

Mountain Goat Research in the Washington Cascade Mountains

Progress Report
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10 December 2003

Introduction

In 2002, the Department of Fish and Wildlife initiated a mountain goat research project. Cooperators in this project include the U.S. Forest Service, the National Park Service, the Sauk-Suiattle Tribe, the Stillaguamish Tribe, and Western Washington University.

This study has short and long-term objectives. The short-term objectives are to evaluate habitat relations for mountain goats in the Cascade Mountain Range and to develop and refine survey protocols for mountain goats in the state of Washington. Habitat studies include habitat suitability mapping in the North Cascades based on reported sightings of mountain goats, which is nearing completion, and a similar effort based on locations recorded from mountain goats fitted with GPS tracking collars, which is in the initial stages. Collared mountain goats will also provide information for studies of habitat selection, home range, and movements. Survey protocol development will emphasize the development of a sightability bias model for use in adjusting aerial surveys of mountain goats based on survey trials with the collared mountain goats.

The long-term objective of this project is to assess the magnitude, extent, and causes for the reported declines in mountain goat populations in Washington. Work to address this objective are in the planning stages.

This report covers the capture of mountain goats and initial findings based on GPS locations acquired to date.

Study Area and Methods

Mountain goats are found throughout the Cascade Range in Washington and on the Olympic Peninsula. For the purposes of this study, this range was divided into 4 areas, the Olympic Peninsula, the North Cascades (from Snoqualmie Pass north to the Canadian border and west of the Cascade crest), the South Cascades (from Snoqualmie Pass south to the Oregon border and west of the Cascade crest), and the East Cascades (from the Canadian border to the Oregon Border, east of the Cascade crest). Initial efforts (2002 and 2003) have emphasized the North and South Cascades areas with expansion to the East Cascades expected to take place in 2004 and to the Olympic Peninsula in 2006.

Within each area, a conceptual distinction was made between sites with extensive habitat and substantial numbers of mountain goats (> about 50) and isolated habitats with smaller mountain goat numbers (usually 10-20). This distinction was made for use in study planning to ensure that the results would incorporate potential differences in habitat and survey design considerations for these populations.

For the North and South Cascade areas, the desired distribution of mountain goat collars was determined by convening a working group comprised of study partners for each area.

These working groups evaluated the approximate distribution of mountain goats in each area and allocated collars by each habitat area to achieve a representative sample subject to some logistical constraints. One such constraint was the restriction on the use of helicopters for mountain goat capture within designated wilderness. In the North Cascades, the Forest Service supported helicopter captures in wilderness. Due to local concerns, this was not possible in the South Cascades.

Mountain goats were captured by darting with an immobilizing drug, either from a helicopter or on the ground. Generally, we used helicopter darting unless their use was constrained by regulations. Either the experimental drug A3080 (usually 2.5 mg with 50 mg of xylazine) or Carfentenil (usually 1.5 mg) were used. A3080 and Carfentenil were reversed with Naltrexone (usually 250 mg) and the xylazine was reversed with Tolazine (4 ml). Time to recumbency and recovery after reversal were noted when feasible. After helicopter captures, the approximate pursuit path was traced on a topographic map and the distance and elevation change during pursuit and induction were recorded.

Captured mountain goats were fitted with a Vectronic GPS Plus 4 D collar, measurements were taken, and many were scored for body condition using the palpation system developed for mule deer by R. Cook (similar to that for elk, Cook 2000). Rump fat thickness and loin muscle depth were measured using an iLook25 portable ultrasound. In some cases, measurements were not taken due to the need to release the animal promptly. Age was estimated based on horn rings.

Herculite was attached to collars to form 3 bands of color on each side to allow individual visual identification. Colors used were red, yellow, black, and light blue. Collars were programmed to attempt a GPS fix every 3 or 5 hours with the exception of 1 collar which was set at a 30 min interval. Fixes stored on the collar were acquired by remote download, usually from fixed-wing aircraft.

GPS fixes were plotted using ArcView (v8.2) and three-dimensional representations were created in ArcScene (3D Analyst extension to ArcView).

During helicopter surveys of Mt. Baker and Mt. Shuksan in the North Cascades, attempts were made to evaluate mountain goat movements in response to survey flights. For the Mt. Shuksan survey, GPS collars on the 2 mountain goats in the survey area were set to collect fixes at 5 minute intervals.

Results and Discussion

Captures

Between 26 September 2002 and 26 September 2003, 32 mountain goats were captured and fitted with collars (Fig. 1) during 34 capture operations. One animal was captured in 2002 and again 2003 for collar replacement and one animal (a non-lactating adult female) died during capture. This mortality was the result of an overdose while using the experimental drug A3080 and after this experience we discontinued its use. Helicopter darting was used for 25 of the captures, the remainder were darted from the ground (including the mortality). Despite the precipitous terrain occupied by mountain goats, we had good success in using the helicopter to maneuver them onto safe terrain for darting and constraining their movements during induction.

