

## A Ground-Based Paintball Mark Re-Sight Survey of Mountain Goats

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**Abstract:** Mountain goats (*Oreamnos americanus*) were first transplanted to the Lone Peak area of northern Utah by the Utah Division of Wildlife Resources in 1967. The transplant was successful and mountain goats were subsequently moved to several sites around the state. They were transplanted to the Willard Peak area in 1994 with a supplemental transplant in 2000. Since its establishment, this herd has exhibited impressive growth. It is now one of the largest herds in Utah, and its growth and possible effects on the habitat have been a cause of both interest and concern. This study was conducted in the Willard Peak – Ben Lomond area of Box Elder and Weber counties in northern Utah. Mountain goats were marked using recreational paintball equipment and paintballs specifically intended for marking animals. We conducted 12 re-sight surveys between July 11 and August 31, 2007. Estimates of abundance were calculated using the Chapman-modified Lincoln-Petersen population estimate model. We concluded that marking from the ground can be both effective and feasible. However, conducting re-sight surveys from the ground can pose several challenges when trying to formulate accurate population estimates.

**Key Words:** Lincoln-Petersen population estimation, mountain goats, paintballs, Utah.

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One of the major challenges faced by wildlife biologists is the accurate estimation of population size. Population estimates are often used when creating population models and determining harvest recommendations. We wanted to explore the feasibility, utility, and accuracy of a method of population estimation known as a mark re-sight survey. In this particular case, we utilized recreational paintball equipment.

This method may seem unconventional, but it is increasingly being implemented by researchers as well as wildlife and natural resource management agencies to estimate species abundance (e.g., Cichowski et al. 1994; Pauley and Crenshaw 2006). Several studies involving mountain

goats, including those from these aforementioned references, have evaluated the effectiveness of aerially marking and surveying. Yet efforts to determine the utility and accuracy of ground-based marking and surveying are lacking. During an extensive literature review of mark re-sight surveys using paintball guns, we could not find any examples of ground-based surveys that employed this method. In addition to exploring this method's feasibility and accuracy, we also wanted to determine the areas of mountain goat use and concentration in the study area, investigate whether they were intermingling and moving throughout the entire area, and

gain a better overall understanding of the herd.

Recreational paintball equipment has been used to mark mountain goats to estimate population sizes (Cichowski et al. 1994; Pauley and Crenshaw 2006). Based on their aerial use of this technique, Pauley and Crenshaw (2006: 1354) concluded that the paintball mark re-sight method was effective in estimating abundance stating, “The paintball mark–resight approach provides significantly less biased abundance estimates than simple enumerations from aerial surveys.”

Cichowski et al. (1994) also conducted an aerial mark re-sight study utilizing paintball guns to estimate mountain goat abundance. They too felt that this method could be used for determining population estimates of other mountain goat populations. They concluded that their mark re-sight survey was cost effective and satisfied the assumptions associated with mark re-sight estimates. The assumptions for using this approach are:

1. All individuals have the same re-sighting likelihood
2. The population is closed: no emigration or immigration (static population size)
3. Individuals do not lose their markings during the course of the experiment.

### Study Area

Mountain goats were first transplanted to the Lone Peak area of Utah by the Utah Department of Fish and Game (now the Utah Division of Wildlife Resources (DWR)) in 1967. The transplant was successful and individuals were then transplanted to several sites around the state,

including Willard Peak. The Willard and Ben Lomond peaks herd was chosen for study because it is likely the most accessible in the state, making it ideal for observation. The herd is also well suited for study because most of its goats spend the majority of their time along the Skyline Trail in the summer (personal observations) (see Figure 1); this is the main path in the study area.

Willard Peak (coordinates: 41°22'59"N, 111°58'29"W) and Ben Lomond Peak (coordinates: 41°27'N, 111°57'36"W) are located on the Wasatch Range in northern Utah between Brigham City and Ogden (Figure 2). Their elevations are 2,976 meters and 2,960 meters respectively. In recent years, it has been common to see at least 70 goats concentrated just below the summit of Willard Peak in the early summer.

