Morice & Lakes IFPA

Morice & Lakes Innovative Forest Practices Agreement

Non-Alpine Habitat Use and Movements of Mountain Goats in North-Central British Columbia

Summary of 2003-2004 Activities

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Executive Summary

Mountain goat (*Oreamnos americanus*) use of isolated rocky bluff habitats in forested landscapes has been studied by the authors since 1996. Research for this study has concentrated within the Nadina Forest District of the Northern Interior Forest Region of the Ministry of Forests and the Skeena Region of the Ministry of Water, Land and Air Protection (MWLAP), located in northwestern British Columbia between the towns of Houston and Burns Lake, BC. This project was initiated in mid-2002 as a three-year study with the general goal to develop management strategies for the conservation of mountain goat habitats and populations while maintaining a viable timber harvest. During the 2003-2004 project year, project funding was unavailable from the original funding source and had to be obtained from other sources. Some of the planned project activities were postponed due to the funding limitations, although much of the planned activities were completed. This project report outlines the activities completed in 2003-2004 and reports on the results of the telemetry flights, home range and movement analysis, DNA analysis and mortality investigations.

In January and March 2003, 27 mountain goats were captured on six sites within the study area, including Morice Mountain, Bob Creek Bluffs, Dungate Creek Bluffs, China Nose, Foxy Creek Canyon and Klo Creek Bluffs. Eight animals were fitted with global positioning system (GPS) and 19 animals with very high frequency (VHF) radio collars. During the 2003-2004 project year the collared animals were relocated every four to six weeks in order to identify movements, mortality, trends in habitat use and to monitor collar function. All collars were located at each of 16 telemetry sessions and 381 telemetry points were mapped from these flights. Landscape position and habitat information were recorded for most telemetry locations.

In March 2004, all GPS collars were recovered and the data was downloaded for a preliminary analysis of telemetry locations for home range and movement patterns. Differences in mean home range sizes for seasons, animal sex, and age, were not found to be significant, while comparisons between individuals and general use locations were. Daily movement distances between individuals showed significant differences, but not between animal sex or age. There were also significant differences in the daily movement distances between the individuals of different ages and between months, seasons and locations.

Mortality investigations were carried out on four animals that died during the summer and fall of 2004. The mortality rate of 15% suggested by these deaths was higher than expected, with at least two mortalities likely caused by predators. Tissue and hair samples were obtained from collared animals in the 2003 capture sessions and analyzed in 2004to determine the potential for distinguishing individuals. Based on the DNA analysis, it was considered to be very likely that individuals would be able to be identified in this population using tissue and hair samples.

Future work planned for this project include: continuation of telemetry monitoring of the VHF collared animals, completion of habitat use assessments and analysis, more in-depth analysis of movements and activity data. Uncertainty in future funding for this project, however, have jeopardised the ability for the goals of this project to be completed as planned.

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Introduction

Mountain goat (*Oreamnos americanus*) use of forested habitats adjacent to non-alpine cliff and canyon features has been documented but the level of knowledge on the extent of this forested habitat use is poor. Mountain goats are known to use forested habitats as travel routes, thermal cover, snow interception cover, feeding habitat and mineral licks. Most commonly, these activities occur in forested areas at higher elevations and in close proximity (300 m to 500 m) to escape terrain (Casebeer *et al*. 1950, Chadwick 1973, Russell 1974, Schoen and Kirchoff 1982). The use of low elevation forested habitats in proximity to cliff or canyon features has also been documented (Hebert 1967, Russell 1974, Fox 1978, Schoen and Kirchoff 1982, Smith 1982, Harrison 1999, Turney *et al*. 2000). Recent work on mountain goats in the Morice Forest District (Turney *et al*. 2002, Blume *et al*. 2003), however, indicates that forested habitat use by mountain goats may be more extensive and intensive than previously identified. The degree to which forested habitats are used and the distances from the security of cliff and rock that mountain goats will venture have not been quantified and it is possible that the importance of forested habitats to this species is underestimated.

Approximately 30,000 ha of potential mountain goat habitat is found in the Morice and Lakes Forest Districts with a significant portion adjacent to existing and proposed harvest areas (Turney *et al.* 2001 and 2002). Assessments of mountain goat sign and population surveys indicate that some of these forested cliff and canyon features are no longer used (Turney *et al*. 2000) although the reason for their abandonment is unclear. There are concerns from resource managers that the loss of mountain goats from these features may be permanent, which may affect overall mountain goat population dynamics.

