3rd order polynomial lines fitted in Excel (r^2 = 0.89 and 0.68 for residents and non-residents, respectively).

The proportion of females in the harvest increased through the late 1980s and early 1990s, and subsequently declined, with the lowest levels recorded during 2001 to 2005 (Table 5). This lower level in recent years likely was the result of increased hunter education initiated around 2000, and increased awareness of the consequences of not reducing the female goat kill (e.g., greater impact on the populations, resulting in further restrictions to hunting opportunities). Guide-outfitters typically harvest 8–14% fewer females in their harvests than residents (Table 5). Females comprised a higher proportion of the harvest by both residents and G/Os in GMZ 4Ec (northern third of the EK), and to a lesser extent in the 2 WK GMZs (Table 6). Note that residents typically harvest 91% of the comparatively few goats (13) taken annually in GMZ 4Wa.

Table 5. Proportion (%) of female mountain goats in residents and guide/outfitters (G/O) harvests averaged over 5-year periods, Kootenay Region, 1981 to 2005.

Period	Residents	G/O	Overall
1981–85	39	28	37
1986–90	38	30	36
1991–95	40	26	37
1996–00	34	25	31
2001–05	26	18	23

Table 6. Proportion (%)of female mountain goats in residents and guide/outfitters (G/O) harvests from 2001 to 2005 for game management zones (GMZ) in the Kootenay Region.

GMZ	Residents	G/O	Overall
4Ea	22	14	19
4Eb	20	20	20
4Ec	33	29	32
4Wa	30	33	30
4Wb	31	21	28

Age as determined by tooth sectioning was correlated with age as determined by horn annuli counts (r = 0.80, $P < 0.0001$), with mean tooth ages on average 4% greater than comparable horn ages).

Mean age of male and female goats harvested in the Kootenay has varied over time, peaking in the late 1980s and early 1990s (Fig. 13). Mean ages have generally declined since the early 1990s, although mean age of females trended up during 2003 to 2005. Mean ages were significantly different among time periods for both females (PROC GLM; $F = 4.66$, 4 df, $P = 0.001$) and males ($F = 7.98$, 4 df, $P < 0.0001$), with female ages greater during 1991–95 than during 1981–85, and greater during 1986 to 2000 compared with other periods for males (LSD test, $P < 0.05$; Fig. 13b).

During 2001–2005, mean age of goats harvested by guided non-residents was slightly but not significantly higher than mean ages of goats killed by residents for both females (5.9 ± 0.51 years and 5.5 ± 0.24 years, respectively; $P = 0.44$) and males (5.2 ± 0.15 years and 4.9 ± 0.13 years, respectively; P = 0.11).

The distribution of age of harvested goats was concentrated in the younger adult categories (Fig. 14). Males 3–5 years of age accounted for 53% of the male harvest, and 75% of the male harvest comprised animals 2–6 years of age. Fully 77% of the female harvest comprised animals 2–7 years of age, with slightly greater representation of the 2–5 year age classes. Goats 6–9 years of age comprised 30% of the female harvest.

