Movements of a Localized Mountain Goat Herd: Implications for Harvest

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ABSTRACT Mountain goat (*Oreamnos americanus*) numbers in the White River watershed of western Washington State, USA, near the Muckleshoot Indian Tribe's reservation have declined, and as a consequence sustainable harvest opportunity for all user groups in this area has ended. The Tribe conducts annual helicopter surveys of mountain goats in areas of the Cascade Mountain range near the reservation to document trends in goat numbers. Our objective was to assess whether goats found in one area of the White River are migratory and part of a larger east Cascades sub-population that could be large enough to allow harvest, or are a localized, isolated western Cascades herd. We radio-marked 1 female and 4 male goats out of an estimated 10 to 15 animals present to document movements and migrations. We used two types of GPS collars that transmitted locations to satellite at 9 and 23 hour intervals, and relayed them to us. Both collar types collected adequate data to reveal that goats in this small area are west-side animals and represent a small group that would not be sustained if harvest occurred.

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Mountain goats (*Oreamnos americanus*) exist in small, somewhat isolated groups and are sensitive to harvest due to demographic and environmental stochasticity (White et al. 2011), low recruitment rate, advanced age of female sexual maturity (Festa-Bianchet et al. 1994), and misidentification of female goats where males are hunted. Hamel et al. (2006) found that small populations of goats <50 had high extinction risk even in the absence of hunting and that nonselective harvest rate >1% was not sustainable short term. Gonzalez-Voyer et al. (2003) concluded that factors other than hunting contributed to the decline of some herds, and that a herd of 100 individuals could sustain a harvest of only 1 or 2 males. Rice and Gay (2010) concluded that past harvest on goats in several herds in Washington State, USA led to declines and recommended that there be no harvest on populations <50 individuals. Their modeling and conclusions were consistent with Côté et al. (2001), Gonzalez-Voyer et al. (2003), and Hamel et al. (2006), who all concluded that harvest in small goat herds was destabilizing and could lead to localized decline or extirpation.

Indian tribes in Western Washington who have recognized treaty hunting rights establish their own harvest regulations. Although tribal members are not bound by regulations promulgated by the Washington Department of Fish and Wildlife (WDFW), many tribes consider themselves as co-

managers with WDFW, and are concerned about long-term sustainable game populations and hunting opportunities. Most, if not all, tribes that are federally recognized as part of the 1855 Treaty of Point Elliott limit mountain goat hunting by issuing only limited permits, but the demand for animals exceeds availability. WDFW harvest guidelines as of 2016 specified that population estimates must be >100 goats within an identified hunting area before that group of mountain goats can be subject to recreational harvest, female harvest must be limited, and harvest must be 4% or less of the estimated local population aged one year-old and above (WDFW 2014). Because the spatial scale and definition of a mountain goat population in this area remains an issue under consideration, an objective of our work was to shed light on these questions. Tribal members of the Muckleshoot Indian Tribe (MIT) have a long history of harvesting mountain goats and using their hair, horns, hooves, bones, meat, and other parts for a variety of necessary cultural purposes. When hunting opportunity for a culturally important species is limited, tribal members find it difficult to carry on their traditions. As managers of wildlife resources for the MIT, we are frequently asked to find harvest opportunities for goats but have found this difficult in recent years due to the low numbers of goats seen.

The Muckleshoot Tribe has been surveying goats since 2003 covering an area near the MIT's reservation, south of Interstate 90 Highway (I-90), north of Mount Rainier National Park (MRNP), and west of the Cascade Crest including the Cedar, Green, and White River watersheds. The MIT began coordinating Cascade Crest surveys with WDFW in 2009 to improve data collection and sharing. Most of the MIT survey area lacks specifically delineated survey blocks because habitat patches are relatively small and isolated, and because mountain goat group sizes are small. Along the Cascade Crest, however, the WDFW has delineated blocks used for conducting sightability surveys based on potential habitat, elevation, time to survey the block, and local expert knowledge (Rice et al. 2009). We have seen large groups of goats in some survey blocks along the crest but we have never seen groups >10 in the Mutton Mountain survey block, located 4 km west of the crest. Because the Mutton Mountain block is only about 1 km from the Castle Mountain survey block where we had recently observed more goats, we hypothesized exchange between these blocks, as well as movement between east and west of the crest. If exchange occurred, this could provide support for including Mutton Mountain animals as part of a larger population, and offer a very limited opportunity for MIT goat hunters.

