

## A METHOD USED FOR ESTIMATING MOUNTAIN GOAT NUMBERS IN THE BABINE MOUNTAINS RECREATION AREA, BRITISH COLUMBIA

DEBORAH B. CICHOWSKI, BC Parks, Bag 5000, Smithers, B.C., V0J 2N0

DEBRA HAAS, BC Parks, Bag 5000, Smithers, B.C., V0J 2N0

GEORGE SCHULTZE, BC Environment, Bag 5000, Smithers, B.C., V0J 2N0

**Abstract:** A mark-recapture method was used to estimate the mountain goat population size in the Babine Mountains Recreation Area in northwest British Columbia. Mountain goats were marked using a Rebel 90 paint-ball gun fired from a helicopter. Marks on individual goats ranged from single hits to flanks marked by brushing against rocks that were hit with paint balls. A total of 28 goats was marked. The study area was surveyed 1 week after marking and population size was estimated using the Peterson mark-recapture estimate. Assumptions of the Peterson estimate with respect to this technique are discussed.

Mountain goats (*Oreamnos americanus*) are most often associated with high elevation open habitat such as alpine meadows, grassy talus slopes, cliffs and rocky ridges (Banfield 1974). Consequently, mountain goat inventories typically consist of censusing goats seen in those open habitats (Hatler and Hazelwood 1985, van Drimelen 1985, Barichello et al. 1989). However, some individuals use forested or partially forested habitats (Joslin 1986a, van de Wetering 1989) and are not counted during census of open terrain. Because the entire population is not censused, a minimum population size is obtained.

Correction factors have been used widely for wildlife population estimates to correct for animals not seen during surveys (Smith and Bovee 1984, Gasaway et al. 1986, Jones 1988, Seip 1990) based on both qualitative and quantitative information. An intuitive estimate of the proportion of the population not seen (a best guess) is often used when information for more quantitative approaches is lacking (Jones 1988). Quantitative correction factors vary depending on the type of survey being conducted. In Alaska, a sightability correction factor for stratified random block moose (*Alces alces*) surveys was developed based on intensively resurveying a portion of several blocks (Gasaway et al. 1986). Mark-recapture estimates, based on the proportion of marked animals seen during surveys, are also often used to correct for

animals not seen during surveys (Smith and Bovee 1984, Seip 1990).

For the mark-recapture technique, animals may be marked with radiocollars, visual collars, ear tags, paint or any other marks that are visible during future surveys. Marking animals with radiocollars is desirable since all radio-collared animals can be located, whether they are within or outside the survey area, and the proportion of marked animals in the survey area can be determined. Radio-collared goats have been used for goat inventories in southeastern Alaska (Smith and Bovee 1984) and Montana (Joslin 1986a). However, a sample of radio-collared animals is expensive to obtain. Marking animals with paint or dye is a less expensive method for obtaining a marked sample. Aerial application of dye has been used on mountain goats in Alaska (Nichols 1980), Dall sheep (*Ovis dalli dalli*) in the Northwest Territories (Simmons 1971), and caribou (*Rangifer tarandus*) and moose in Newfoundland (Mercer et al. 1989).

For the Babine Mountains Recreation Area mountain goat inventory, we investigated a technique for marking goats with paint, using a paint-ball gun fired from a helicopter. The technique had been tested on moose in central British Columbia, but marks were too small to be conspicuous during surveys (H. Langin, pers. comm.). No other attempt at using a paint-ball gun for marking ungulates was found.

Because 'ferry' time by helicopter from Smithers to the Babine Mountains Recreation Area was only 5 minutes, the area was ideal for economically testing the marking technique on mountain goats. This paper outlines the techniques used to mark mountain goats and the resulting population estimate for the Babine Mountains Recreation Area.

The objectives of the project were:

1. To test a method for marking mountain goats using a paint-ball gun fired from a helicopter.
2. To determine the size of the mountain goat population in the Babine Mountains Recreation Area using the Peterson mark-recapture estimate.

