Efficiency of aerial surveys of mountain goats

Alejandro Gonzalez-Voyer, Marco Festa-Bianchet, and Kirby G. Smith

Abstract Because managers often rely on aerial surveys to monitor wildlife populations, it is important to estimate the proportion of animals observed. We compared the number and age classification of mountain goats (*Oreamnos americanus*) seen during aerial surveys to the actual number of goats in a marked population in west-central Alberta from 1989 to 1999. On average, 69.5% of the goats were seen during aerial surveys, but the proportion of goats seen in any one survey ranged from 55 to 84% (CV=12.3%). Observed and actual numbers of adult goats were best correlated. Yearlings and kids appeared difficult to classify from the helicopter; therefore, estimates for these 2 age classes were poor. Aerial surveys detected broad population trends over a number of years.

Key words aerial surveys, Alberta, efficiency, ground counts, mountain goats, *Oreamnos americanus*

Aerial surveys are a practical way to monitor wildlife abundance over vast and remote areas (Mourão et al. 1994). Helicopters are often used to conduct wildlife surveys in rugged and mountainous terrain (Thomson and Baker 1981). Wildlife managers use aerial surveys for a diverse array of species, including kangaroos (*Macropus* spp., Clancy et al. 1997) and wood storks (*Mycteria americana*, Rodgers et al. 1995). Information obtained through aerial surveys is used to make management decisions, such as establishing hunting quotas (Clancy et al. 1997). Managers therefore require information on the reliability of aerial surveys.

Despite the important role played by aerial surveys in management decisions, no one has assessed the efficiency of aerial counts by comparing them to actual numbers of animals in marked populations over several years. Many studies have estimated the proportion of marked animals seen during surveys; for example, Cichowski et al. (1994) saw 68% of 28 marked mountain goats (*Oreamnos americanus*) during aerial surveys. Gilbert (1957) compared aerial counts of mule deer (*Odocoileus hemionus*) to population estimates obtained through the drive method, whereas Wolfe and Kimball (1989) compared estimates of the size and composition of a population of bison (*Bison bison*) obtained through aerial surveys to results obtained from a near-total roundup of the herd. LeResche and Rausch (1974) compared aerial counts of moose (*Alces alces*) over fenced 2.6-km^2 enclosures containing a known number of animals. Rodgers et al. (1995) compared aerial survey estimates with ground counts of stork nests. However, no study has compared aerial survey estimates with known population size and age structure over several years.

Mountain goats are frequently found in inaccessible terrain where helicopter surveys are the only practical method to estimate population size and composition. Smith (1986) suggested that managers should monitor numerical changes of mountain goat populations and apply a tracking harvest strategy. Mountain goats often are counted only once a year because of the high cost of helicopter time and because this species is particularly sensitive to helicopter harassment (Côté 1996). Annual aerial counts in west-central Alberta from 1973 to 1999 were used by the Alberta Natural Resources

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Service to monitor 12 goat populations, some of which were hunted (Smith 1988). After 1983, survey results suggested a decrease in goat numbers, despite a reduction in harvest. Based on those aerial counts, hunting was closed in 1987.

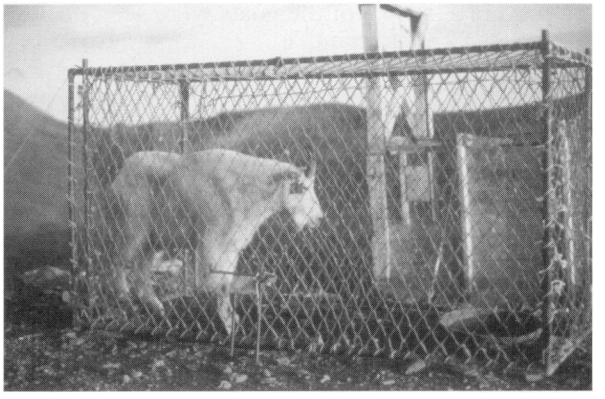
Herein, we examine whether aerial counts of mountain goats can estimate population size and detect population trends. We assess the overall survey efficiency, variability in efficiency from year to year, and efficiency by age class.