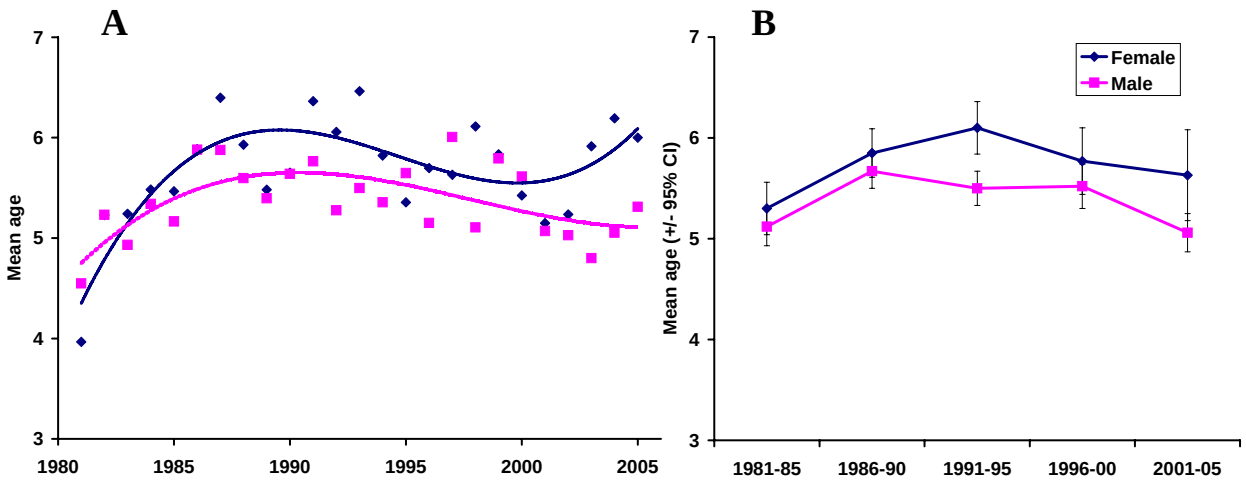

Figure 13. Mean age of female and male mountain goats harvested in the Kootenay Region, 1981–2005; A) mean age by year with fitted 3rd order polynomial lines in Excel; (r^2 = 0.62 and 0.44 for females and males, respectively), and B) mean age by 5 year period (1981 to 2005) with associated 95% confidence intervals (CIs).

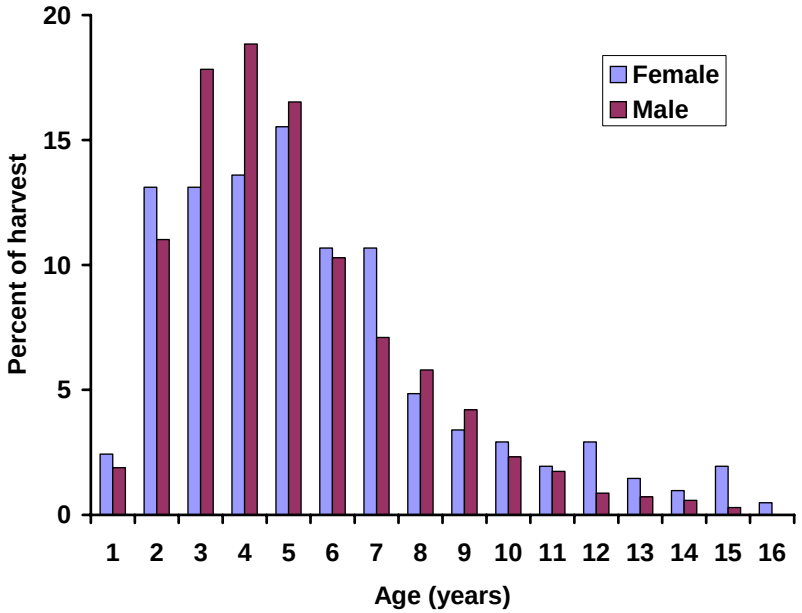

Figure 14. Distribution of age of harvested female (*n* = 206) and male (*n* = 690) mountain goats, Kootenay Region, 2001–2005.

Mountain goats were harvested throughout the months of September to November, with slightly higher harvests between late September and late October (Fig. 15). Over the past 5 years, roughly 12.5% of males and 11.1% of females were harvested during the peak of rut (9–23 November).