This lack of detailed information on forested habitat use by mountain goats restricts the ability to formulate and implement effective timber harvest access and management strategies that take into account conservation of mountain goat habitat and populations. Of concern to resource managers is the lack of quantitative information on movement and habitat use patterns of mountain goats adjacent and between these forested cliff and canyon features. It is unknown if the current management strategies, which include no harvest areas, harvest timing restrictions and access management are effective in the management of mountain goat populations and habitats. In order to increase the level of knowledge of mountain goat forested habitat use upon which informed management decisions could be made, a multi-year study was proposed in the spring of 2002 with the following goal:

To develop management strategies that provide for the conservation of mountain goat habitats and populations and maintain a viable timber harvest.

The proposed objectives to meet this goal are to:

1. Monitor movements of mountain goats among isolated cliff and canyon features to determine frequency of movements between these areas and identify critical habitat features such as mineral licks, natal areas and winter use areas.
2. Monitor the differences in habitat use and movement patterns of mountain goats in areas with and without proposed forest harvesting activities.

3. Determine a sightability factor for mountain goats in forested habitats during winter and summer.
4. Investigate the feasibility of using DNA analyses of tissue and hair samples to determine individuals within the population of mountain goats in the study area and the use of hair sampling as a method for population surveys or movement detection.
5. Provide management recommendations to forest and wildlife managers to minimize impacts from forest harvesting activities on mountain goat habitats and populations.

Summary of Past Activities

This project was initiated in the fall of 2002, and in January and March 2003, 27 mountain goats were captured in the study area and eight animals were fitted with global positioning system (GPS) and 19 animals with very high frequency (VHF) radio collars. Animals were located approximately every two to four weeks by aerial telemetry methods until the end of March 2003. Telemetry locations were mapped using a geographic information system (GIS) for analysis of the extent, timing and frequency of animal movements. A summary of the habitat characteristics of mountain goat aerial relocations was completed and snow levels in the study area were monitored. A population estimate and determination of a winter sightability factor were completed as well. This information was used to initiate a model of mountain goat habitat requirements and to assist in producing a predictive model of mountain goat habitat selection. A report (Turney *et al.* 2003) summarizes the results of the work completed in the first year of study and provided recommendations for further study.

Summary of Current Activities

During the 2003-2004 project year, a number of project tasks were completed including:

- continuation of radio-telemetry tracking every four to six weeks to monitor habitat use, movements and mortality;
- investigations of mortalities to determine, if possible, the cause of death;
- extraction and analysis of DNA from tissue and hair samples collected from collared animals to determine potential for distinguishing individuals;
- recovery of GPS collars and downloading of the GPS data; and
- preliminary analysis of telemetry locations for habitat parameters and movement patterns.

Due to insufficient funding the determination of a summer sightabilty factor was determined to be of lower priority and not completed during 2003-2004. This report summarizes the current activities and provides recommendations for continuation of the study.

Background

Mountain goats are known to be an easily disturbed species that may abandon key habitats if development approaches within 400 m (Chadwick 1973). This species has been observed to have negative reactions towards logging operations, road traffic, petroleum exploration, hydroelectric development and aircraft (Singer 1978, Foster and Rahs 1985, Penner 1988, Cote 1996). Many studies have commented on the increase in hunting pressures due to increased road access in mountain goat range (Chadwick 1973, Pendergast and Bindenagel 1977, Smith 1982, McCallum 1983, Foster and Rahs 1985). It has also been noted that timber harvest may result in the reduction of important snow interception cover forests (Fox 1978, Schoen and Kirchoff 1982). Disturbance has been suggested to potentially cause increased metabolic rate at the expense of growth, development and reproduction (McCallum 1983), avoidance of optimal habitats and overcrowding of secure habitats (McCallum 1983, Cote 1996, Foster and Rahs 1985), higher vulnerability to predation and occurrence of nannie-kid separation (Foster and Rahs 1985) and a disruption of daily and seasonal behaviours and habitat use patterns (Smith 1982, Foster and Rahs 1985). Documentation and quantification of the effects of disturbance, however, have been limited.