East of the Cascade Crest and south of I-90, mountain goats are abundant enough to allow WDFW to authorize permit-only hunting in 3 delineated hunt areas (named Naches Pass, Blazed Ridge, and Bumping River). Within the area west of the Cascade Crest, south of I-90, and north of Mount Rainier National Park, available information suggests that goats are not sufficiently abundant to support hunts permitted by either WDFW or tribal authorities. Mountain goats are more abundant in certain areas north of I-90 to the Canadian border west of the crest within the Point Elliott Treaty area, and the WDFW manages permit-only hunts for goats in these areas. Some of the Point Elliott Treaty tribes issue goat permits in these areas we well. Some MIT hunters, however, prefer to stay near home in familiar landscapes, and to reduce travel expense.

Our objective was to document movements of mountain goats captured west of the Cascade Crest (in the Mutton Mountain survey block) to assess whether they form part of a larger population of goats that reside mostly east of the Cascade Crest, and thus if these animals could provide harvest opportunity for members of the MIT. We also

compared movements of these goats to a study animal captured nearby as part of an earlier WDFW study (Rice 2006, 2008).

Study area

The 80 km^2 study area was west of the Cascade Crest within the Mount Baker-Snoqualmie National Forest (MBSNF), approximately 3 km east of MRNP in Washington State. It encompassed lands within the Treaty of Point Elliott as well as the WDFW White River Game Management Unit (GMU) 653 (Fig. 1). The study area contained all of the Mutton Mountain goat survey block (9.1 km^2) and most of the Castle Mountain goat survey block (7.6 km^2), but did not extend south as far as the Norse Peak mountain goat survey block (Fig. 1). The study area included the WDFW Corral Pass goat hunt unit west of the Cascade Crest which had been open for WDFW hunting until 2010. We refer to the Castle Mountain survey block as Corral Pass for ease of understanding because the 2 roughly overlap (Fig. 1). The area to the east of the Cascade Crest and adjacent to the study area is in GMU 346, contained the WDFW Naches Pass mountain goat hunt unit, and was outside of the Treaty of Point Elliott boundary. The Forest Service Corral Pass Road provided access to a campground and trails within 2 km of Mutton Mountain at Corral Pass (Fig. 1), making goats in this area particularly vulnerable to hunting, poaching, and human disturbance. Elevations within the study area vary between 800 and 1,900 m. Potential natural vegetation zones include Pacific silver fir (*Abies amabilis*), subalpine fir (*Abies lasiocarpa*), mountain hemlock (*Tsuga mertensiana*), and parkland (Franklin and Dyrness 1988, Henderson et al. 1992).