Methods

The Willmore Wilderness Park (WWP) in west-central Alberta (Canada) included several mountain complexes. It was characterized by long, cold winters and cool, wet summers (Smith 1988). We used the Caw Ridge population of mountain goats to assess efficiency of aerial surveys by comparing them to number of individuals present on the ridge at the time of the aerial survey. Caw Ridge is one of 12 goat survey areas in and near the WWP. It is a 28-km^2, rolling mountain complex east of the front range of the Rocky Mountains, similar to other ranges used by mountain goats in this area. Goats used alpine tundra and subalpine spruce (*Picea engelmanii*) forest at elevations of 1,750 to 2,170 m. Timberline was at about 1,900 m. Festa-Bianchet et al. (1994) provided a detailed description of Caw Ridge.

Annual helicopter surveys of several populations of goats, including Caw Ridge, were conducted from 1973 to 1999 by flying over mountain complexes above timberline. A Bell 206 Jet Ranger helicopter was flown in a counterclockwise direction around each mountain complex between timberline and ridge top, at an air speed of 120 to 150 km/hour. The navigator-principal observer was seated to the left of the pilot, the second observer was in the left rear seat, and the recorder was in the right rear seat. All surveys in this paper were done by the same observers, except for a different principal observer in 1997 and a different secondary observer in 1998. Over the last 11 years, 4 pilots were involved. However, all were experienced in mountain flying and the navigator ensured that the helicopter coverage was similar for each year surveyed. Mountain goats were classified as kids, yearlings, and adults. When group size exceeded 20 goats and a useful vantage point was available, the helicopter landed and goats were classified from the ground with a 20–45X spotting scope. Most surveys were conducted in the first week of July after nursery herds had congregated; survey dates ranged from 28 June to 21 July. We tried to fly between 0600 and 0900 hours and between 1700 and 2200 hours, when goats were most active. The principal observer was familiar with goat distribution in summer over the study area; therefore the flight route covered all known areas of goat habitat and was repeated each year.

The Caw Ridge population was the object of an intensive investigation of mountain goat ecology and behavior from mid-May to mid-September in 1989–1999. Over 80% of goats one year of age and older were marked in most years (Table 1), and each marked goat was seen 5–50 times each summer. In 1989–1993, we estimated number of unmarked goats by assuming we saw all adult males on days when we saw all marked adult males and assuming that we saw all unmarked goats other than adult males on days when we saw all marked goats other than adult males, something that happened 3–5 times each summer. After 1993, unmarked goats were individually known by their morphology, sex, and age. Unmarked kids were known by their association with marked mothers. In no case was a marked goat missed one year ever seen again on Caw Ridge; sighting probability was therefore 100% between May and September each year. Thus, similar to other studies based on long-term monitoring of marked populations in open habitats (Clutton-Brock 1992, Jorgenson et al. 1997), accurate information on population size and composition was available for the day of the aerial count. We do not claim 100% accuracy as we did not know exact dates of death for all goats, and it is possible that our ground estimates were off by 1 or



Mountain goat male in a Clover trap. About 80% of adult and yearling mountain goats on Caw Ridge were individually marked during the study.

Table 1. Mountain goat population size and composition obtained through ground censuses and percentage of goats seen by aerial surveys during 1989–1999, on Caw Ridge, west-central Alberta, Canada.

	Adults			Yearlings			Kids			Total		
Year	Total	Marked	% seen	Total	Marked	% seen	Total	Marked	% seen	Total	Marked	% seen
1989	61	19	70.5	14	10	64.3	20	13	75.0	95	42	70.5
1990	50	35	78.0	12	10	41.7	18	11	94.4	80	56	77.5
1991	57	42	56.1	13	7	30.8	16	4	68.8	86	53	54.7
1992	60	50	58.3	8	2	87.5	17	9	70.6	85	61	63.5
1993	63	54	60.3	12	10	50.0	26	10	61.5	101	74	59.4
1994	57	54	70.2	20	13	60.0	26	0	69.2	103	67	68.0
1995	70	68	75.7	15	12	26.7	26	5	73.1	111	85	68.5
1996	71	70	66.2	14	8	71.4	20	7	80.0	105	85	69.5
1997	71	68	80.3	8	5	25.0	19	9	121.1	98	82	83.7
1998	73	66	71.2	13	11	69.2	34	0	41.2	120	77	70.0
1999	72	67	93.1	29	13	24.1	26	0	103.8	127	80	79.5
Mean	64.1	53.9	70.9	14.4	9.2	50.1	22.5	6.2	78.1	101.0	69.3	69.5
S.D.	7.7	16.4	10.8	5.8	3.4	21.9	5.5	4.7	21.6	14.6	14.5	8.5
C.V.	12.1	30.5	15.2	40.7	37.4	43.8	24.3	76.2	27.7	14.4	21.0	12.3

2 units in some years. Survey efficiency was calculated by comparing number of goats seen during aerial counts to our estimate of those actually on the ridge.