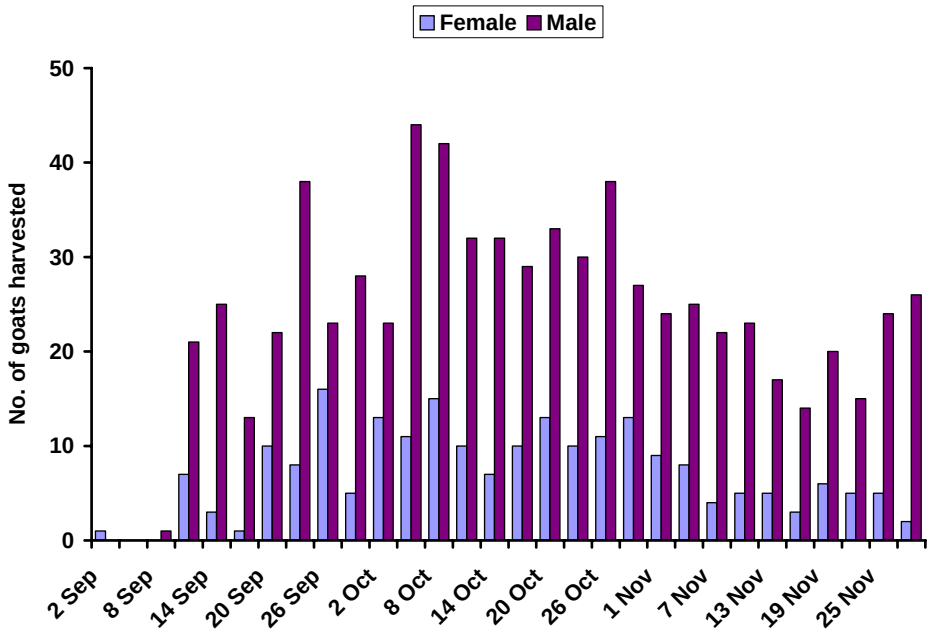

Figure 15. Distribution of mountain goat harvest summed by 3-day periods, 1 September to 30 November, 2001–2005, Kootenay Region. Sample size for females = 216; for males = 711.

Harvest rate

Harvest rates as examined by GMZ have declined overall since the late 1980s, and during 2001–05 averaged 2.2% (range 1.8–2.4%) as compared with the 2005 population estimate (Table 7). I have presented the average annual harvest data with the population estimate that corresponds most closely in time. However, I question many of the 2000 population estimates, in part because of the vast increases in population estimates between 2000 and 2005, increases that are well beyond the reproductive capability of native populations of mountain goats (Côté and Festa-Bianchet 2003). Therefore, I also provided a comparison of the 1996–00 harvest data with the 2005 population estimate. This leads to a drop in the calculated mean 1996–00 harvest rate from an annual average of 3.7% to 2.6%.

The data suggest far higher harvest rates during the mid-1980s to late 1990s than are documented for the most recent 5 years of harvest data and 2005 population estimate (Table 7). The differences in harvest rate between the late 1990s and first half of 2000 is considerable if the MoE 2000 population estimate is used in the analysis. Although absolute harvests were on average about 20% higher during 1996–00, the population estimates were also about 30% lower, resulting in 70% difference between the harvest rates in 1996–00 (using the 2000 population estimate) and 2001–05 (using the 2005 estimate). Because of some of the large increases in estimated population size between 2000 and 2005, I question whether the calculated harvest rates from 1996–00 are accurate. However, severe winters in the mid to later half of the 1990s may also have resulted in population reductions in some areas.

Harvest rates for 2001–05 and the proportion of the females in the harvest vary widely among MUs (Table 8). Note that over half (18/30; 60%) of the individual MUs during 2001–05 have annual harvests of <4 goats, where a few goats can have a large effect on harvest rates and the proportion of females in the harvest.

Table 7. Calculation of mountain goat harvest rate by game management zone (GMZ), sub-region (EK = East Kootenay; WK = West Kootenay), and region by comparing average annual harvest for periods 1986–90 to 2001–05 with population estimates derived in 1986, 1992, and 2000 (MoE, unpublished data), and 2005 (updated data with recent surveys; K. Poole, unpublished data). Mean proportion of females in the 2001–05 harvest also provided. See text for further discussion.

Parameter	4Ea	4Eb	4Ec	EK	4Wa	4Wb	WK	Kootenay
Annual harvest								
1986–00	235	48	73	355	15	39	54	409
1991–95	208	57	64	330	24	38	61	391
1996–00	122	27	44	192	9	25	34	226
2001–05	101	20	31	152	13	23	36	188
Population estimate								
1986	4705	1055	1277	7037	535	1117	1652	8689
1992	5385	1550	1277	8212	605	1127	1732	9944
2000	3069	470	932	4471	650	997	1647	6118
2005	4175	941	1638	6754	650	1264	1914	8612
Annual harvest rate								
1986–90 harvest with 1986 estimate	5.0%	4.5%	5.7%	5.1%	2.8%	3.5%	3.3%	4.7%
1991–95 harvest with 1992 estimate	3.9%	3.7%	5.0%	4.0%	3.9%	3.4%	3.5%	3.9%
1996–00 harvest with 2000 estimate	4.0%	5.7%	4.7%	4.3%	1.4%	2.5%	2.1%	3.7%
1996–00 harvest with 2005 estimate	2.9%	2.8%	2.7%	2.8%	1.4%	2.0%	1.8%	2.6%
2001–05 harvest with 2005 estimate	2.4%	2.1%	1.9%	2.2%	2.1%	1.8%	1.9%	2.2%
Percent females in 2001–05 harvest	19%	20%	32%	22%	30%	28%	29%	23%

Table 8. Mountain goat harvest rate by management unit (MU), calculated by comparing average annual harvest for periods 1996–00 and 2001–05 with population estimates derived in 2000 (MoE, unpublished data) and 2005 (updated data with recent surveys; K. Poole, unpublished data), respectively. The average proportion of females in the 2001–05 harvest is also provided. All MU estimates have national parks removed. See text for further discussion.