This area has apparently been ideal for the mountain goats. Since the herd was established in 1994, the region has experienced relatively mild winters. There are few predators, adequate escape terrain, and an ample forage base unexploited by other ungulates. This herd’s abundance has been estimated by the DWR primarily through the use of aerial surveys and subsequent population models that have been formulated.

The herd began with a transplant of six goats by the DWR in 1994. It received a supplemental transplant of four individuals in 2000, and increased to around 180 individuals by the fall of 2006 (DWR personal communication). One hunter-choice tag was issued for this herd from 2000 through 2004. Because of the herd’s rapid growth and increasing concerns about possible habitat degradation, the number of permits increased to three in 2005, and again to 25 in 2006 with 5 hunter-choice tags and 20 nanny tags being issued. Twenty-five permits were again issued in 2007.

In its management plan for this herd (State of Utah 2006) the DWR has identified 27 square miles of suitable mountain goat habitat between the North Ogden Divide and Willard Canyon. According to their management plan, the DWR has adopted the U.S. Forest Service's recommendation of 6 goats per square mile (which is the recommended density for southeastern Alaska). This density objective yields a population of approximately 160 mountain goats for the Willard Peak area. According to the Willard Peak management plan, if future monitoring shows that goats are using more area than was identified, or are not having detrimental effects on habitat, the objective could be raised (State of Utah 2006).

## Methods

Two paintball guns were used to mark mountain goats numerous times with brightly colored, biodegradable, oil-based paintballs. We used 'Animal Mark' paintballs manufactured by Nelson Paint Company (Kingsford, MI). These particular paintballs are specifically intended for marking animals; ranchers and farmers use them on livestock. Their paint is thicker and tends to last longer than that of recreational paintballs. To recognize specific individuals, we used four different colors of paintballs in our marking: red, orange, green, and blue.

We used two Tippmann A-5 paintball guns (Buffalo Grove, IL) during the marking process. Each gun was modified for fully automatic firing and was equipped with an Apex barrel (Fort Wayne, IN) for increased shooting distance and accuracy. During pre-marking testing, the paintball guns were judged to be accurate to within about 30 yards. At the outset of this study, we were unsure if it would be possible to get close enough to mark the

goats. We were also not sure how the goats would react immediately after being marked.

Compared with other various methods of investigation, this one appears to be relatively non-invasive; it seemed to cause minimal physical stress on individuals. The marking process did not appear to alter the animal's long-term behavior nor its overall health. It is conceivable that a goat's blood pressure, stress level, and heart rate may have increased immediately after being marked. Some bruising may have occurred. The animals that were marked were not unnecessarily pursued; individuals were quickly marked and left alone.

Based on discussions with DWR biologists, we determined that at least 20 goats needed to be marked to have an adequate sample size. This assumption was based on the 2006 DWR population estimate of 180 goats. We assumed that if we were able to get close enough to mark that many goats, that it would be an extremely time consuming process.

On June 29, 2007 the first attempt to mark goats was made around 5:00 AM. Christopher and Richard Schulze arrived at Inspiration Point near the summit of Willard Peak. As many as 6 or 8 goats could have been marked during this session but because of gun malfunctions, only 3 were successfully marked. Red paintballs were used. Marking stopped at around 10:00 AM because of the equipment failures.

On July 6, 2007 the second attempt to mark goats occurred. Darren Debloois (DWR District Biologist), Dax Mangus (DWR Biologist), Jim Christensen (DWR Technician), Christopher Schulze, and Richard Schulze arrived at Inspiration Point at around 5:00 AM and marked 14 goats below the summit of Willard Peak (see Figures 3 and 4). Red, orange, blue, and green paintballs were used; some of the

goats were marked with multiple colors. Marking finished at around 11:00 AM.