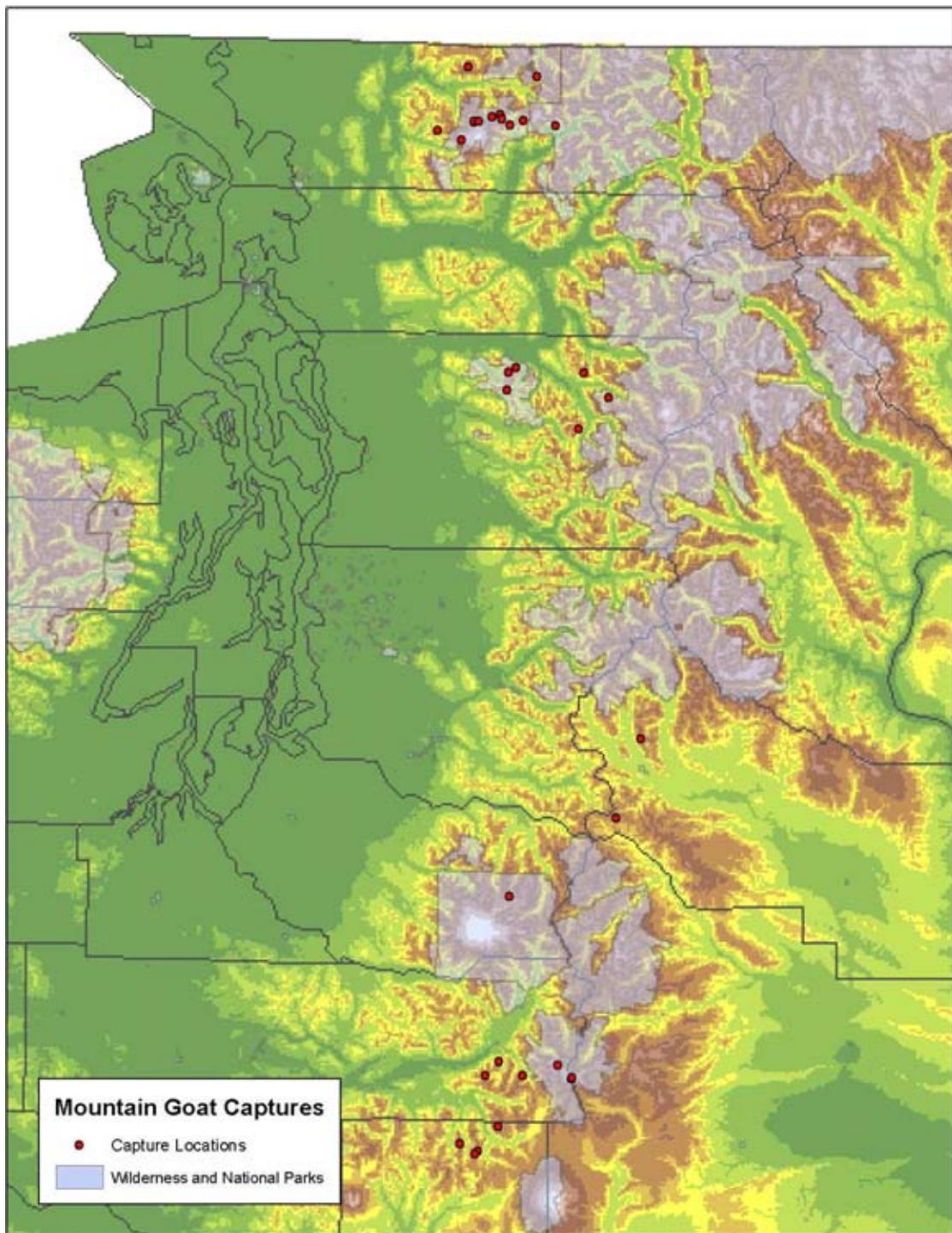


Figure 1. Locations of mountain goat captures, 2002 and 2003.

In the North Cascades, we successfully allocated collars according to the distribution determined desirable by the working group. In the South Cascades, where wilderness captures had to be by ground darting, captured goats in wilderness were underrepresented due to the low efficiency of that method of capture. One female was captured near

Easton where its range is expected to overlap with that of collared mountain lions being studied in that area.

Captured mountain goats were of various sex and ages (Table 1). The representation of males was somewhat greater than intended as it proved difficult to distinguish young males from females during approach and pursuit.

Table 1. Distribution of mountain goat captures by area, sex, and estimated age.

Area	Sex	Estimated Age								Not recorded	Total
		1	2	3	4	5	6	8			
North	F	1		3	3	4	1	1		1	14
Cascades	M		3		2						5
	Total	1	3	3	3	6	1	1		1	19
South	F		3	1						1	5
Cascades	M		1	2	2	1					6
	Total		4	3	2	1				1	11
East	F			1							1
Cascades	M				1						1
	Total				1	1					2
All Areas	F	1	3	5	3	4	1	1	2	20	
	M		4	2	3	3					12
	Total	1	7	7	6	7	1	1	2	32	

The cost of helicopter captures varied greatly depending on the abundance of mountain goats in the area (Table 2). In the vicinity of Mount Baker, captures/hr of flight time were >1, whereas around Darrington, this dropped to <0.5, reflecting costs of about \$500-\$2,000 per capture.

For body condition, rump scores ranged from 1.5–4.0 (mean=2.58, n=21), rump fat (measured by ultrasound) ranged from 0–0.24 cm (mean=0.68, n=17), withers pinch ranged from 1/8–1 in (mean=0.32, n=21), and loin muscle depth ranged from 2.5–4.5 cm (measured by ultrasound, mean=3.17, n=17). The sample sizes are small for analysis of patterns in condition, but in general showed remarkably low levels of rump fat. In mule deer, rump fat levels typically range 0.5-2cm (W. Myers, pers. comm.). Whether this is due to differential fat deposition between mountain goats and mule deer or a consequence of a relatively dry summer is uncertain.