	Annual harvest		Population estimate		Harvest rate (%)		% female
MU	**1996–00**	**2001–05**	**2000**	**2005**	**1996–00**	**2001–05**	**2001–05**
4-01	8.6	6.0	312	436	2.8%	1.4%	24
4-02	4.2	3.6	50	58	8.4%	6.2%	33
4-06	1.4	2.6	45	45	3.1%	5.8%	33
4-08	0.4	0.2	20	20	2.0%	1.0%	0
4-14	0.2	0.2	30	30	0.7%	0.7%	0
4-16	2.4	6.0	140	140	1.7%	4.3%	27
4-17	3.2	2.2	100	100	3.2%	2.2%	45
4-18	1.4	1.4	45	45	3.1%	3.1%	14
4-19	0.2	0.8	130	130	0.2%	0.6%	50
4-20	10.6	5.8	150	430	7.1%	1.3%	24
4-21	5.6	2.8	95	135	5.9%	2.1%	29
4-22	32.0	25.8	685	883	4.7%	2.9%	18
4-23	38.0	32.4	1135	1266	3.3%	2.6%	14
4-24	20.0	19.4	530	932	3.8%	2.1%	19
4-25	13.2	10.6	262	465	5.0%	2.3%	26
4-26	16.0	14.2	295	486	5.4%	2.9%	19
4-27	2.2	2.8	150	300	1.5%	0.9%	21
4-28	0.4	0.4	80	80	0.5%	0.5%	100
4-29	2.2	1.2	60	60	3.7%	2.0%	17
4-30	3.0	1.2	50	50	6.0%	2.4%	50
4-31	2.2	2.6	90	90	2.4%	2.9%	42
4-32	1.8	0.6	50	50	3.6%	1.2%	33
4-33	2.8	2.2	100	100	2.8%	2.2%	18
4-34	11.4	3.0	197	344	5.8%	0.9%	27
4-35	16.6	17.4	230	470	7.2%	3.7%	24
4-36	8.2	4.8	265	364	3.1%	1.3%	46
4-37	3.8	4.2	80	190	4.8%	2.2%	52
4-38	8.0	11.0	297	414	2.7%	2.7%	27
4-39	2.4	0.8	120	120	2.0%	0.7%	0
4-40	3.6	1.6	270	270	1.3%	0.6%	25

Discussion

Population estimate

Survey data suggest that mountain goat populations in the Kootenay region increased from low levels in the early 1970s, increased through to the late 1980s to early 1990s, declined to lower levels by the late 1990s, and have since increased. This pattern is broadly mirrored at the provincial level up to the early 2000s (Hatter 2005b). However, goat numbers appear to have declined in recent years in the Okanagan and Thompson regions, although this conclusion comes from limited survey data (B. Harris, MoE, Penticton, and D. Jury, MoE, Kamloops, personal communications, April 2005). Trend data from Kootenay and Yoho national parks are sparse, but suggest half the numbers from 1999 through the early 2000s compared with the 1980s (A. Dibb, Parks Canada, Radium, personal communication, October 2005). In Alberta on provincial lands, unhunted goat populations have increased by roughly 2% annually from 1972 to 1999, while hunted populations declined from 1972 to 1986, and increased from 1988 to 1999 after hunting was closed (Alberta Sustainable Resource Development 2003). Although regional fluctuations in numbers have occurred, state-wide estimates for goats in Idaho have remained relatively constant since 1955, with some declines suspected from 2000 to 2004 (Toweill 2004). Thus, trends in numbers of goats in the Kootenay region are not similar among adjacent jurisdictions.

Approximately 65% of the current estimated goat population in the Kootenay region has been surveyed since 2002 (Clark 2004, Poole 2003, 2004, Poole and Adams 2002, Poole and Mowat 2002, Poole and Klafki 2005). Surveys conducted in the past 4 years have generally resulted in increases to both the number of goats observed and the estimated number of goats present, despite use of lower sightability correction factors (i.e., we assumed we saw a greater proportion of the goats present in later surveys than in most surveys conducted prior to 2002). Since 2002, surveys have been standardized for effort and protocol, and for all but Clark (2004) have provided calculations of estimated density within potential goat habitat (census zone).