The third and final attempt to mark goats was made by Christopher and Richard Schulze on July 7, 2007. We arrived at Inspiration Point around 5:00 AM. Heavy motorcycle traffic on Skyline Trail distracted the goats, making marking more difficult this day. Seven more goats were marked though, bringing the final number of marked individuals to 24. Marking was again completed by 11:00 AM.

We also observed two adult goats with radio collars and green ear tags from the supplemental transplant in 2000; these were counted as marked individuals. This brings the total number of marked goats used to derive our population estimate to 26. Fifty-two total person-hours (6.5 person-days) were spent attempting to mark goats, which was considerably less than what was originally anticipated.

The personnel involved in the marking process were able to get surprisingly close to the goats (4.5-27.5 meters). Because of the rugged and heavily vegetated terrain, those involved in marking the goats were frequently able to get within 27.5 meters; an adequate distance to successfully mark. This type of broken terrain made it possible to more easily stalk the goats. Because mountain goat kids are born between late May and early June, we determined that the kids were too young to include at the time of marking. Yearlings and adults of both sexes were marked. From July 11 through August 31, twelve re-sight surveys were conducted.

We used a Lincoln-Petersen population estimate model with the Chapman bias modifier to estimate the total number of goats in the population (e.g., see discussion about these techniques in White et al. 1982). The Chapman modifier corrects for low sample size (i.e., low re-sighting probability). The equation for the

Lincoln-Petersen model is illustrated by the following formula:

$$\check{N} = \left[ \frac{(n_1+1)(n_2+1)}{(m+1)} \right] - 1$$

Where:

$\check{N}$  = total number of goats

$n_1$  = number of marked animals present at time of survey

$n_2$  = total number of animals (marked and unmarked)

$m$  = number of marked animals observed during re-sight.

## Results

Prior to formulating our population estimates, we concluded, based on our own knowledge of the herd, our field surveys from 2007, and the 2006 DWR population estimate of 180, that a population estimate greater than 300 was not realistic. The DWR's population growth models support this assumption and illustrate that even under the most optimistic conditions, the population could not be above 300.

Of our 12 surveys, 6 yielded population estimates between 180 and 300. If we eliminate the 6 population estimates that lie above 300, we arrive at a mean population estimate of approximately 249 goats for the six remaining surveys (Table 1).

In September 2007, DWR biologists conducted an aerial survey of the herd in which 181 goats were counted. The DWR estimates an 80% *sight ability* during its aerial surveying of mountain goats, yielding a population estimate of around 217 (DWR, personal communication). Based on the aerial survey, DWR biologists estimate that the 2007 population was between 200 and 225 individuals, making our re-sight survey population estimate of 249 goats 10-20% higher than the agency's.

There appear to be two main explanations for this difference. The simplest one is the fact that two different methods are being utilized to estimate population size. The second possible reason for a difference in the estimates is the likelihood that certain assumptions pertaining to mark re-sight analysis were violated during our surveys. The most obvious assumption which was violated is that all marked individuals had an equal chance of being re-sighted. We quickly concluded after our marking period that not all individuals had an equal chance of being re-sighted. We also determined that certain paint colors worked better than others for re-sighting. Further, some goats were marked more thoroughly than others; several were marked with too few paintballs and/or were marked on an area of the body that was difficult to view at certain times.

In addition, several of our surveys were conducted during or after rainstorms. These surveys produced what were concluded to be unrealistic population estimates ( $\geq 300$  individuals). During these surveys, goats were often covered with dirt or mud, making the viewing of markings difficult.

During our surveys, it was difficult at times to distinguish the green and blue paint markings from shadows or soiled areas on the goats. This makes it likely that we missed some markings during our surveys. Orange and red paint appeared to be the most visible. We also were concerned about the longevity of the paint used. Last, those goats that were marked numerous times in the head and neck areas were consistently the easiest to re-sight.

The majority of the goats that were marked were on the west-facing slope just below the summit of Willard Peak. During our subsequent surveying, however, we observed marked goats throughout the entire study area. Therefore, we determined that

goats were moving throughout the entire study area, exhibiting relatively little site fidelity. We observed that the goats utilize the entire study area with concentrations immediately west of Willard and Ben Lomond Peaks.