One hundred percent of the serum samples (n=21) from mountain goats captured in 2003 tested positive for 1 or more serovars of Leptospirosis. This is a highly unusual finding which deserves further investigation. Leptospirosis affects both humans and other animals and varies in the severity of its affects, but can cause abortion in domestic animals and liver damage, kidney failure and internal bleeding in humans. In addition, 9 animals from around Mt. Baker tested positive for bovine viral diarrhea.

Table 2. Mountain goat capture costs for 14 captures in the North Cascades.

Operations	September 2003 date				Total (w/out ferry time)	Total (incl. ferry time)
	2	3	4	5		
Total Time		5.9	4.8	5.7		16.4
Ferry Time		1	0.5	0.7		
Capture Time		4.9	4.3	5.0	14.2	
Ferry Cost		700	346	479	1,525	
Capture Cost		3,430	3,014	3,511	9,955	11,480
Driver Pay	125	125	125	125		
Per diem Driver/Pilot	85	85	85	85		
Fuel Truck Mileage				330		
# Goats		7	5	2	14	
Goats/Hr		1.43	1.16	0.40	0.98	1.17
\$\$/Goat		490	603	1,756	711	820

*Three Fingers, Whitechuck, Round Lake, Falls Creek, South Cascade Glacier

The 4 mountain goats captured in 2002 were from isolated ridges west of the Goat Rocks Wilderness. Other captures took place in the summer and fall of 2003, so results reported here are preliminary.

For all collars, of the 17,481 attempted fixes (as of the most recent downloads), 58% achieved 3D fixes, 19% achieved 2D fixes, and 23% did not achieve a fix. This differed substantially among collars, range 3D fixes = 13–93%, 3D+2D fixes = 45–94%, no fix = 6–55% (n = 41–1,916). Time to achieve a fix or turn off after failing to do so averaged 103 seconds and the average ranged among collars 59–144 seconds.

Movements and Habitat Use

To date, observations suggest that the following generalizations are likely to emerge after further tracking:

1. Older males (age>4) move relatively little (at least during the fall, Fig. 2.).
2. Some younger males (age=2 and 4) exhibit large movements (Fig. 3).
3. Adult females in higher extensive habitat areas range wider than those in isolated habitats (Figs. 4 and 5).

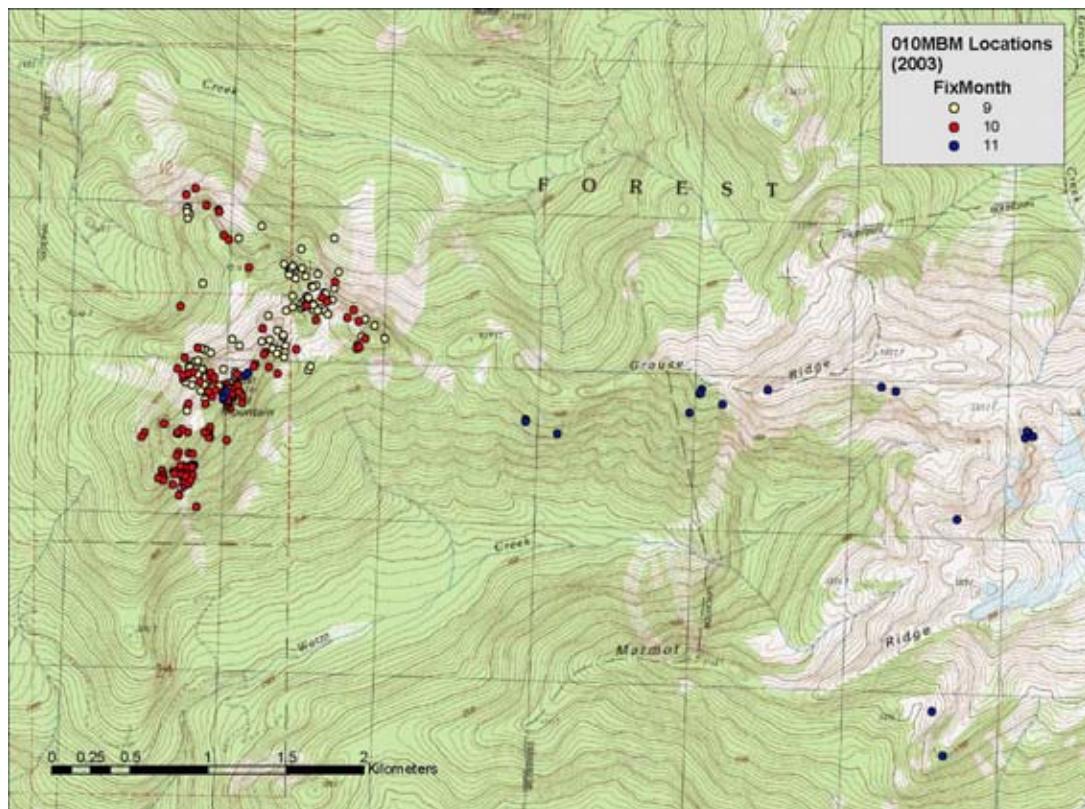


Fig. 2. Locations for mountain goat 010MBM, male, estimated age=5 years, 03Sep-04Nov 2003. 010MBM confined his movements to the vicinity of Groat Mtn. until the beginning of November and the approach of the rut.