The survey was conducted by BC Parks in cooperation with BC Environment, Fish and Wildlife Branch. Funding for the mountain goat inventory was provided by BC Parks. George Schultze operated the paint gun during the marking expedition. Tom Brooks (Canadian Helicopters) piloted the helicopter for the marking expedition and the surveys. Dave Ciriani kindly loaned us his paint-ball gun to mark the goats. Rick Marshall, Herb Langin, Darryl Hebert, Jean Carey, Dale Seip, and Dave Hatler provided advice on our marking technique and survey design. Kent Jingfors and Ian Hatter provided comments on an earlier draft of the manuscript.

## STUDY AREA

The Babine Mountains Recreation Area is located in northwestern B.C., 16 km northeast of Smithers (Fig.1). It covers 32,400 ha of the southern Babine Ranges in the South Skeena Mountains Ecoregion (Demarchi 1993). The Recreation Area consists of primarily Alpine Tundra (AT) and Engelmann Spruce-Subalpine Fir (ESSF) biogeoclimatic zones, and the mountains rise up to 2400 m from the Babine-Stuart Plateau to the east, and the Nechako Plateau to the south and west (BC Parks 1991). Vegetation in the ESSF zone consists primarily of subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), black huckleberry (*Vaccinium membranaceum*) and false azalea (*Menziesia ferruginea*). The AT zone is characterized by

krummholz and alpine scrub at lower elevations and herb meadows, dry alpine communities, grass slopes, exposed rocky slopes and glaciers at higher elevations. A forested valley (Harold Price Creek and north Reiserer Creek drainages) separates the southern Babine Mountains from the northern Babine Mountains which lie north of the Recreation Area. For survey purposes, the Recreation Area was divided into 2 zones separated by the Driftwood and Cronin Creek drainages.

## METHODS

### Marking Technique

Goats were marked in the Babine Mountains Recreation Area between 0700 and 1000 on June 16, 1991, 1 week prior to the survey. A Bell 206 helicopter was used to locate and mark goats in alpine and partially forested areas throughout the Recreation Area. Single goats and individuals within groups were targeted. Marking was conducted by firing oil-based, Nelson "007" paint balls (The Nelson Paint Company, 48 Industrial Park Cres., Saulte Ste. Marie, Ont., P6B 5P2) from a pump-action, Rebel 90 paint-ball gun (Rebel 90 paint-ball gun based on Nelson paint gun design), from the helicopter. The paint-ball gun was powered by a 200 gm (7 oz.) CO<sub>2</sub> tank and firing velocity was set at approximately 140 m/sec. Goats were marked either by a direct hit with red or orange paint balls, or by brushing against nearby rocks that had been hit by paint balls. Each group was examined immediately after marking to determine the number of goats marked and the marking patterns on each animal.

### Survey Technique

The Recreation Area was divided into 2 zones for surveying (Fig.1). Zone 1 was censused twice (July 22 and 24) and Zone 2 was censused once (July 23). Each zone was surveyed between 0630 and 1100 to minimize missing animals which moved below treeline during the heat of the day (Nichols 1980). All open and semi-open areas were searched. Surveys were conducted by Bell 206 helicopter with 3 observers, using the method described by van Drimmelen (1985). Locations of groups were plotted onto a 1:50 000 mapsheet and individual goats were classified as adult males,

adult females, yearlings or kids. Classification was based on pelage and morphological characteristics, and presence or absence of a vulval patch (Hatler and Hazelwood 1985, van Drimmelen 1985, Smith 1988).