Some of the earlier surveys, particularly those conducted in 1998, observed few goats and resulted in lower than historic estimates for a number of MUs in the EK. There are indications that low survey effort (Davidson 2000) or unusually hot weather (Hatler 2001) may have contributed to the lower numbers of goats observed during the 1998 surveys. These results help reinforce the conclusions that aerial surveys for goat should be conducted under ideal and consistent survey conditions, and that they should be treated as a trend indicator of major changes in population size (Gonzalez-Voyer et al. 2001, Poole 2007). Limited stock must be placed on a single survey, especially if it is out of line with perceived trends and data available from elsewhere.

Hunting is only one factor affecting mountain goat productivity and survival, with predation and winter/spring weather other major proximate factors (Côté and Festa-Bianchet 2003). Regional management of goat populations must be sensitive to changes in these parameters on the sustained yield of populations. Increased populations of cougars through the 1990s and declines in the 2000s coincided with declines and increases in estimated goat numbers in the region. Relatively mild winters with low snowfall during the past 5 years may have contributed to the apparent increases in population size observed in many areas of the Kootenay. Harsh winters, such as experienced during 1996–97, could increase over-winter mortality and reduce productivity and recruitment such that current rates of harvest may not be sustainable over the short term.

To the best of my knowledge, all goat population estimates used by MoE and discussed here are based on all animals observed during surveys. Most recent surveys in the Kootenay have classified goats only into kids and non-kids (yearlings and older; generally called adults). This standardization has occurred in part because of difficulty of reliably distinguishing kids, yearling, and 2-year old goats (and sexes) during surveys (Gonzalez-Voyer et al. 2001), the late age of first reproduction (Festa-Bianchet et al. 1994) rendering accurate counts on the recruited reproductive adult population impossible, and the desire to reduce disturbance associated with attempts to obtain more detailed composition data. Harvest

allocations and discussions of trend data based on the adult (≥2 years old) population alone would be more biologically relevant (Côté et al. 2001), reducing the influence of annual variation in kid productivity and survival to survey date (generally July to September). Given current aerial survey techniques, use of "adults" (≥1 year of age) alone (ignoring kids) in population trend analysis would likely reduce the inherent variance compared with total population numbers.

Harvest data and rates

Evidence from Caw Ridge and other small to medium sizes populations in the western Alberta foothills suggest that harvest rates greater than 3% are not sustainable (Côté and Festa-Bianchet 2003, Gonzalez-Voyer et al. 2003). Côté and Festa-Bianchet (2003) suggest that the best management strategy for native populations of mountain goats is to combine a 2–3% yearly harvest with a strong encouragement to harvest adult males. Current harvest rates estimated for the 5 GMZs in the Kootenay are within or below the target 2–3% harvest rate, and female harvests have decreased in most areas. I suggest these harvest rates are biased low in most GMZs in the Kootenay because of dated or suspected underestimates on goat population estimates. Examples of poor or dated survey data include: GMZ 4Ea: MU 4-21 and 4-25; 4Eb: 4-06; 4Ec: 4-34; 4Wa and 4Wb (all MUs).

Hatter (2005b) suggested that the only GMZ in the Kootenay where the average annual harvest for 1995–99 exceeded the potential biological removal was GMZ 4Ec. I suggest this comparatively high harvest rate primarily was a result of a significant underestimate in the population size. Calculations using 2001–05 harvest data and the 2005 estimate indicate that the current 4Ec harvest rate of 1.9% is the lowest in the EK. However, this GMZ does bear closer scrutiny because of the high proportion of females in the harvest.

Data from Caw Ridge suggest that kid production peaks for females 6–9 years of age, and survival of females >5 year old has the greatest potential to influence population changes (Côté and Festa-Bianchet 2001, Hamel et al. 2006). Thirty percent of the females harvested from 2001–05 were 6–9 years of age. Since the age distribution in the population is unknown, it is difficult to determine whether this segment of the population is being preferentially selected. Regardless, declines in the proportion of females in the Kootenay goat harvest since 2000 should enhance kid production and recruitment in most areas, increasing the sustained yield of populations. Indeed, kid ratios observed in the East Kootenay since 1998 appear to be higher than ratios observed prior to 1991 (Figs. 5, 6). The decrease in females in the harvest occurred concomitant with an increase in hunter success, suggesting greater selection of males did not come at the cost of lowered hunter success. Increased efforts at hunter education and goat identification efforts since 2000 appeared to have paid off in most areas of the Kootenay; continuing efforts should be directed in particular at GMZ 4Ec where both resident and G/Os continue to obtain a high proportion of females in the harvest. The proportion of females in the GMZ 4Ec harvest is 70% greater than GMZ 4Ea (Table 7), with most of the MUs contributing to this total (Table 8).