Fig. 3. Locations for mountain goat 005DDM, male, estimated age=3 years, 02Jul-13Oct 2003. 005DDM moved from the capture site at Jumbo Peak about 11 km to the southeast (in 2 stages), then returned to Juniper Ridge traveling about 9 km north of the capture site.

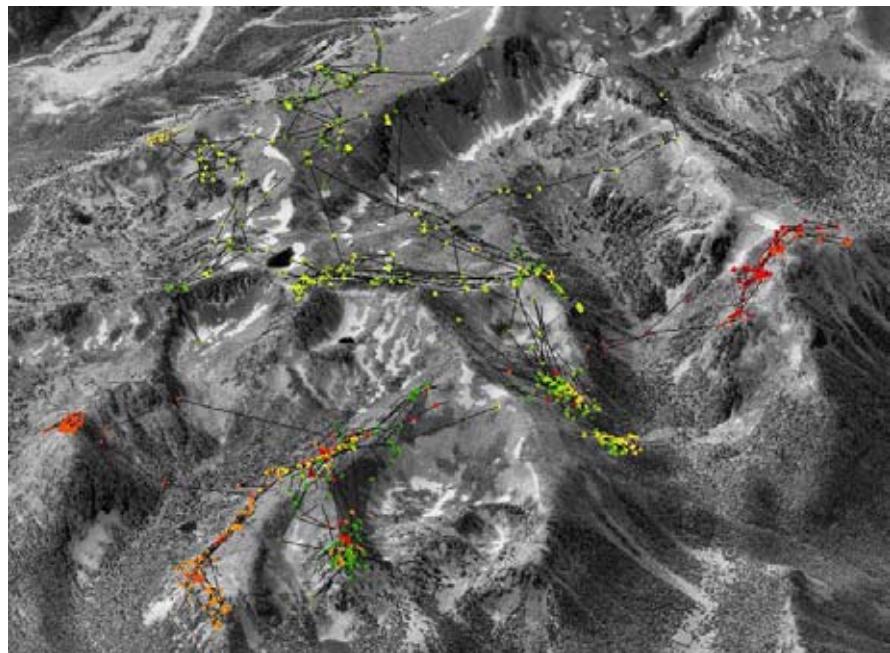


Fig. 4. Locations for mountain goat 030MRF, female, 08Sep-24Oct 2003. Viewed from the north, the image is about 5 km wide. Burrows Mtn. is at the upper center, Skyscraper Peak in the mid-right, McNeely Peak at the lower left. Colors represent time (yellow->green->red)

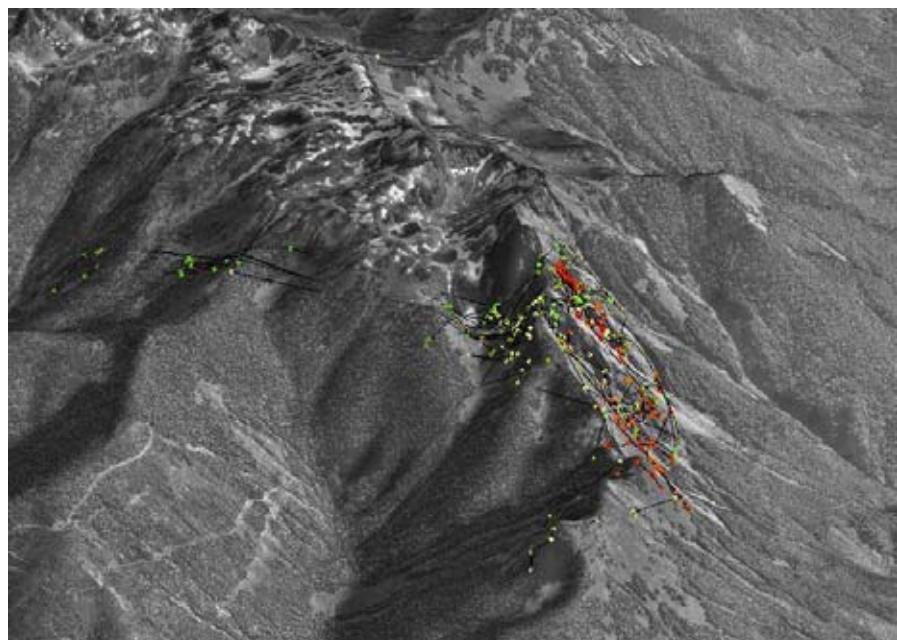


Fig. 5. Locations for mountain goat 017CMF, female, 04Sep-4Nov 2003. Viewed from the west, the image is about 4 km wide. Church Mtn. is near the center of the image. Colors represent time (yellow->green->red)

Whether such generalizations are premature and do not reflect overall annual spatial use patterns remains to be seen.

Annual information is available for 2 of the mountain goats captured in 2002. The difference in seasonal use for one of these is illustrated in Figs. 6 and 7. During summer, 003SCF generally remained near the crest of Stonewall Ridge, predominately on the west side. During the summer, 003SCF also utilized a rocky knoll on the southern end of the ridge, an area not utilized in the winter. Winter utilization was noteworthy in the large number of locations low on the west side of the ridge near a rock outcrop above a clear cut (as low as 1,150 m). There were 3 smaller areas at low elevations on the east side of the ridge which were also visited in winter. Notably, significant utilization of the ridge top took place during winter months. Areas at low elevation used solely in winter were termed winter zones. Between 28 September 2002 and 14 August 2003, 003SCF visited winter zones on 14 occasions, many of which were not in the winter (Table 3), but most were in the winter or spring, the longest being during the second half of February through March.