Methods

We darted mountain goats from a helicopter using 1 mL Pneu-Dart transmitter darts with 32 mm double-barbed needles containing 3.0 mg carfentanil and 30 mg xylazine. The helicopter hazed animals to a safe area and remained in the air to guide a ground crew who hiked to the site. Once goats were immobilized, the ground crew applied a blindfold and secured the them in safe positions. Goats were injected with2.0 mL 8-way clostridium vaccine, 2.0 mL MuSe, 8.0 mL vitamin B complex, and 8.0 mL penicillin G procaine. Age was estimated based on horn growth annuli. Goats were collared and finally, anesthesia antagonized by injecting them with 200 mg naltrexone subcutaneously, and 200 mg naltrexone with 30 mg yohimbine intravenously. Capture and handling followed the American Society of Mammalogists guidelines for the use of wild mammals in research (Sikes et al. 2011) adopted by the Muckleshoot Wildlife Program. We used 2 types of Vectronic Aerospace collars, a GPS Plus 2010 Globalstar 1D collar programmed to acquire locations at 9-hour intervals, and a Vertex Survey Globalstar 1D collar programmed to acquire locations at 23- hour intervals. The GPS Plus collars had integrated drop-offs with a life expectancy of 3 years; the Vertex Survey collar did not have a drop-off and had a life expectancy of 4 years. Additionally, we incorporated into our analysis GPS locations for a female goat that was studied by Rice (2006, 2008) from August 2004 through June 2006.

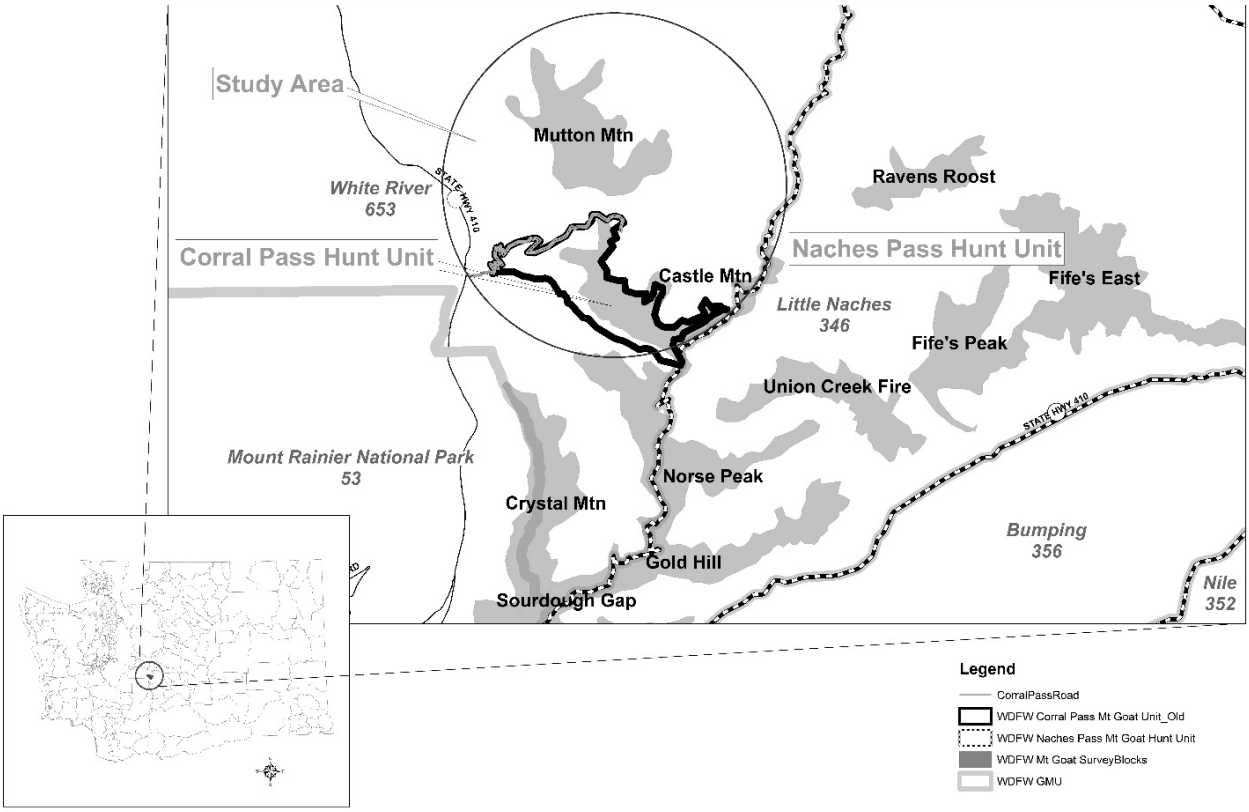

Figure 1. Study area within Washington State (diagonal hatching) showing location ofnamed survey blocks, Corral Pass and Naches Pass hunt units, Mount Rainier National Park, and WDFW Game Management Units.