Mountain goats exhibit small scale migrations consisting of altitudinal shifts as they occupy different summer and winter ranges (Russell 1974, Smith 1977) and dispersals over long distances, which are related to density dependant factors such as food availability, access to mates, competition, sex, and age (Smith and Raedeke 1982, Stevens 1983, Williams 1999). Casebeer *et al*. (1950) found that goats remained in an area year-round if the area was windblown and relatively snow free in winter so that they could forage on exposed vegetation. In areas where the summer ranges were deeply covered by snow in winter, they would move to lower elevation winter range where rocky bluffs extended into upper montane zones. Movement from winter range to summer range in spring has been found to be governed by the upward retreat of the snowline (Casebeer *et al*. 1950, Hebert 1967, Russell 1974, Stevens 1983). Stevens (1983) documented dispersals up to 37.5 km for introduced herds in Washington's Olympic Peninsula and Williams (1999), studying an introduced herd in Montana, observed dispersal to other mountainous habitats from the original introduction site with animals crossing four kilometres of non-escape terrain (prairie) habitat.

Most studies that have focused on mountain goat use of forested habitats and movements have made use of sign transect surveys, visual observations or VHF telemetry data (e.g. Chadwick 1973, Foster 1982, Smith and Raedeke 1982, Fox et al. 1989). The use of GPS technology to track animal movements and habitat use is relatively recent and studies of mountain goats that employ this method are limited. Poole (1998) studied forest use by mountain goats in the Robson Valley of east-central BC and compared the performance of VHF and GPS collars. Taylor (2002) examined GPS fix acquisition bias of goats in the mountainous terrain of south-coastal BC. Blume *et al*. (2003) and Poole and Heard (1998) used GPS collars to evaluate mountain goat forested habitat use in central BC.

GPS telemetry has several advantages over VHF telemetry, including the potential to collect large amounts of high quality data (Rodgers 2001, Rumble et al. 2001), locations are recorded in all weather conditions and at all times of day (Rempel et al. 1995, Poole

1998, Rodgers 2001), aircraft disturbance of animals is minimized giving a more accurate assessment of habitat use and movements (Poole 1998), detection of rare or unique movements or habitat use is more likely (Poole 1998, Rodgers 2001), and the collected data is readily imported to a geographic information system (GIS) for analysis (Rodgers 2001). Prior to 1 May 2000, the accuracy of GPS locations was intentionally downgraded by the US Department of Defence by a process called Selective Availability (SA), which introduced signal errors through constant and random satellite clock and ephemeris (orbital information) errors (Hulbert and French 2001). Once SA was removed, the potential accuracy of civilian GPS receivers increased dramatically and provided locational accuracy of less than 20 m (Dussault *et al*. 2001, Hulbert and French 2001, Janeau *et al*. 2001, D'Eon *et al*. 2002). The accuracy of GPS telemetry is equal to or better than most habitat mapping data and GIS applications (Hulbert and French 2001, Rodgers 2001) and is generally more accurate than locations obtained through VHF radio-telemetry (Rumble *et al*. 2001).

GPS technology does have several disadvantages, including higher initial and operating costs and a lower reliability than VHF technology, which result in higher data-related risks and a lower number of monitored animals for a given budget (Johnson *et al*. 2002). Studies of species, which inhabit forested areas and mountainous terrain may suffer from locational error and GPS fix rate bias (Bowman *et al*. 2000, Biggs *et al*. 2001, Dussault *et al*. 2001, Hulbert and French 2001, Rumble *et al*. 2001). Fix acquisition rate is a measure of the number of acquired GPS fixes compared to the number of fix attempts (D'Eon *et al*. 2002) and can be affected by animal behaviour, vegetation, topography and satellite geometry. Generally, open areas have the highest fix acquisition rate and the rate decreases with increasing vegetation or forest canopy closure (Blake *et al*. 2001). Forest canopy affects GPS accuracy by intercepting satellite signals, which reduces the number of satellites acquired by a GPS receiver and interferes with optimal satellite geometry (Dussault *et al*. 2001). The movement of collared animals to forested habitats for forage, security and thermal/snow interception cover causes a reduction in GPS fix accuracy.