We first calculated percentage of each age class seen during aerial counts for the 11 years of the study, then used a Kruskall-Wallis analysis of variance to test for differences in detection rates among age classes. We used linear regressions to compare observed and actual number of goats. Finally, we used analysis of covariance with year as a factor to test whether aerial counts detected population trends.

Results

On average, 69.5% of the goats were seen during helicopter surveys (Table 1). Counting efficiency, however, varied among age classes: 71% for adults; 78% for kids; and 50% for yearlings (Kruskall-Wallis test, $\chi^2_2=8.303, P=0.016$). Observers likely misclassified kids and yearlings; in 2 years they counted more than 100% of the kids present but reported seeing only about 25% of the yearlings. Therefore, these 2 age classes were pooled into a "juvenile" class for some subsequent analyses. Yearly variation in counting efficiency for the kid (CV = 28%) and yearling (CV = 44%) classes was greater than for the adult class (CV = 15%, Table 1).

We found a linear relationship between total number of goats and number counted from the helicopter ($F_{1,10}=24.94, P=0.001$, Figure 1), and a similar relationship for the number of adult goats ($F_{1,10}=14.90, P=0.004$, Figure 1). However, neither the yearling ($F_{1,10}=1.42, P=0.26$) nor the kid age class ($F_{1,10}=0.54, P=0.48$) showed a significant relationship between observed and actual numbers (Figure 1). There was a significant linear relationship between number of juveniles (yearlings and kids) present and number observed during surveys ($F_{1,10}=9.59, P=0.012$). Analysis of covariance revealed that the goat population increased during the study (year effect, $F_{1,22}=43.46, P<0.001$). There was no interaction between type of count (aerial survey or actual count) and year ($F_{1,22}=0.007, P=0.93$), indicating that the slopes of population trends obtained with the 2 methods did not differ (Figure 2). Aerial surveys underestimated the number of goats (type of count; $F_{1,22}=72.01, P<0.001$).

Discussion

Our research suggests that helicopter surveys detected trends in total population size and number of adults for mountain goats. As expected, aerial counts underestimated total number of goats. Both our study and Cichowski et al. (1994) reported an average sightability of about 70%, suggesting that this figure may apply widely to mountain goat helicopter surveys. Individual surveys detected between 55 and 83% of the goats in the population; therefore accuracy of individual surveys was

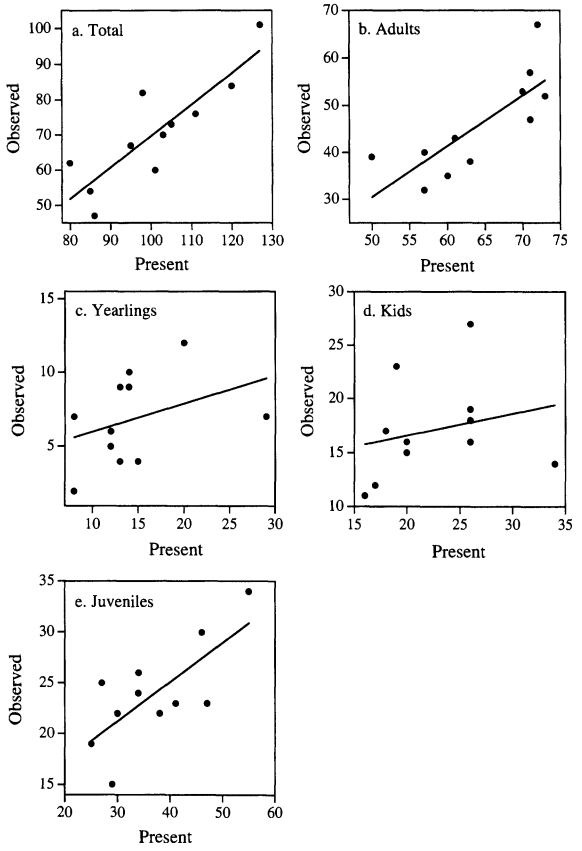


Figure 1. Total number of adult, yearling, kid, and juvenile goats seen during aerial surveys (1989–1999) and number present on Caw Ridge, west-central Alberta, Canada. (a. Total: $y = 0.89x - 19.57$, $r^2 = 0.74$; b. Adults: $y = 1.08x - 23.54$, $r^2 = 0.62$; c. Yearlings: $y = 0.19x + 4.10$, $r^2 = 0.14$; d. Kids: $y = 0.20x + 12.53$, $r^2 = 0.06$; e. Juveniles: $y = 0.39x + 9.59$, $r^2 = 0.53$).