We also conducted surveys to understand the broader distribution of mountain goats relative to the marked animals, and identify where there may be opportunity for harvest. MIT staff conducted goat surveys by helicopter in late August beginning in 2003 using a BellJet Ranger and 3 observers. These surveys included the WDFW goat survey blocks described above, as well as potential goat habitat throughout the area west of the Cascade Crest, south of I-90, and north of MRNP. Starting in 2009 MIT staff have coordinated surveys on the crest with WDFW, and all data have been shared between the two management entities.

We summarized goat harvest data from WDFW game harvest reports dating back to the 1994 hunting season. The harvest data are complimentary to survey data showing distribution of harvest relative to marked animals, and where there may be harvest opportunity provided populations meet minimum number criteria. They may also reveal overharvest, and explain the low abundance of mountain goats found in some areas.

Results

GPS location and movement data

We captured and collared 5 mountain goats between 2012 and 2014. We equipped 2 adult male goats captured in late July 2012 with equipped with GPS Plus collars. In late July 2013, we placed Vertex Survey collars on 1 adult male and 1 adult female. In August 2014, we collared 1 adult male with a GPS Plus collar retrieved from a mortality. We monitored goats for 109 to >1,033 days each, fewer than the expected collar life, due to goat mortality or early collar failure. We acquired

from 262 to 2,079 valid locations per animal (Table 1). The GPS Plus collars had higher fix success rates and higher satellite upload success rates than the Vertex Survey collars,

Four of the 5 marked goats confined their movements to GMU 653; goats M11078-1 (♂) and F12960 (♀) had 100% of their locations, and male goats M11078-2 and M12907 had 99.1% and 99.6% of their locations within GMU 653, respectively. These movements are consistent with the results of the female earlier collared by WDFW, 040CPF, whose locations remained in GMU 653 99.4% of the time from 2004 – 2006 (Fig. 2). The maximum distance from the GMU 653 boundary for these 3 goats was 1 km. One goat, M11077 (♂), moved east during rut in 2 consecutive years, with 87.3% of its locations in GMU 653 and the remainder within GMU 346. His locations east of the Cascade Crest occurred during early November through mid-January, coinciding with rut and return to winter range. He returned to the study area in winter despite snow depths >75 cm in early January 2014 and >90 cm in December 2014-January 2015 (Corral Pass site 418 SNOTEL).

Although all goats generally remained in GMU 653, some goats made smaller-scale movements between the survey blocks. For goat M12907, 22% of it locations were in the Mutton survey block and 28% were in the Corral Pass survey block. Male goats M11077 and M11078-1, however, had 44% and 40% of their locations in Mutton, with less than 5% in Corral Pass. Female goat F12960 had 30% of her locations in Mutton and none in other survey blocks, whereas 040CPF goat had 72% in Corral Pass, 21% in Norse Peak, and none in Mutton. Locations outside of survey areas were associated with winter range, small isolated patches of habitat outside survey blocks, or movements between areas (Fig. 2). During the 2 winters we had her marked, F12960 made a horizontal movement to winter range below 1,400 m (Fig. 2). Male M11077 also moved to the same winter range for part of the first winter (January 30-May 4, 2013) but only for 2 weeks (January 12-26, 2014) during the second. He then minimized his movements, and used an area only 0.12 km^2 from January 27 to May 4, 2014. Male M11078-2 used the same separate winter range area as did female F12960 but only from December 2, 2014 to January 9, 2015, and then moved up to summer range area where the Corral Pass SNOTEL snow depth reported 75 to 120 cm during January through April. The male goats generally spent winter in various parts of their summer range below 1,400 m, and rarely moved among portions of their range through the winter, but generally did not exhibit the distinct horizontal movement to winter range that F12960 did.