Aebischer *et al*. (1993), in their paper on habitat use analysis of VHF radio-telemetry data, stated that a minimum of six animals are required to provide an estimate of habitat use by a population, with more than ten and above 30 collared animals being a preferable number. Where a comparison in habitat use between different categories of animals is desired (e.g. sex, age, region), at least ten animals in each category should be tracked. In this paper it is stressed that it is the animal that is the sample unit, and not the location data. Locations represent a subset of a particular animal's movement and habitat use and the number of locations for each animal provides a measure of the accuracy with which habitat use was estimated. Any use of locations themselves to represent sample size is considered pseudo-replication (Aebischer *et al*. 1993). Thus, in the case of VHF telemetry it is more important that as many animals as possible be collared rather than as many locations as possible be achieved. The use of GPS telemetry gives the added benefit that once an animal is collared, there is the potential to acquire thousands of locations for each animal. A competing trade-off between number of animals tracked and number of locations acquired that occurs with VHF technology is not the case with GPS technology. However, where budget is a constraint, the use of VHF collars can increase the size of the sample unit.

Population surveys for mountain goats can be difficult as the sightability for this species is poor, especially during the winter season. Individual animals may be missed during a survey for a variety of reasons including winter use of forested habitats for foraging and snow interception cover, summer forested habitat use for thermal cover and mineral licks, and animals hiding in caves, under cliff overhangs and in forest stands due to aircraft disturbance during an aerial survey (Cote 1996, Gonzalez-Voyer *et al*. 2001, RIC 2002). The difficulty of sighting mountain goats in winter is further compounded by the difficulty of seeing an animal with white hair against a snow background. This sightability bias results in an underestimate of population size and inaccuracy in determining population distribution across the landscape. In order to improve the accuracy of a population estimate and quantify the level of accuracy in the detection of mountain goats in winter, a winter sightability factor can be calculated using mark-resight methods (Krebs 1989), using the collared mountain goats as the marked portion of the population.

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Study Area

The study area consists of non-alpine cliff and canyon features located in northwestern British Columbia between the towns of Houston and Burns Lake. These features are contained within a greater area of approximately 3,000 km^2 and elevations range from 600 to 2,200 m above sea level. Approximately 70 non-alpine cliff and canyon features comprising a minimum of 200 km^2 of used and potential mountain goat habitat are contained within the study area. It is estimated that a population of 160 animals are found on these features, based on reconnaissance and intensive aerial surveys conducted in the area since 1998 (Turney *et al*. 1999, 2000, 2001a, 2001b and 2002). Administratively the study area is within the Nadina Forest District (formerly Morice Forest District and the Lakes Forest District) of the Northern Interior Forest Region (formerly the Prince Rupert Forest Region) of the Ministry of Forests and the Skeena Region of the Ministry of Water, Land and Air Protection (MWLAP). Mountain goats were captured on 6 study sites, including Morice Mountain, Bob Creek Bluffs, Dungate Creek Bluffs, China Nose, Foxy Creek Canyon and Klo Creek Bluffs. Figure 1 outlines the location of the study area within the province itself, and the locations of the features that the mountain goats were using during the study.

According to the Ecoregion Classification of Demarchi (1995), the study area is within the Bulkley Basin Ecosection of the Fraser Plateau Ecoregion within the Central Interior Ecoprovince. The Central Interior Ecoprovince is typified by a continental climate of cold winters, warm summers and a precipitation maximum occurring in late spring to early summer. The area experiences some climate moderation from the Pacific Ocean air mass, and also experiences a rainshadow effect from the coastal mountains to the west (Demarchi *et al.* 1990). The mean monthly temperature ranges in the area (Smithers Airport) from a low in January of –14.9°C to a high of 21.1°C in July. Mean annual rainfall is 512.2 mm with approximately 38% occurring as snowfall (Environment Canada 1996). In the Central Interior Ecoprovince, spring consists of the months May and June, July and August make up summer, September and October are the fall season and an extensive winter period occurs from November through to April (RIC 1999). The growing season includes spring, summer and fall. It must be kept in mind that these seasons are specified for lower elevation areas and that winter may likely occur earlier at the higher elevations inhabited by mountain goats (i.e. in October).