Table 3. Dates of utilization of winter zones for mountain goat 003SCF on Stonewall Ridge.

First Date	Last Date	Days
10Nov2002	14Nov2002	5
11Dec2002	24Dec2002	14
24Dec2002	27Dec2002	4
27Dec2002	01Jan2003	6
12Jan2003	17Jan2003	6
29Jan2003	05Feb2003	8
06Feb2003	07Feb2003	2
18Feb2003	30Mar2003	41
27Apr2003	27Apr2003	1
29Apr2003	01May2003	3
07May2003	07May2003	1
08May2003	08May2003	1
15May2003	22May2003	8
08Aug2003	09Aug2003	2

I examined the relationship between snow, temperature, and winter zone use by comparing 003SCF's records with snow and temperature data from the Snotel (<http://www.wrcc.dri.edu/snotel.html>) records from Pigtail Peak, south of White Pass. This station is at the same elevation as the top of Stonewall Ridge and 22 km to the northeast. I computed snow accumulation by subtracting consecutive daily Snow Water Equivalent measures from Pigtail Peak.

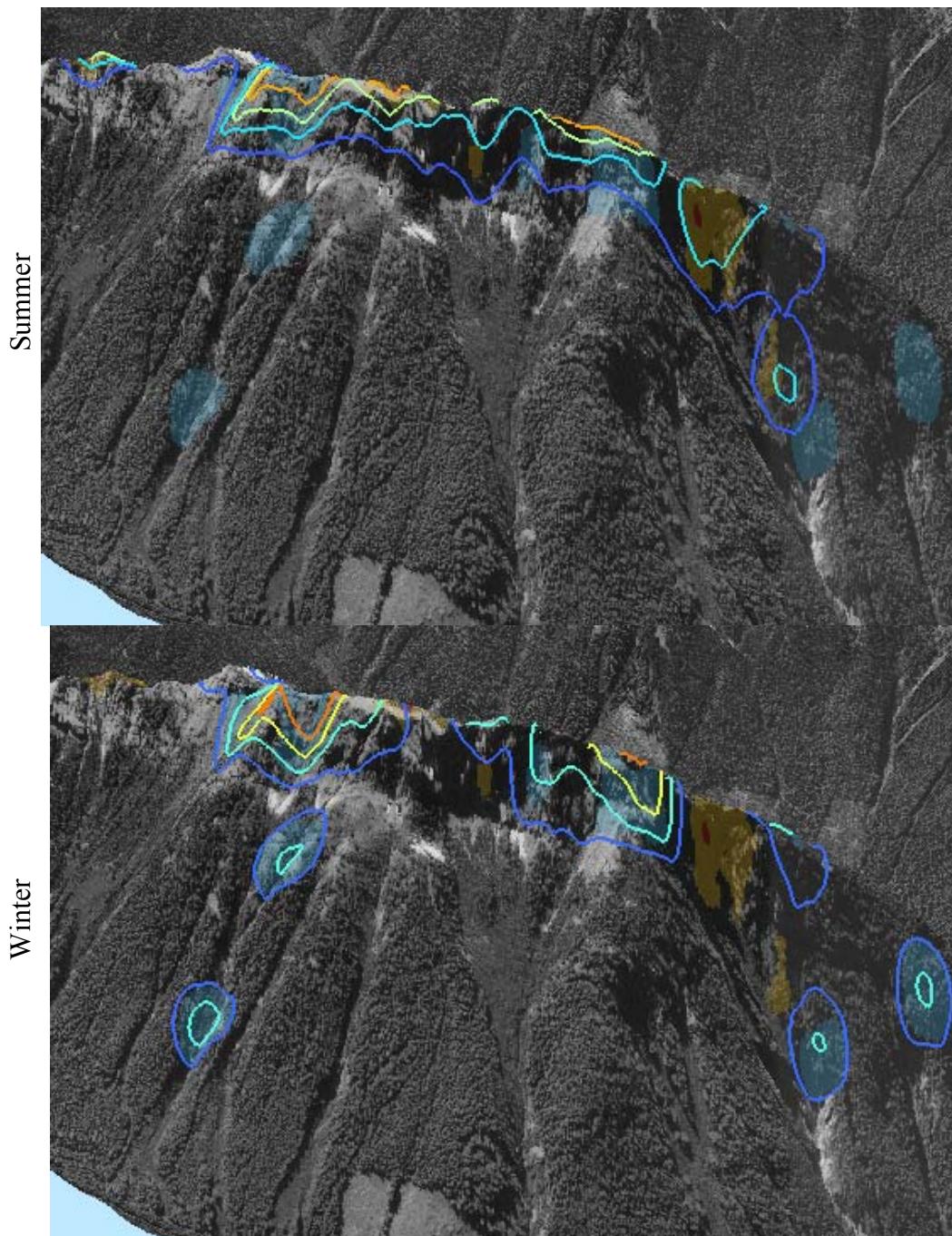


Figure 6. Fixed kernel utilization estimates for mountain goat 003SCF on Stonewall Ridge, Washington during summer (June-August 2003) and winter (December 2002-February 2003) viewed from the east. Contours shown at 0.8 (blue), 0.6 (turquoise), 0.4 (yellow) and 0.2 (orange) of total volume of utilization. Washes show summer and winter differences (summer-winter = -0.2--0.5 (gold), summer-winter < -0.5 (red), winter-summer = -0.2--0.5 (light blue), winter-summer < -0.5 (dark blue). Based on 535 GPS collar locations.