## Discussion

We concluded that a ground-based mark re-sight survey utilizing paintball guns is feasible, cost-effective, and has the potential to produce reliable population estimates. Marks were probably missed at times, especially during surveys conducted in immediately after inclement weather. Despite this concern, we feel that with some modification and refinement, that this method can be reliable.

Ground-based surveying posed several challenges that may not occur if the surveying was done aerially. For example, goats were often observed to all be facing the same direction and it was not possible to gain a  $360^\circ$  view of every goat for possible markings. Also, at times some goats were simply too remote for us to distinguish any markings. It would not have been feasible to hike to every goat and obtain a  $360^\circ$  view of each one.

During this project, we gained a better overall understanding of this population. Many hours were spent in the field observing this herd. For example, over the years there has been some question as to the availability of water in the area. In previous years of surveying, goats were not observed to be utilizing any of the available water sources. However, during this project, we “discovered” a spring which goats were utilizing. Also, on one occasion we observed a goat being harassed and pursued by a golden eagle (*Aquila chrysaetos*). Such observations led to an increased understanding of this herd.

### **Management Implications**

With some modification and refinement in methodology and surveying techniques we feel that this method could be an accurate tool for wildlife investigators. There are, however, several issues that should be considered concerning the accuracy associated with re-sighting. For example, several goats were marked with only one paintball or were marked with blue or green paint which proved to be extremely difficult to notice. Further, some goats were marked in almost unnoticeable locations on the body, which further complicated the likelihood of re-sighting.

For those contemplating marking mountain goats from the ground, we offer the following recommendations: the goats should be marked only with brightly colored red or orange paint. They should be marked as many times as possible; preferably towards the head, neck, and chest portions of the animal. Multiple re-sight surveys should be conducted within one week of their final marking to ensure a minimal amount of paint loss. A subsequent aerial re-sight survey should be done as soon as possible to gain more thorough survey coverage.

This type of mark re-sight surveying may be promising for concentrated and easily accessible mountain goat populations in which surveying the entire herd from the ground is feasible. This procedure could be utilized in instances where mountain goat populations are relatively dense, time and budgets are limited, and the population size is unclear and a more precise estimate is desired.

This type of project also can provide good public relations for wildlife management agencies. Our study area receives a significant amount of use from hikers, mountain goat and other wildlife enthusiasts, campers, and ATV riders. Our project appeared to be well received by the

public. People were excited and pleased to see DWR personnel actively conducting research in the field. Many expressed an interest and offered to help were the project to continue next year.

Because of its extremely low cost (our entire project was conducted for under \$1,200), relative non-invasiveness, and promising potential, we urge and recommend that wildlife managers and researchers explore and refine this method to capitalize on its potential as an effective tool in population estimation.

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*Associate Editor:*

Table 1. Mark re-sight results from the Willard Peak study area in Utah, USA.

Date	NO	NM	$\hat{N}$	95% Confidence Intervals
11-Jul	87	13	240	160-320
12-Jul	111	14	298	204-391
14-Jul	59	7	303*	143-462
20-Jul	109	7	519*	241-797
27-Jul	92	5	553*	199-906
31-Jul	49	13	180	121-239
3-Aug	61	2	764*	68-1460
10-Aug	46	6	308*	131-484
17-Aug	97	7	465*	216-713
22-Aug	56	6	296	127-465
24-Aug	71	9	291	160-421

31-Aug

24

4

193

63-324

Mean population estimate: 249

Where:

NO= Number of adults and yearlings observed

NM= Number of marked goats observed

$\check{N}$ = Estimated population using Chapman-modified Lincoln-Petersen model

\*Population estimates that were determined to be unrealistic

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Figure 1. Willard Peak mountain goats below the summit of Willard Peak near the Skyline Trail