According to the biogeoclimatic classification system (Banner *et al*. 1993), elevations above 1,700 m are classified as the treeless Alpine Tundra zone (AT) and elevations from 1,100 m to 1,400 m are within the Englemann Spruce-Subalpine Fir moist cold subzone (ESSFmc). Between the AT and ESSFmc subzones is a transitional area called the Englemann Spruce-Subalpine Fir moist cold parkland subzone (ESSFmcp). This subzone consists of a mosaic of small stands of stunted trees, herbaceous meadows, heath, grassland and scrub forest. Elevations below 1,350 m are in the Sub-Boreal Spruce moist cold subzone Babine variant (SBSmc2), although the transition from the SBSmc2 to the ESSFmc is gradual and marked by a shift towards a total dominance by subalpine fir (*Abies lasiocarpa*). Below 1,100 m in elevation is the Sub-Boreal Spruce dry cool subzone (SBSdk).

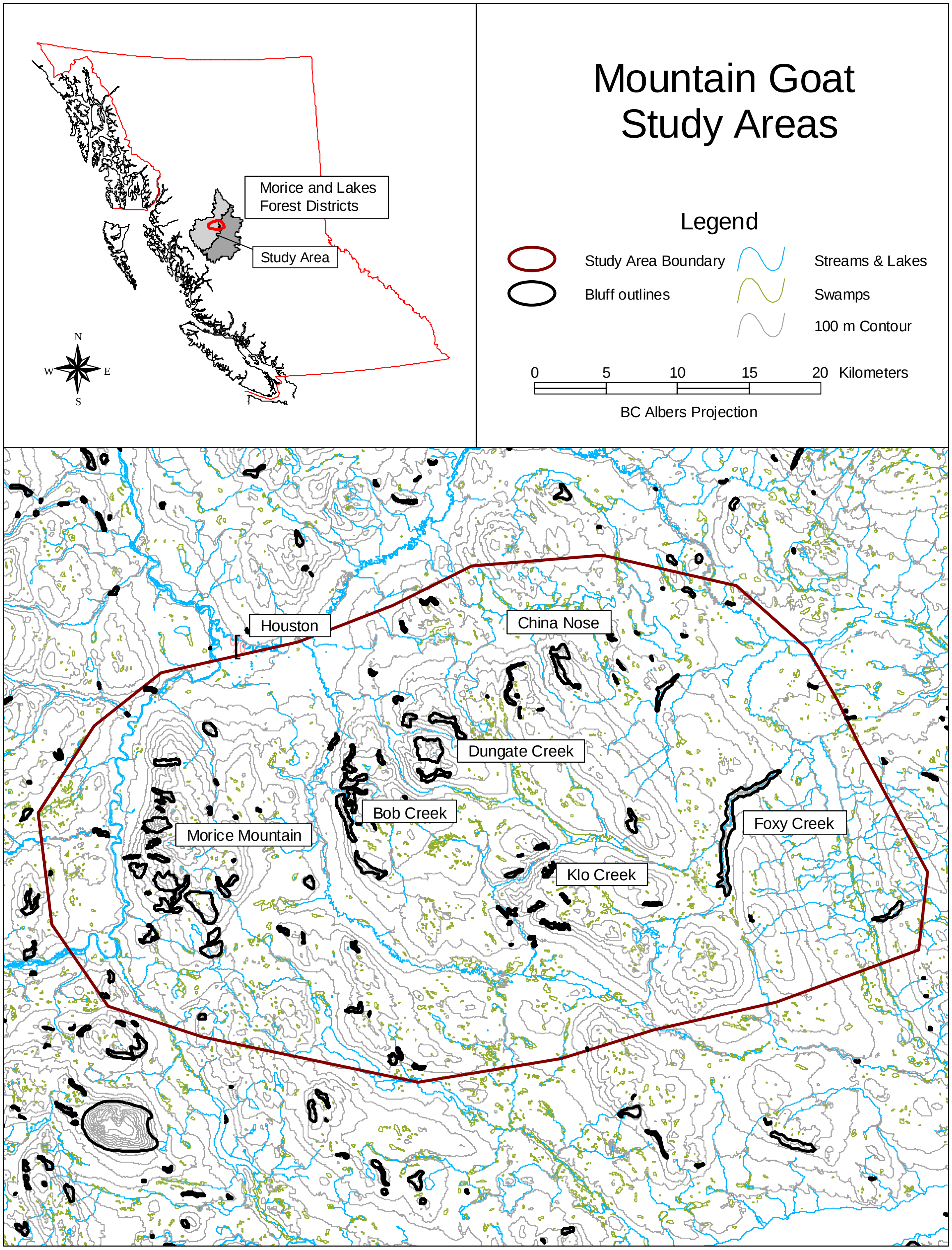


Figure 1. Location map of the study area and study sites.