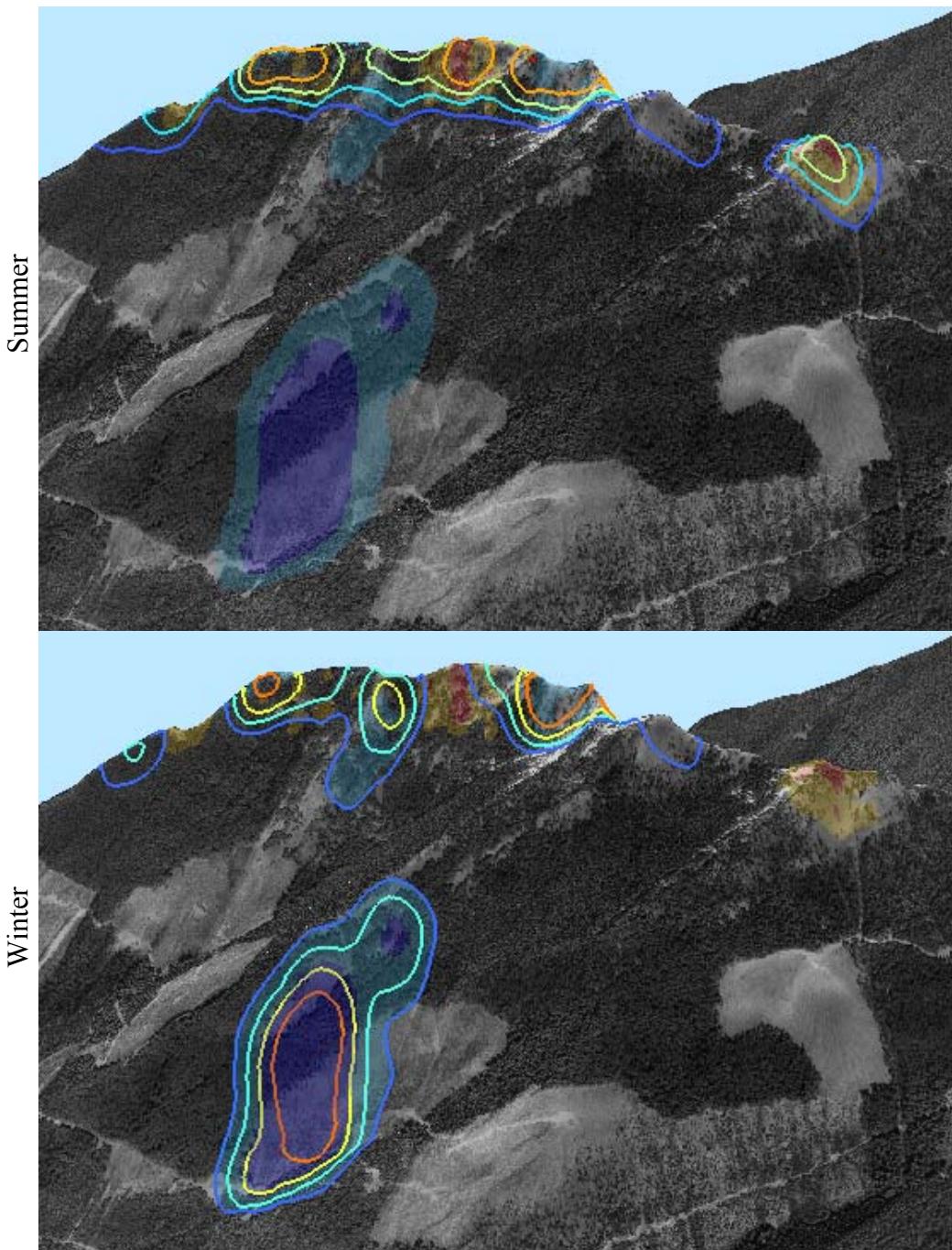


Figure 7. Fixed kernel utilization estimates for mountain goat 003SCF on Stonewall Ridge, Washington during summer (June-August 2003) and winter (December 2002-February 2003) viewed from the west. Contours shown at 0.8 (blue), 0.6 (turquoise), 0.4 (yellow) and 0.2 (orange) of total volume of utilization. Washes show summer and winter differences (summer-winter=-0.2--0.5 (gold), summer-winter<-0.5 (red), winter-summer=-0.2--0.5 (light blue), winter-summer<-0.5 (dark blue). Based on 535 GPS collar locations.

Both snow accumulation and average daily temperature were significantly related to winter zone use ($P<0.0001$), their respective coefficients in the logistic regression being 0.089 (se 0.021) and -0.132 (se 0.013), indicating that when snow accumulated, use of winter zones increased, whereas it declined with increasing temperature (Fig. 8).