Harvest levels in the Kootenay are based on a target of up to 4–5% through allocation of tags between residents (allocated 75% of tags) and G/Os (25%). Actual harvest rates are far below the tag allocation rates because of hunter success for both residents and non-residents, and particularly apparent low interest by residents (18% of LEH zones had fewer applications for resident tags than tags available in 2004, and residents hunted on roughly 20% of the tags available to them). While I suggest that many areas of the Kootenay can likely sustain higher harvest rates than currently experienced, managers should be cognisant that the differential harvest effort and success between residents and non-residents means that allocation of a greater proportion of the goat tags to G/Os can change the harvest rate, even given no overall change in tag allocation. The critical parameter to goat populations is the harvest rate, which is a function of tag numbers, allocation between residents and G/Os, and harvest success, and managers need to be fully aware of these interactions.

Summary, and research and monitoring requirements

In summary, estimated mountain goat numbers have increased since 2000, although at least some of this increase is likely due to more rigorous survey methodology. Real population increases may have occurred, possibly as a result of relatively mild winters, reduced harvest levels, and reductions in the proportion of the females in the harvest. Changes in numbers of predators (cougar numbers likely have declined since the late 1990s) and greater amounts of fire activity (as a result of hotter and drier summers) may have contributed to increased goat productivity and survival. Increased kid ratios and increased hunter success since the late 1990s may reflect actual increases in populations. During this same period resident hunter effort appears to be declining rapidly, with a large number of LEH tags not used. Harvest rates for 2001–2005 in most areas of the Kootenay are within or below levels thought to result in sustained harvests.

The size of goat populations appears to have been underestimated in portions of the Kootenay prior to the early 2000's. While updated population estimates have been obtained for many areas over the past 4 years, a number of MUs still have dated or likely inaccurate estimates. Because of variable (and often undocumented) survey effort and conditions of some of the earlier surveys, it is difficult if not impossible to "correct" and update older population estimates to current values without re-survey.

Very few surveys have been conducted in WK MUs in the past decade, primarily because of the difficulty of survey in more forested habitats encountered and the sense that changes in population could be detected using local knowledge and hunter success (G. Woods, MoE, Nelson, personal communication, January 2006). While estimates from the southern WK may be more difficult to obtain (primarily because of perceived smaller populations with areas of greater amounts of forest cover), it may be useful to attempt to update population estimates in some areas. This may be especially important in light of reported declines in goat numbers in the Okanagan (Gyug 2005; B. Harris, MoE, Penticton, personal communication).

As pointed out earlier, many aspects of goat ecology are unknown or poorly known, in particular the dynamics surrounding the apparent lack of density dependence responses in established, native populations. Much of the recent data and understanding comes from intensive research conducted at Caw Ridge and surrounding small to medium sized, discontinuous populations in the western Alberta foothills, which may not be indicative of larger populations residing in the continuous alpine and subalpine habitat of the Kootenay. Research programs in the Kootenay focussed on clarifying parameters of fecundity and mortality (e.g., female age at first reproduction) could be linked in with data and models derived from Caw Ridge to examine population dynamics and refine levels of sustained yield. This would require more than trivial effort, but the dividends would include greater confidence in managing for sustainable harvest rates within the region.

Consideration should be given to establishing an aerial survey study area where more frequent (possibly biannual) surveys could be conducted to examine trends in numbers over time, and the variation in survey results. Survey methodology and reporting should be standardized (Poole 2007) and well-documented, including calculation of goat density within potential goat habitat. Both total counts and estimated numbers should be provided. Using research results and published results, Poole (2007) suggested 60–65% sightability may be appropriate during surveys over broad areas of the Purcell and Rocky mountains.

Recent surveys in adjacent areas of the Rocky Mountains (Elk: 1.69; White: 1.66; Bull: 1.83 goats/km^2) and Purcell Mountains (St. Mary: 0.67; MU 4-26: 0.62 goats/km^2) have generated fairly similar goat densities among areas. These consistencies lend support for an ecological basis for goat densities in the East Kootenay, 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.