The SBSmc2 subzone experiences seasonal extremes of relatively warm, moist short summers and cold winters with heavy snowfall. Mature upland forests are dominated by a mixture of subalpine fir and hybrid white spruce (*Pinus glauca* x *engelmanii*). Subalpine fir dominates at higher elevations and hybrid white spruce is more common on moist and nutrient rich sites within the subzone. Lodgepole pine (*Pinus contorta* var. *latifolia*) occurs throughout the subzone, but is more widespread in drier sites. Fire is the main disturbance event in the SBSmc2 subzone and the resulting seral stands of lodgepole pine and trembling aspen (*Populus tremuloides*) are frequent and extensive. In mesic ecosystems within the subzone, the shrub layer is diverse and includes varying amounts of black huckleberry (*Vaccinium membranaceum*), thimbleberry (*Rubus parviflorus*), highbush-cranberry (*Viburnum edule*), soopolallie (*Shepherdia canadensis*), black twinberry (*Lonicera involucrata*), alder (*Alnus* spp.) and black gooseberry (*Rubus lacustre*). A moderate to well-developed herb-layer consists of bunchberry (*Cornus canadensis*), twinflower (*Linnaea borealis*), heart-leaved arnica (*Arnica cordifolia*), queen's cup (*Clintonia uniflora*), five-leaved bramble (*Rubus pedatus*), palmate coltsfoot (*Petasites frigida* var. *palmatus*) and fireweed (*Epilobium angustifolium*). The forest floor of mesic ecosystems is carpeted by a layer of feathermosses. Wetter sites can have devil's club (*Oplopanax horridus*) and common horsetail (*Equisetum arvense*), while drier sites display sparse herb and shrub layers (Banner *et al*. 1993).

The influence of the SBSdk biogeoclimatic subzone on the study area expresses itself on west, southwest and south facing slopes at lower elevations (700 - 1,100 m). Stands of trembling aspen can be found at these locations, and shrub and herb layers tend to be more diverse and well developed than the typical sites of the SBSmc2 subzone, while the moss layer is less developed. At these sites prickly rose (*Rosa acicularis*), birch-leaved spirea (*Spiraea betulifolia*) and saskatoon (*Amelanchier alnifolia*) are dominant in the shrub layer and purple peavine (*Lathyrus nevadensis*), showy aster (*Aster conspicuus*) and fireweed (*Epilobium angustifolium*) are common in the herb layer.

The transition from the SBSmc2 subzone to the ESSFmc subzone is not obvious, and is marked by a gradual increase in subalpine fir, and the appearance of false azalea (*Menziesia ferruginea*), Sitka valerian (*Valeriana sitchensis*), Indian hellebore (*Veratrum viride*) and arrow-leaved groundsel (*Senecio triangularis*) as elevation increases into the ESSFmc subzone. The ESSFmc subzone has a short, cool and moist growing season and a long winter with cold temperatures and deep, long-lasting snowpack. As a result of these harsh conditions, the forest experiences slow tree growth and stands are relatively open. The dominant tree species is subalpine fir and lesser amounts of hybrid white spruce and lodgepole pine occur. Mesic sites within the subzone have well-developed and diverse shrub and herb layers. Commonly found shrub and herb species include black huckleberry, black gooseberry, false azalea, oval-leaved blueberry (*Vaccinium ovalifolium*), heart-leaved arnica, five-leaved bramble, three-leaved foamflower (*Tiarella trifoliata*), Sitka valerian, Indian hellebore and rosy twisted stalk (*Streptopus roseus*). Wetter sites can also display varying amounts of devil's club, common horsetail, lady fern (*Athyrium filix-femina*), oak fern (*Gymnocarpium dryopteris*) and Sitka burnet (*Sanguisorba canadensis*). Crowberry (*Empetrum nigrum*) and common juniper (*Juniperus communis*) can be found on drier sites (Banner *et al*. 1993).

Morice Mountain (Figure 2, Photo1) is a large, complex mountain feature located in the Morice Forest District approximately 20 km southwest of Houston, BC on the east side of the Morice River. The upper portions of Morice Mountain consist primarily of alpine and subalpine meadows and krummholtz with large portions of rock outcrop and cliff.