#### Population Estimation Using the Peterson Mark-recapture Estimate

The size of the mountain goat population in the Babine Mountains Recreation Area was estimated using the Chapman estimator of the Peterson mark-recapture estimate (Seber 1982):

$$N = \frac{(n+1)(M+1)}{(m+1)} - 1$$

where:

N = total number of goats in the population

n = number of goats counted during the survey

M = number of goats marked

m = number of marked goats counted during the survey

and an approximately unbiased estimate of the variance is:

$$\text{Var}(N) = \frac{(M+1)(n+1)(M-m)(n-m)}{(m+1)^2(m+2)}$$

A 95% confidence interval for the estimate was calculated as:

$$N \pm 1.96 \times (\text{Var}(N))^{0.5}$$

Assumptions associated with the Peterson mark-recapture estimate that must be satisfied by the marking and survey techniques for the population estimate to be valid are addressed in the discussion.

## RESULTS

### Marking

A total of 28 goats (26 adults, 2 yearlings) from 8 groups was marked in 2.3 hours of helicopter time, for a marking rate of 1 goat / 5 minutes of helicopter time (Table 1, Fig.1). Helicopter time included 'ferry' time between groups and 'ferry' time to and from the study area. Marks on individuals included single hits, multiple hits, and flanks brushed against rocks that were hit with paint balls (Fig.2). Accuracy was greatest when the helicopter was 20-40 m away from the goats, and when the

helicopter was positioned directly beside and at the same level as the goats. Paint balls fired at goats above, below, in front, or behind the helicopter were deflected by 'prop wash'.

### Survey

The weather during all 3 days of the survey was sunny or slightly overcast. Table 2 summarizes the number of goats counted during the surveys. Only 6 marked animals were observed in Zone 1 on July 22, out of a possible 13 that were marked in that zone. We believed that we missed seeing some marks on goats in larger groups due to inexperience of some observers with the survey procedure. Therefore, we resurveyed Zone 1 on July 24.

Data for Zone 1 from July 24, and for Zone 2 from July 23 were combined to estimate the total population size (Table 2). Using the unbiased estimator, the summer population size was estimated at  $283 \pm 64$  (95% CL) and the adult and yearling population was estimated at  $253 \pm 53$  (95% CL).

More goats were counted in Zone 1 on July 22 than on July 24 (Table 2). Data for Zone 1 from July 22 and for Zone 2 from July 23 were combined for a minimum population size of 236 goats. Zone 2 contained proportionally more males and yearlings and fewer females and kids than Zone 1, but, the ratio of kids:100 females was consistent for both zones and for both days of surveys in Zone 1, and averaged 34.5 kids:100 females (Table 3). The age/sex ratio of goats marked (7 adult males: 19 adult females: 2 yearlings) did not differ from the age/sex ratio of goats counted during the survey (51 adult males: 95 adult females: 16 yearlings) ( $X^2=0.86$ ,  $p<0.05$ ).

## DISCUSSION

### Marking Technique

Marking mountain goats with a paint-ball gun from a helicopter was an effective and cost-efficient method for marking goats for short-term purposes. As the shooter and pilot became more familiar with the behaviour of the paint balls in the 'prop wash', marking success and efficiency increased. Marking frequency of 0.2 goats/minute was lower than the marking frequency of 1.1 caribou/minute in

**Table 1. Summary of goats marked with paint in the Babine Mountains Recreation Area, July 16, 1991.**

Group No. <sup>a</sup>	No goats in group	Sex	Location of mark
1	40-50	Female	b
		Female	b
		Female	b
		Female	Top front shoulder
		Female	Left rump
		Female	Left neck
2	40-50	Female	Left flank
		Female	Left shoulder
3	6	Male	Left shoulder/neck
		Male	Head
		Male	Head
		Male	Left shoulder and side
		Male	Head, head, left flank
4	10-15	Female	Right rump
		Female	Right side
		Female	Right side
		Female	Right side
		Female	Left side
		Female	Left side
5	8-10	Female	Top shoulders
		Female	Left neck
		Female	Left neck
		Male	Left neck
		Female	Left rump
6	9	Male	Left shoulder/upper leg
		Male	Right shoulder/upper leg
7	2	Female	Back, left front leg
8	1	Male	Right shoulder

<sup>a</sup> group numbers correspond to numbered locations in Fig. 1.