Figure 2. Willard Peak mountain goat study area

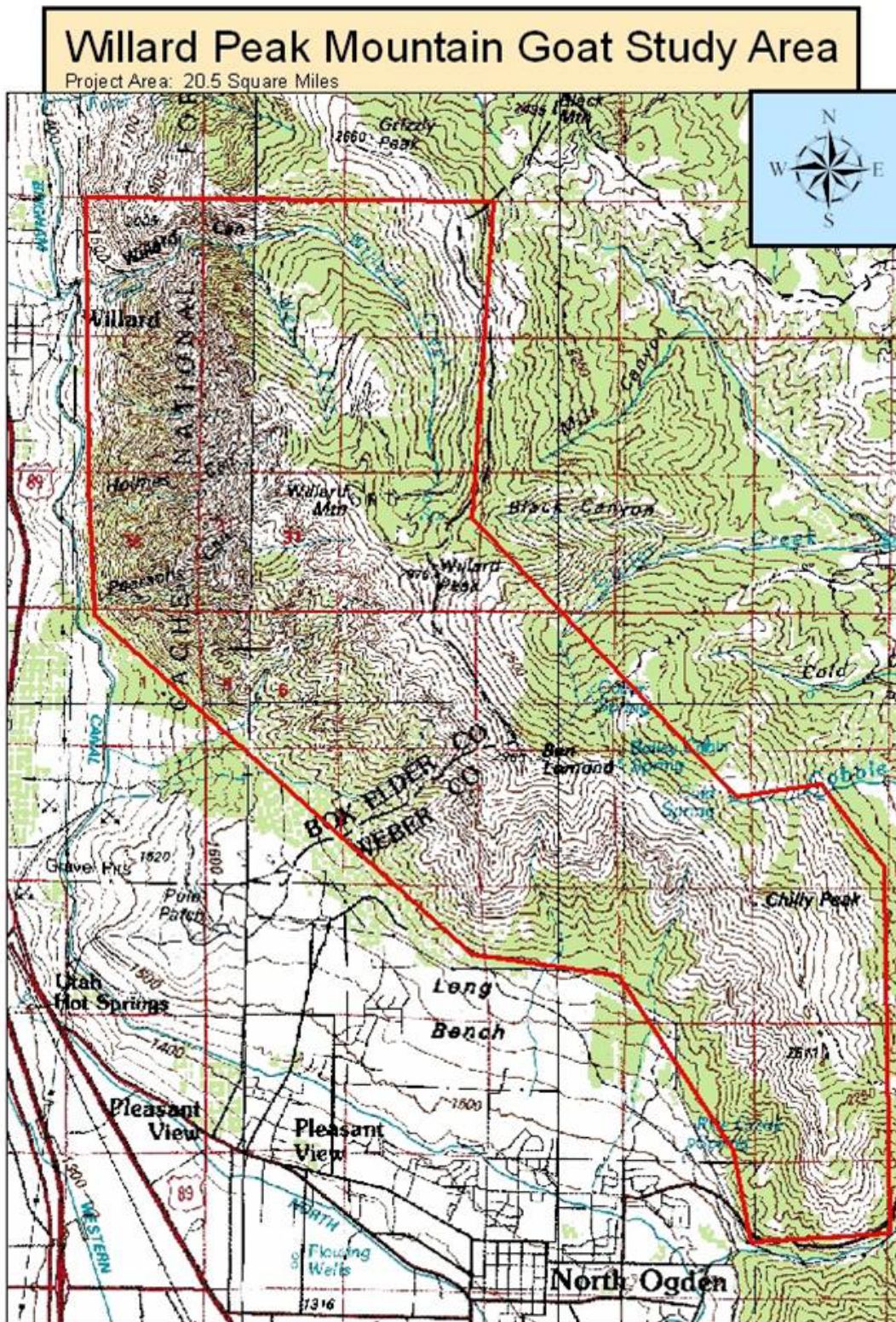


Figure 3. DWR biologists aiding in the marking process



Figure 4. Marked mountain goat at Willard Peak, Utah, USA