Mortality and collar longevity

Three goats died and one prematurely went off air during the study period (Table 1). Goat M11078-1 died November 8, 2012 during the rut but we were not able to get to the animal early enough to examine the carcass. Goat F12960 died May 18, 2015 from breached birth complications and had fallen off a cliff. Goat M11078-2 died July 14, 2015 and was consumed by the time we investigated it on August 3. We did not receive an immediate mortality message due to animal position and location of the carcass not having a clear sky view. No evidence suggesting the cause of mortality was found due to extensive scavenging. We acquired locations from M11077 for 841 days through November 22, 2014 when the collar began emitting a double-beep recovery mode VHF signal. We continued intermittent VHF tracking and located this animal by helicopter east of the Cascade Crest on December 17 and 30, 2014, and west of the crest on March 18 and July 7, 2015 when it was last heard. As of January 31, 2017 goat M12907 was alive and being tracked.

Table 1. Animals captured including animal ID, collar type, GPS fix interval, number of locations (*n*) received via satellite relayand offloaded from collar, number of valid locations collected, amount of time monitored, and fate of animal.

ID	Type	Interval	*n*[3]	*n*[4]	*n*[5]	%[6]	Fix Success[7]	Age at capture	Sex	Days monitored	Fate
M1107 7	GPS Plus	9 h	2,1 24	est 2,242	2,079[1]	95%[2]	98%[1]	7-10	M	841	Premature failure, collar not retrieved
M1107 8-1	GPS Plus	9 h	229	288	262	80%	91%	7-10	M	109	Died -unknown, suspect rut injury
M1107 8-2	GPS Plus	9 h	827	918	887	90%	97%	5+	M	344	Died - unknown
M1290 7	Survey	23 h	680	est 1,078	516[1]	63%[2]	76%[1]	4-5	M	1033+	Ongoing as of January 2017
F1296 0	Survey	23 h	514	687	579	75%	84%	4-5	F	658	Died – suspect parturition related

[1]Based on data received via satellite only for % fix success
[2]Estimated from time monitored and expected number of locations
[3]*n* = number of locations received relayed through satellite
[4] *n* = number of locations downloaded from retrieved collar
[5] *n* = number of attempted locations that had a valid GPS location
[6]% = percent of location attempts that were relayed through satellite and received viaemail
[7]Fix success = percent of location attempts that resulted in a valid location

Surveys

From 2003 through 2015, larger numbers of goats were counted in the Corral Pass and Norse Peak blocks than the Mutton Mountain block (Table 2). The highest count for the Corral Pass block was 57 goats in 2011, with the largest group containing 42 individuals. The highest count for Norse Peak block was 84 goats in 2008, with a large group of 53 individuals. Counts in Corral Pass were variable, and were likely related to goats moving between Norse Peak and Corral Pass in a given year during the survey window. In 11 annual surveys of Mutton Mountain the largest group was only 8 and the maximum total was only 16 (Table 2).

Historical harvest

The total State of Washington goat harvest for the Corral Pass hunt unit during 1994–2003 was 20 (i.e., $\bar{x}$ = 2/yr) from 30 permits issued. This hunt unit excluded the Mutton Mountain survey block and was separate from the Naches Pass hunt unit. The Naches Pass hunt unit harvest was 30 (i.e., $\bar{x}$ = 3/yr) with 37 permits issued during 1994–2003. The Corral Pass unit was merged with the larger east side Naches Pass unit in 2004 through 2009, and had a total harvest of 9 from11 permits issued. The Corral Pass hunt unit was removed from the Naches Pass unit in 2010 and closed by WDFW to State goat hunting. Goats living in the Corral Pass survey block, however, are likely susceptible to harvest when travelling to the east side of the block or to the east side of the Norse Peak block, which are both inside the Naches Pass hunt unit, and still open to permit hunting. Data on tribal harvest from this area were not available because they were reported at the coarser GMU scale, but it was likely very low because the total reported harvest in GMU 653 was only 3 during the 16-year reporting period 2000—2015 (Northwest Indian Fisheries Commission Big Game Harvest Reports http://nwifc.org/publications/big-game-harvest-reports/ accessed August 1, 2016).