<sup>b</sup> location of marks on the first three goats was not recorded.

**Table 2. Total number of goats counted during helicopter surveys in the Babine Mountains Recreation Area, July 22-24, 1991.**

Zone	Date	Marked goats seen	Adult males	Adult females	Yrags	Kids	Total
1	22/07/91	6	14	80	8	28	130
2	23/07/91	9	36	42	14	14	106
1	24/07/91	10	15	53	2	19	89
2+1	23+24	19	51	95	16	33	195

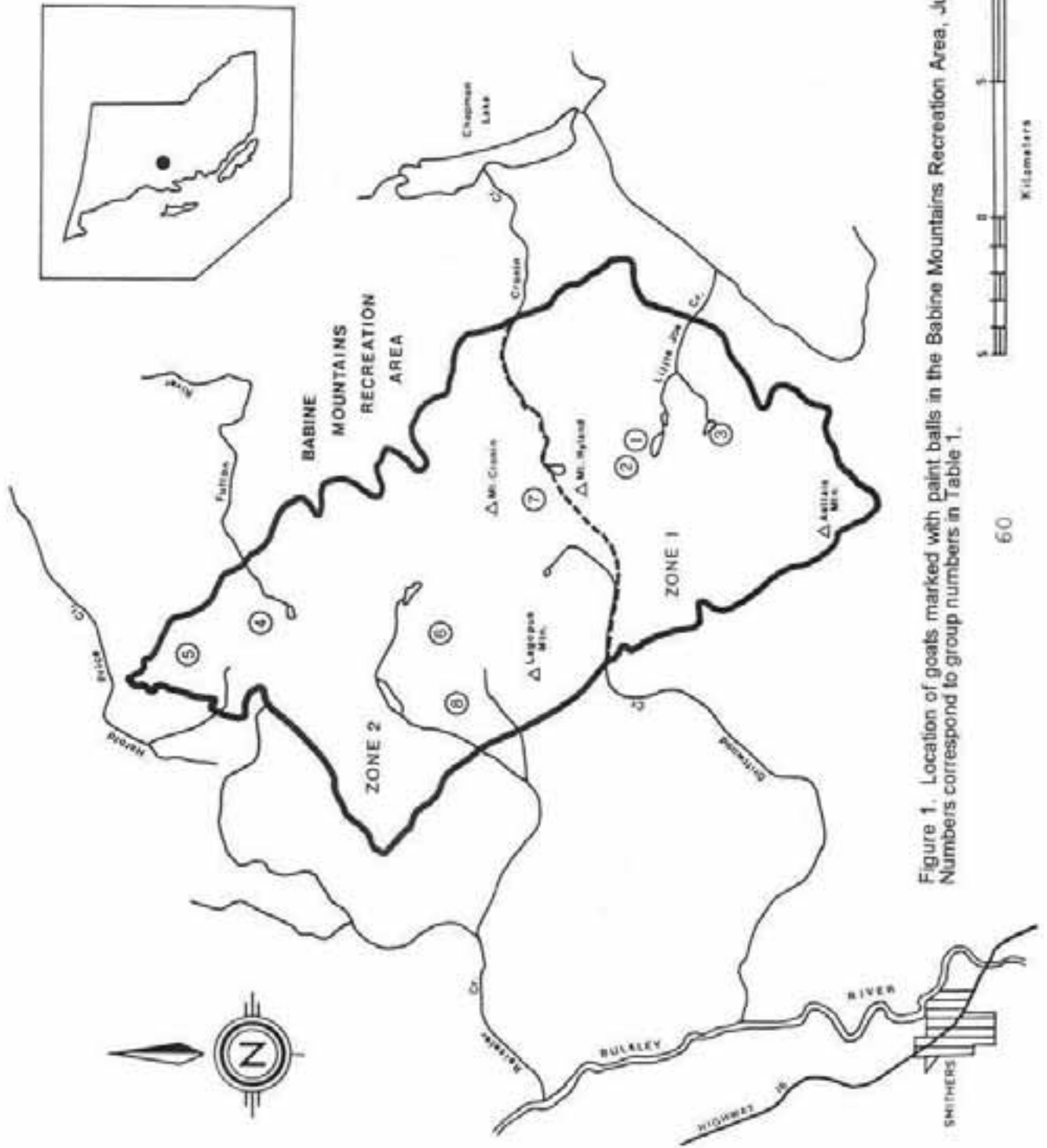


Figure 1. Location of goats marked with paint balls in the Babine Mountains Recreation Area, July 16, 1991. Numbers correspond to group numbers in Table 1.





Figure 2: Goats marked with paint balls, Babine Mountains Recreation Area, July 1991.

**Table 3. Age/sex class percentages and ratios of goats counted during helicopter surveys in the Babine Mountains Recreation Area, July 22-24, 1991.**

Zone	Date	% Adult males	% Adult females	% Yearlings	% Kids	Total	Kids: 100 females
1	22/07/91	10.8	61.5	6.2	21.5	130	35.0
2	23/07/91	34.0	39.6	13.2	13.2	106	33.3
1	24/07/91	16.8	59.6	2.3	21.3	89	35.9
1+2	22+23	21.2	51.7	9.3	17.8	236	34.4
2+1	23+24	26.2	48.7	8.2	16.9	195	34.7

Newfoundland using a paint spray apparatus (Mercer et al. 1989). However, the density of caribou (4.7 caribou/km<sup>2</sup>) was greater and the size of the study area (20 km<sup>2</sup>) was smaller than for the Babine Mountains goat population (0.9 goats/km<sup>2</sup>, 324 km<sup>2</sup>), which likely contributed to higher marking efficiency. Marking efficiency of the paint ball technique on the Babine Mountains goat population was comparable to the paint spray technique (0.15 caribou/minute) on caribou in Newfoundland when the density of unmarked caribou dropped to 1.0 caribou/km<sup>2</sup>.

Red and orange paint marks were highly visible on both smooth and shaggy animals during surveys; however, both sides of each goat had to be observed since individuals may have had marks on either side. In large groups (>20 goats), both sides of individual goats were sometimes difficult to observe. Consequently, more time was spent looking for marks than would have been if all individuals had been marked on the same side. Future attempts to mark mountain goats with paint balls should focus on marking all individuals on the same side to increase survey efficiency.