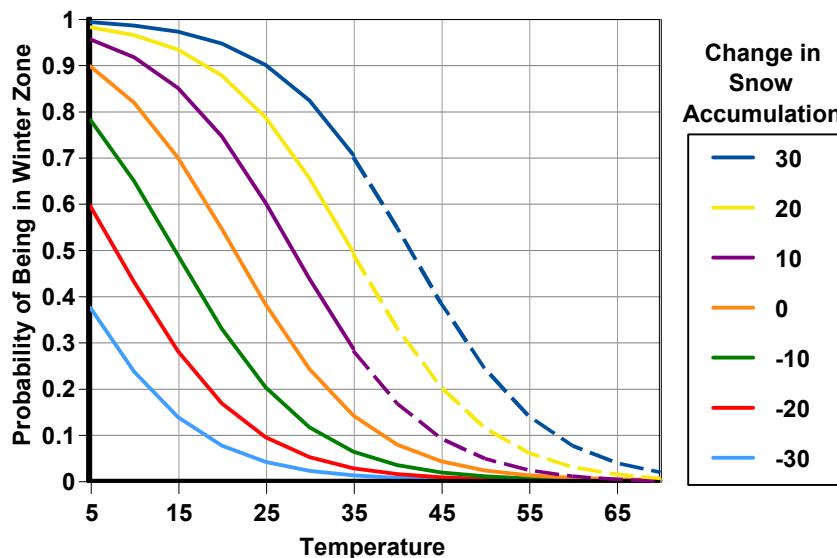


Figure 8. Relationship between probability of use of winter zones by mountain goat 003SCF according to temperature and snow accumulation during September 2002 - August 2003. Curves for positive snow accumulation above 35°F are dashed because snow is unlikely to accumulate at those temperatures.

Summer and winter space utilization by mountain goat 003SCF was noteworthy in that there was considerable overlap between the seasons. However, even along the top of the ridge, there was some differentiation in the particular areas used in these 2 seasons. The physiography of the primary winter zone on the west side of Stonewall Ridge agreed with the expected in that it included rocky cliffs at low elevation surrounded by forest, and as was found in the Tolt and Mine Creek drainages in Washington, there was considerable use of a clear cut below the cliffs (Gilbert and Raedeke 1992). 003SCF provides an additional illustration of the complex interplay between slope, exposure, forest cover, forage, snow, and temperature as they affect mountain goat movements and habitat choice (Wright 1977, Reed 1983, Fox et al. 1989). Further observations in 2003 and 2004 from additional goats from isolated habitat patches and those that extensively use high-elevation areas in the summer should further our understanding of these influences.

Response to Helicopter Survey

The helicopter survey of Mt. Shuksan took place on 01 October 2003 and flew over mountain goats 008SHF and 028SHF. Neither was seen during the survey. The response of these goats to helicopter overflight is difficult to determine because the flight track of the helicopter was not available or had the segment missing in the vicinity of the mountain goat. Nevertheless, records of the mountain goat locations show no obvious movements from their center of activity at that time.

The survey of Mt. Baker took place on 22 September 2003. Mountain goats that were observed during the survey moved ¾-1½ km and climbed upwards on the morning of the survey, clearly more than they usually did on September mornings (Table 4, Fig. 9). Notably, 015MBF did too even though she was not counted, but was close to the flight path. 011MBM, who was about 480 m from the flight path, moved less than usual. 029MBM did not move very much more than usual, (although it is hard to tell with the small sample), while he was about 1,400 feet below the helicopter.

Table 4. Response of mountain goats to survey. Time indicates the time frame over which movement after the survey was estimated (PST). Mean and median are for movement and elevation change measurements during September 2003 (22nd excluded) from the same time frames (6-9 for Sight-9 and 6-9 and 6-12 for 6-12). Only 3D-3D GPS fixes were used for elevation measurements.

Mtn. Goat Status	Time	22Sep03	Distance			Elevation Change (m)		
			Mean	Median	n	22Sep03	Mean	Median
010MBM Missed (outside)	No data ¹		98	95	4		-10	-10
011MBM Missed	6-12	94	461	443	23	26	74	84
012MBM Sighted	Sight-9 ²	1,575	398	251	19	76	-31	-10
013MBF Sighted	Sight-9 ²	1,634	301	258	17		1	-14
014MBF Sighted?	No data ¹		144	122	16		27	44
015MBF Missed	6-9	1,381	303	233	18	174	34	63
016MBF Sighted	Sight-9 ²	1,065	358	304	15	105	40	11
019MBF Sighted	6-9	934	182	32	23	312	34	10
029MBM Missed (low)	6-12	284	204	204	2			0

¹ Consecutive fixes not available.

² From time of sighting to 0900 hrs.

During surveys, it is typical to closely approach mountain goats that are seen to verify total counts for groups. Hence, these animals are usually disturbed and that they moved more than usual is not surprising, although the magnitude of the movements is, perhaps, more than expected. Detailed records of movements will be of interest in further quantifying this disturbance.