Table 2. Helicopter aerial survey counts of total number of mountain goats observed in 3 survey blocks, 2003-2015, western Washington State, USA. Data for 2003-2008, 2014, and Mutton Mountain data collected by the Muckleshoot Indian Tribe. Italicized data for Corral Pass and Norse Peak 2009-2013, and 2015 are from WDFW.

Year	Mutton Mtn.	Corral Pass	Norse Peak
2003	13	1	26
2004	7	12	11
2005		1	14
2006			
2007	9	2	52
2008	10		84
2009	16	*3*	*74*
2010	4	*1*	*49*
2011	4	*57*	*1*
2012	10	*13*	*30*
2013	9	*26*	*48*
2014	10		50
2015	*4*	*8*	*65*

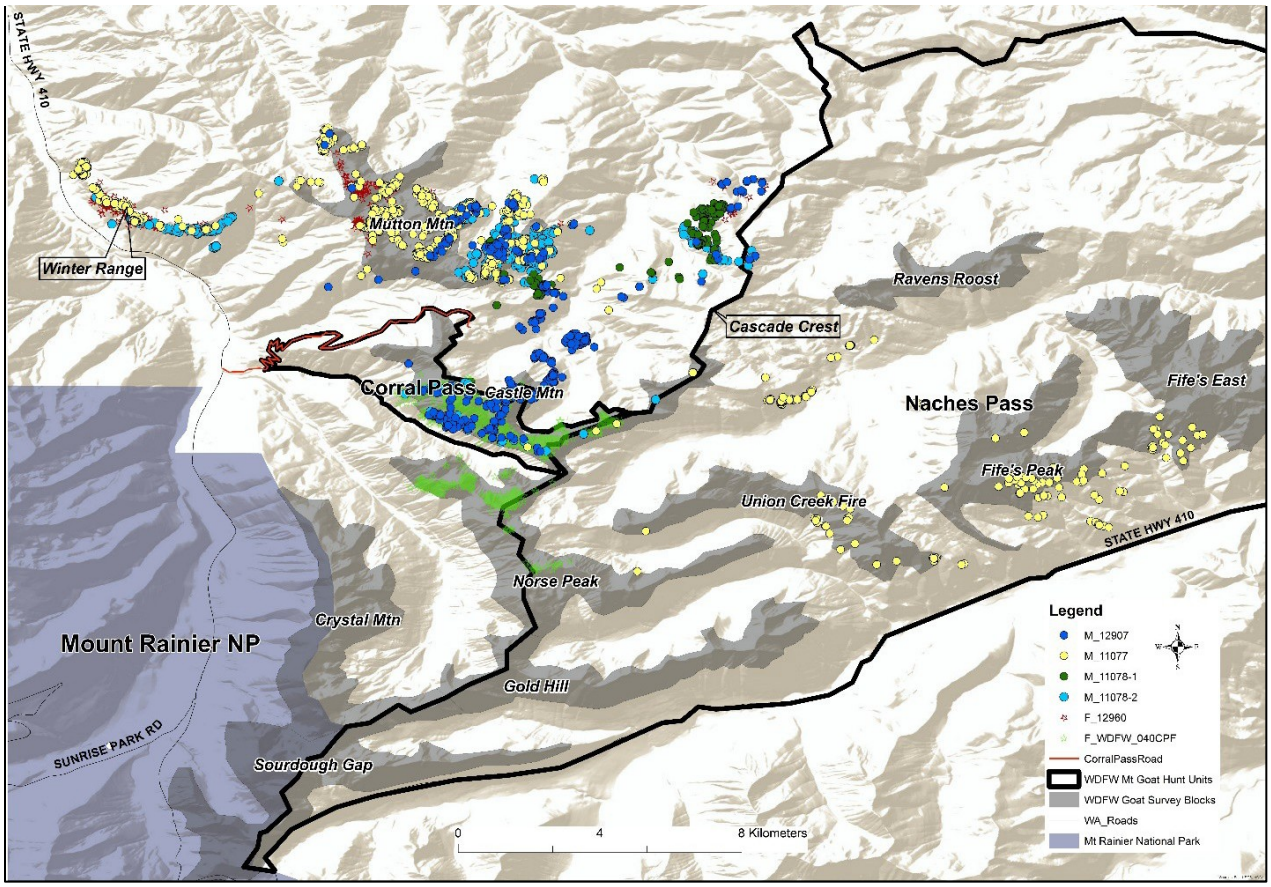

Figure 2. GPS locations for 4 collared males, and 1 collared female mountain goats and one WDFW collared goat relative to survey blocks (grey shading) and goat hunt units (black boundary lines).

Discussion and management implications

Our objective was to determine if mountain goats in the Mutton Mountain survey block area constituted a separate demographic unit from the nearby Corral Pass (Castle Mountain) and Norse Peak survey block animals. If Mutton Mountain goats were separate, then hunting should not occur in this area because it was a very small population. In contrast, if goats observed at Mutton Mountain migrated to the east side, or were part of a larger population, then there could be limited harvest of these goats because they would be replaced by animals from other areas where they are already hunted.

Our survey data suggest that Mutton Mountain goats were somewhat isolated based on consistently small groups and low numbers observed in the block during surveys conducted beginning in 2003 (Table 2). Larger groups and more animals were consistently found in the nearby Corral Pass and Norse Peak survey blocks (Table 2). Although sample sizes were small, our marked animal location data supported our assessment that the Mutton Mountain animals were relatively isolated, particularly females. Neither the female goat marked in this study, nor the female in the prior WDFW study (040CPF), showed any movement between the Mutton Mountain and Corral Pass survey blocks, despite two blocks being only 1 km apart at