#### **Peterson Mark-recapture Estimate**

The population estimate based on the Peterson mark-recapture equation must satisfy a number of assumptions in order for the estimate to be valid (Krebs 1989).

Assumption 1: The population is closed.

The population is closed if no natality, mortality, immigration or emigration occurs between marking and recapture. Because the Recreation Area is flanked by low elevation plateaus to the west, south and east, and is separated from the northern Babine Range by a forested valley,

immigration and emigration during the week between marking and the survey likely did not occur. Also, since most kids are born by mid-June (Banfield 1974), natality was negligible. No kids less than 1 week of age were observed during the survey.

Although mortality was more difficult to assess, no evidence of recent goat mortality was observed during the intensive survey. Because the interval between marking and recapture was short, some evidence of mortality should have been observed had mortality occurred. Kid mortality during the marking and survey period for the present survey was likely negligible. No kid mortalities were reported for a sample of radio-collared kids in west central Alberta prior to August 19 (Smith et al. 1992), or for kids associated with radio-collared female goats in Montana prior to July 28 (Joslin 1986b).

Assumption 2: All animals have the same chance of being marked.

During the marking expedition, individual goats (males and females) and goats in groups were targeted throughout the Recreation Area in alpine and subalpine parkland habitat. Also, the age/sex ratio of marked goats did not differ from the age/sex ratio of goats counted during the survey, indicating that the marked sample represented the population.

Although kids were not marked, the population estimate derived from the yearling and adult population and factoring in the proportion of kids (283) was the same as the population estimate including kids.