Determining the extent that missed animals move is important in developing procedures for sightability modeling because if missed animals move, their location after the survey cannot be used for collecting information on covariates concerning their location when they were missed. While our sample size is low, these results might suggest that mountain goats somewhat removed from the flight path do not move, but those near to it (015MBF) may do so. This will necessitate activating collars before each survey to collect frequent fixes, and comparing the flight path and mountain goat movements to

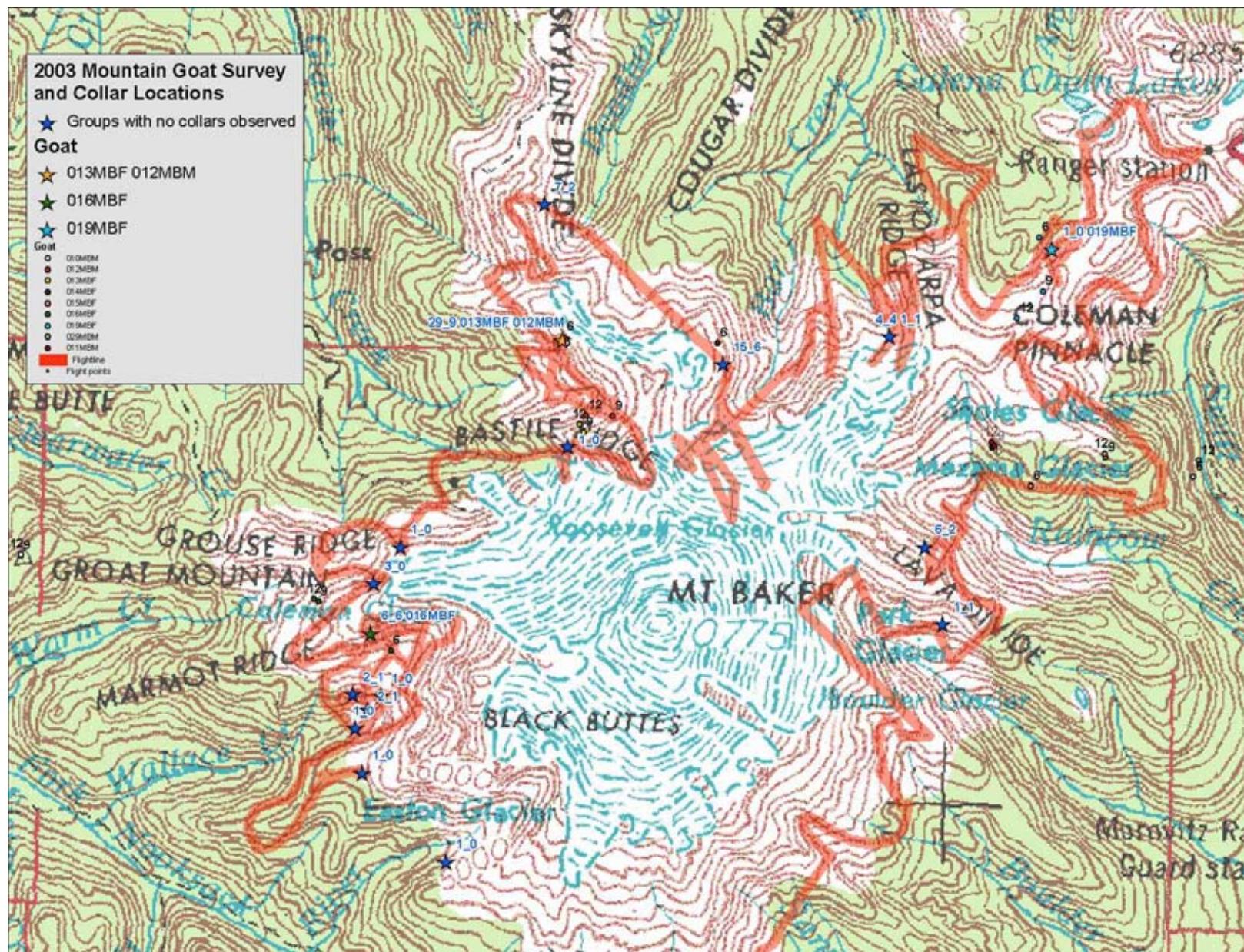


Figure 9. Location of flight path, survey observations, and GPS collar locations for Mt. Baker mountain goat survey, 22 Sep 03 (0613-0823 hrs PST). GPS locations are for 0600-1200 hrs and indicated by labels for each fix's hour.

determine the location of the mountain goat when it was missed by GPS fix rather than by its location after the survey is complete.

Conclusions

For this study, we captured mountain goats from helicopter and on the ground. Ground captures, however, are labor intensive and provide less opportunity to select where and which mountain goat will be captured. The cost of helicopter captures varies considerably with the circumstances, but are about \$1,000 per mountain goat.

The proportion of fixes achieved by the GPS collars were somewhat lower than others have experienced with other species (Frair et al. in press), which may be related to terrain shielding as our rates are comparable to those of Taylor (2002) for mountain goats in British Columbia. Certainly, a valid approach for compensating for GPS fix bias will need to be developed (Frair et al. in press).

Initial patterns are emerging from fixes obtained to date, but detailed analysis will require observations from more mountain goats over longer time periods than we presently have.

At present, we cannot assume that mountain goats that are missed during helicopter surveys remain in the same place. Sightability model development will consequently require integration with fine-scale GPS tracking of mountain goat movements.

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Support

This project is supported by the State of Washington, Federal Aid in Wildlife Restoration, State Wildlife Grants Program, Seattle City Light (Wildlife Research Program), U.S. Forest Service (Mt. Baker - Snoqualmie and Gifford Pinchot National Forests), National Park Service (North Cascades and Mount Rainier National Parks), Sauk-Suiattle Tribe, Stillaguamish Tribe, Upper Skagit Tribe, and Western Washington University.