their closest. Female 040CPF remained largely in Corral Pass, while F12960 stayed in Mutton Mountain. One male exhibited movement between these, but the other 2 that were on the air long enough for analysis had <5% of their locations in the Corral Pass block, and instead spent time in Mutton Mountain and other areas north and east of Corral Pass.

Some goats using Corral Pass may also use Norse Peak as seen with 040CPF and it is possible that goats move readily between these two areas. During annual surveys, large groups were found in either the Corral Pass or Norse Peak blocks, but not in both blocks in the same year (Table 2). Five of the 6 radio-marked animals showed a west side tendency with >99% of their locations in GMU 653; 1 male moved east during the rut. More animals marked over a longer time period might have revealed more interaction, or might strengthen our observations that goats are segregated at Mutton Mountain. However, we feel our sample of 5 goats out of an estimated total herd of 10 to 15 was a fair sample size.

Goats are known to occur in isolated herds but have the ability to immigrate or emigrate 20 km or more although these movements are infrequent and male-biased (Côté and Festa-Bianchet 2003). We did not have any marked goats emigrate, possibly due to the marked goats being mature animals. Our furthest-short-term movement was approximately 15 km for a male who moved during rut and returned soon after. Côté and Festa-Bianchet (2003:1066) stated that "Males could also make extensive movements during the rut in some populations but not in others, depending on the distance between neighboring groups." In our study area, behavioral variation among males may have determined whether they moved long distance during rut or not because all males were not far from neighboring groups and were of mature age.