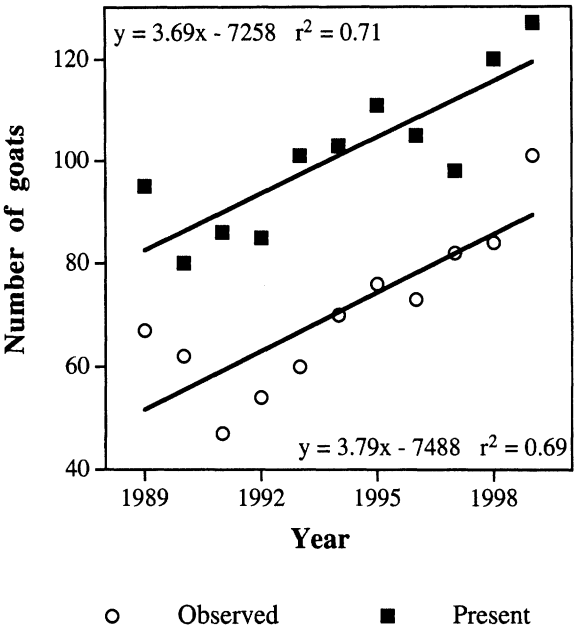


Figure 2. Number of mountain goats observed during aerial surveys and number present on Caw Ridge, west-central Alberta, Canada (1989–1999).

questionable. Aerial surveys of mountain goats appear to be useful only as trend indicators. Results of single surveys should be interpreted with caution and yearly surveys are required to monitor populations.

Other studies have addressed biases associated with aerial surveys. Bodie et al. (1995) found that helicopter surveys located only 61% of bighorn sheep (*Ovis canadensis*) groups observed by ground crews in canyon habitats. LeResche and Rausch (1974) also found that experienced observers saw 68% of moose in enclosures when snow cover was continuous. For pronghorn antelope (*Antilocapra americana*), Wooley et al. (1997) reported that observer error increased with group size and that adult males, which tend to occur alone or in small groups, were more often missed during aerial surveys compared to ground counts. A similar problem may have existed in our study, because adult male goats are often alone or in groups of 2–4 in forested areas. Because goats were not classified by sex during aerial surveys, however, we could not measure sex-specific sightability.

Our results suggest that observers cannot easily distinguish kid and yearling goats during aerial surveys. In 3 years in particular (1990, 1997, and 1999; Table 1), observers may have mistakenly classified yearlings as kids. On average, observers saw only half the yearlings but almost 80% of kids, despite the fact that kids and yearlings are found in the same groups.

Smaller body size, horn-to-ear ratio, and rounded facial appearance can be used to distinguish kids from yearlings during ground surveys (B. Smith 1988). When classifications are done from a helicopter, however, observers rely mostly on differences in body size. In July on Caw Ridge, yearlings are about twice as heavy as kids (Côté 1999). Most yearlings have visible horns in July whereas kids do not, but the small horns of some yearlings are difficult to see from the air. Some yearlings closely follow their mother while the group flees from the helicopter and observers may misclassify them as kids. Our analyses suggest that it is preferable to pool kids and yearlings into a single juvenile class and that estimates of juvenile survival based on comparing kid:adult ratio one year with

yearling:adult ratio the following year would be unreliable.

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Alejandro Gonzalez-Voyer (photo) recently finished his Masters degree at the Université de Sherbrooke, Canada. His thesis explored the effects of different management programs on mountain goat populations. In fall 2001 he will begin a Ph.D. program at the Universidad Nacional Autonoma de Mexico on siblicide behavior of blue-footed boobies. ***Marco Festa-Bianchet*** holds a Ph.D. degree from the University of Calgary and was a NATO postdoctoral fellow at the University of Cambridge before joining the Université de Sherbrooke, where he is professor of ecology. He chairs the IUCN Caprinae Specialist Group and conducts research on behavior and population dynamics of large mammals. ***Kirby Smith*** is an area wildlife biologist for Alberta Environment based out of Edson. He has been employed by the department for 24 years. Kirby holds a B.Sc. from the University of Alberta and is returning to the Department of Biological Sciences to start an M.Sc. on caribou ecology this fall. Kirby has been involved with The Wildlife Society (TWS) through his Canadian summary for the TWS publication "Wildlife Management in North American Wilderness" and as a director of the Alberta Chapter.

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