Assumption 3: Marking individuals does not affect their catchability.

Marking individuals must not predispose them to being more or less detectable than unmarked animals. For example, in this case, because the goats were marked from a helicopter, the marked goats may have been more prone than unmarked goats to hiding when they heard the helicopter coming during the survey. To test for equal catchability, a minimum of 3 recapture or survey sessions is required (Krebs 1989). Because the study area was surveyed only once, we were unable to test this assumption. However, because the whole survey area was searched intensively, (i.e. a total count rather than a sample count), bias associated with not seeing marked animals was minimized.

Fewer goats were seen during the second survey of Zone 1 than during the first. Factors which may have contributed to the decrease in number of goats seen include avoidance or hiding from the helicopter due to exposure to the helicopter during the first survey, and weather conditions. If unmarked goats hid from the helicopter because they were exposed to it during the first survey, then marked goats would have likely avoided the helicopter even more. A smaller proportion of marked goats than unmarked goats observed during the second survey would have been expected. However, more marked goats were seen during the second survey. Because we attributed that increase to not seeing all marks during the first survey, we assumed that the maximum possible number of goats present in Zone 1 during the first survey was equivalent to the number of goats marked in that zone (13). No difference was detected between the ratio of marked goats (10/13) and the ratio of total goats (89/130) seen during the first and second surveys respectively ( $X^2=0.40$ ,  $p<0.05$ ), suggesting that the decrease in total goats seen was proportional to the decrease in marked goats seen, and likely did not affect the population estimate.

Weather conditions may have also affected goat distribution. The first survey of Zone 1 was conducted on a sunny day following several days of cloudy and rainy conditions. The second survey of Zone 1 was conducted on a sunny day following two sunny days. Fox (1977) observed that goats moved more immediately following rainy weather than during clear weather. For the Babine Mountains goat survey, goats may have been more

visible while moving during the first survey of Zone 1 than during the second survey.

**Assumption 4:** No marks are lost between marking and recapture.

Because the paint used was oil-based, and because the interval between marking and recapture was short, it is reasonable to assume that all marks were retained. Also, losses due to mortality were unlikely (see Assumption 1).

**Assumption 5:** All marks encountered during the survey are recorded.

Due to the inexperience of some observers with the survey procedure, we believed that this assumption was violated during the first survey of Zone 1. Not all goats in large groups were observed from both sides so the area was resurveyed. All goats were observed from both sides in Zone 2 on, and during the resurvey of Zone 1. Marking goats on only one side would increase survey efficiency and reduce bias associated with not satisfying this assumption.

Overall, the marking and survey techniques used to estimate the Babine Mountains Recreation Area goat population were effective in satisfying the assumptions of mark-recapture estimates. The survey technique was weakest in satisfying equal catchability. However, because there did not appear to be any movement between the two zones in the Babine Mountains Recreation Area, equal catchability may be tested economically in future surveys by resurveying one of the zones 3 times.

#### **Population Estimate**

The Babine Mountains Recreation Area mountain goat population was estimated at  $283 \pm 64$  (95% CL). During a survey in 1985, the population was estimated at 249 goats (van Drimmelen 1985); however, that estimate was not corrected for animals not seen during the survey. During the present survey, a total of 236 goats were counted on Day 1 and Day 2, without correcting for animals not seen. The 1985 estimate is comparable to the 1991 minimum population count and lies within the 95% confidence limits of the population estimate. The population appears to have remained stable between 1985 and 1991.



## MANAGEMENT RECOMMENDATIONS

The marking and survey techniques used to estimate the mountain goat population in the Babine Mountains Recreation Area were cost effective and generally satisfied the assumptions associated with mark-recapture estimates. We feel this procedure could be used for determining reliable estimates of other mountain goat populations.

Survey efficiency and reliability could be increased by marking goats on only one side of the animal; testing for equal catchability by resurveying a portion of the survey area 3 times; or marking goats from different zones with different coloured paints to identify movements between zones.

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