Our observation of variation among individuals in their use of summer and winter range was similar to that found by Poole and Heard (2003), who documented some goats that moved to distinct winter range while others shifted elevation within their summer range. The horizontal distance of goats that moved to distinct winter ranges was 3-6 km, shorter than the 8 to 13 km for those of Poole and Heard (2003). Our goats had winter altitudinal changes of 400—700 m, similar to that reported by Rice (2008). One of our males moved from summer to distinct winter range in January 2015, when snow was 150-190 cm deep, but in January 2016, with snow only 75–140 cm deep, he spent winter within summer range. Other males also stayed within summer range but used lower elevation and forested habitats during winter. Consistent with our findings, Rice (2008) noted that seasonal altitudinal movements are highly variable, and related to snow depth consistent with our findings. Côté and Festa-Bianchet (2003:1066) wrote "Some populations remain in the same area throughout the year, whereas others have distinct summer and winter ranges." We suspect that many of the Norse Peak and Corral Pass goats move east during winter but lack movement data to support this. Female goat 040CPF stayed within the Corral Pass block during winter, but used lower elevation in 2006 when there was more snow than in 2005.

Our survey data recorded a maximum of 16 goats in the Mutton Mountain unit in 2009, and a largest group size of 9 in 2007. Over time total numbers have been stable at around 10. We have frequently seen 3 kids in late August, barely enough to maintain this herd. The 3 mortalities we experienced were a significant loss to this herd. Parks et al. (2015) reported the goats in the southern Cascades had the lowest genetic diversity of all known goat populations in Washington and were likely separated genetically from the rest of the state by I-90. They hypothesized

"…resistance to landscape-level gene flow may further erode genetic diversity and limit the ability of [Washington] populations to recover." (Parks et al. 2015:1200). Furthermore, Mainguy et al. (2009) have shown that reduced genetic diversity in mountain goats was associated with reduced juvenile survival. If our data represent natural mortality rates for this population, this herd would not be able to support harvest if it is to persist, and would likely benefit from an augmentation to improve genetic diversity.

In 2015 the WDFW observed 161 goats in the Naches Pass hunt unit, a sufficient number to allow a permit-only hunt. During the same flight there were only 4 goats seen in the Mutton Mountain block and 8 in the Corral Pass block. Historically, harvest in the Corral Pass hunt unit averaged 2 per year when open. The harvest may have included Mutton Mountain male goats, as well as Norse Peak animals. The high harvest relative to the number of resident western Cascades animals may have exceeded what was sustainable and has resulted in persistently low numbers west of the Cascade Crest.

The Muckleshoot Tribe and 8 other tribes have reserved hunting rights under the Treaty of Point Elliott which lies mostly west of the Cascade Crest (State v. Buchanan 138 Wash. 2d 186 1999). Tribes who manage a small number of hunters might have tighter control over their hunters and be able to harvest a small number of males in smaller populations by using creative strategies such as alternate or every 3rd-year hunting. Such a strategy might target lone males who have dispersed, but it would rely on replacements from nearby larger populations to sustain opportunity. Hunting opportunity south of I-90, however, is nonexistent to implement a conservative tribal strategy due to too few mountain goats throughout the area, and potential number of treaty tribes hunting.

Because we documented the movement of a female goat between Norse Peak and Corral Pass, the question arises whether the Corral Pass area should be opened for harvest? The marked goat data suggest that some of the animals that use this block are west side animals, which seem to occur in low numbers, certainly less than 50, and as such, should be protected. Hunters in the adjacent Norse Peak unit have a low chance of harvesting a west side goat, and this supports keeping the Naches Pass hunt unit (which includes Norse Peak) open as long as survey data continue to reveal adequate numbers. If additional goats are collared in or near our study area, they should include females from the large groups observed in the Norse Peak or Corral Pass survey blocks. Studying these animals may reveal migrations for those goats and possibly interactions that we did not detect by collaring only Mutton Mountain goats.

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