Comments on individual Management Units

Here I offer comments on individual MUs that fall out of the range of roughly 2–3% harvest rate (as calculated with the latest data), and do not contain small populations:

MU 4-01: The harvest rate and percent females in the harvest suggest an increase in harvest could be sustained.

MU 4-02: The high harvest rate since 1996 at the same time as the increase in population estimate suggest either that goats in this unit may be shared with adjacent populations in MU 4-01, or that the recent census (Poole and Klafki 2005) missed a large number of goats. Given the current estimate of relatively small population, it may be wise to reduce harvest rates until this is clarified.

MU 4-06: Most of this unit has not been surveyed, with the exception of borders with 4-20. The apparent high harvest rate is likely a function of underestimate in population size.

MU 4-16: This unit has not been surveyed in recent years, so it is unclear whether the high harvest rate is sustainable, or a function of a population underestimate.

MU 4-20: Recent increases to the population estimate suggest higher harvests can be sustained.

MU 4-27: Although the population estimate for this unit doubled between 2000 and 2005, only a small portion of the MU has been covered, suggesting the current estimate is still low. Increased harvest opportunities could be presented, although the low application rate for tags by resident hunters (Limited Entry Hunting regulations synopsis 2005–2006) suggest further resident interest in this area is limited.

MU 4-34: Low harvest rates suggest higher harvests can be sustained, especially considering current estimates for goat LEH 4-34A and 4-34C are likely low.

MU 4-35: The estimated harvest rate in this MU is high relative to the population estimate, and could be reduced pending re-survey.

MU 4-36: The harvest rate could be increased, but the high female harvest (46%) suggests caution in large increases in allocation.

MU 4-37: The high female harvest (52%) should be reduced.

MU 4-39 and MU 4-40: Harvest rates in these units are low, but resident hunting opportunities are likely saturated because of open season in portions of the MUs and low application rate (e.g., MU 4-39B, about 20 hunters applied for 39 tags). G/O hunting opportunities could be increased.

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Appendix 1. Reg 4 goat estimates by GO LEH MU May06 v10.xls

This Excel file was developed to detail and document current mountain goat population estimates by guide/outfitter (G/O) area, Limited Entry Hunting (LEH) zones, and wildlife Management Units (MU) within the Kootenay region (Region 4). It provides a series of assumptions and details to derive estimates for each area/unit. This file should be considered a living document, to be updated as new information becomes available.

Assumptions and interpretations

- Used latest databases available for MU; combined surveys if non-overlapping by distinct mountain blocks, used most recent if overlapping;
- Considered only goats observed within Goat LEH zones; used 1,000 m buffer either side at ht of land and split between;
- Used total goat numbers, not adults or non-kids only;
- Teske and Forbes (2001) reported on CB 1998 (initial summary in Davidson 2000), WLAP/CB 2000, and Halko and Hebert 2000;
- For 1998 (CB) and 2000 (Halko) survey database: Corrected 3 locations and used NAD83 projection;
- For 2000 MWLAP/CB data: Obtained some digital data from CB, entered 4-20;
- For 4-36 (Golden north), used 2002 Poole and Mowat survey;
- For Bugaboos/Bobbie Burns (4-34) primarily used Poole and Adams 2002 CMH survey;
- Obtained Parks Canada (J. Woods) data (PC 2001) for Aug 2001 survey of northern 4-34 (Dogtooth Range);
- Used Clark (2004, unpublished data) for 2004 Alberta survey along the edge of 4-01; avoided areas overlapping with Halko and Hebert (2000);
- Used Poole and Klafki (2005) to supersede areas surveyed previously.

Sightability

- Halko and Hebert (2000) suggest sightability as 50%, except for 4-23 where areas missed and conditions poor. I arbitrarily set sightability for 4-23 to 40% (now most resurveyed in 2005);
- Teske and Forbes (2001) reported 40-60% sightability, depending upon MU and survey;
- Poole and Mowat (2002) reported 50%, and Poole and Adams (2002) and Poole (2003) reported 60%;
- Poole (2004) reported 60% for 4-26 and 65% for 4-22;
- Poole and Klafki (2005) reported 60% for 4-20, and 65% for the Flathead, Elk and White;
- Note: the CB 1998 and WLAP 4-20 2000 surveys appear to be particularly poor on goats observed; sightability should be set at 40% max for both surveys.

Literature cited (recent surveys for Excel spreadsheet)

(see Literature cited section in main report)