Middle and lower slopes are frequently broken by deeply incised gullies with sections of cliff. Mountain goats are frequently observed in these small canyons. A large portion of the lower and middle forested slopes of this feature was burned by a fire in 1983. Morice Mountain is accessible by all-terrain vehicles and snowmobiles and has a ski cabin located on the north end within the subalpine zone. This site has been closed to general hunting since 1975. An aerial population survey conducted in 1999 found 57 mountain goats on Mount Morice (Turney *et al*. 2000).

The Bob Creek Bluffs (Figure 2, Photo 2) are found approximately 10 km south of Houston, BC in the Morice Forest District. Bob Creek is a tributary to Buck Creek and contains several south and west aspect cliffs that provide good escape terrain. Upper slopes consist of subalpine meadows and clumps of stunted subalpine fir. Cliffs and rock knobs occur from middle elevations to upper slopes and crest positions. Buck Flats Road runs north-south approximately 2 km to the west of the Bob Creek Bluffs and there is rural development along this road. Population surveys conducted in 1999 located 12 mountain goats on this feature, including three nannie/kid pairs (Turney *et al*. 2000).

The Dungate Creek Bluffs (Figure 2, Photo 3) are found approximately 10 km southeast of Houston, BC in the Morice Forest District. This feature consists of a complex of middle elevation north, south and east facing cliffs clustered over a stream valley. Subalpine habitats of small clumps of stunted conifers interspersed by herbaceous meadow characterize the upper elevations of these features. Lower slopes are densely forested and are in the SBSmc2 subzone. Areas of cliff and rock outcrop are found generally from crest to middle slopes. Small groups of goats have been observed on all of these cliff features, and a total of 11 animals were observed here in the 1999 population survey (Turney *et al*. 2000).

China Nose (Figure 2, Photo 4) is a very large cliff feature above the confluence of Aitken Creek and Heading Creek. It is located approximately 20 km east of Houston, BC in the Morice Forest District. Extensive meadow is found on the plateau above the cliffs, providing forage for a small population of animals. A logging access road and harvest blocks are located along Heading Creek. Small numbers of animals (2 to 6) are regularly observed on this feature (Turney *et al*. 2000).

Foxy Creek Canyon (Figure 2, Photo 5) is located at the western edge of the Lakes Forest District between Maxan Lake and the Equity Mine site in the Morice Forest District, approximately 35 km southeast of Houston, BC. The portion of the stream studied consisted of the upper 20 km of Foxy Creek running from the Equity Mine site to the confluence with Maxan Creek. Within this stream length there is a continuous canyon section beginning approximately 1 km above the Maxan FSR bridge over Foxy Creek and extending approximately 13 km upstream. The canyon depth ranges from approximately 150 m at the downstream end to approximately 50 m at the upstream end. The lower half of the canyon consists of approximately 40% discontinuous, bedrock cliffs and 60% steep forested slopes (Mahon and Turney 2002). Approximately 95% of the upper half of the canyon is steep, forested slopes, with only about 10% of this area being isolated cliffs and bluffs. The entire Foxy Creek Canyon feature is within the SBSmc2 biogeoclimatic subzone. Over the previous 35 years, road networks have been developed over the full length of the canyon to within 1 km of both sides of the canyon rim. Presently, 43% of the area along the canyon rim is in early seral cutblocks, 12% of the area is a pole-sapling stage burn, and 44% is in mature forest stage (Turney *et al.* 2001, Mahon and Turney 2002). An aerial population survey conducted in winter 2000 counted 37 mountain goats on this feature. It was noted during the survey that sightability was poor and that this result should be considered a minimum total count (Turney *et al*. 2001b).

Klo Creek Bluffs (Figure 2, Photo 6) are located approximately 8 km southeast of the Dungate Creek Bluffs and 14 km west of Foxy Creek Canyon. These bluffs are a series of steep rock and forested features that run in a generally northeast to southwest direction with two main bluffs to the north of the area and a series of three large bluffs to the south. All of the bluffs are generally south facing with small cliff features interspersed with dry pine forests and moister sub-alpine fir forests. Klo Creek Bluffs have an estimated population of 20 mountain goats.

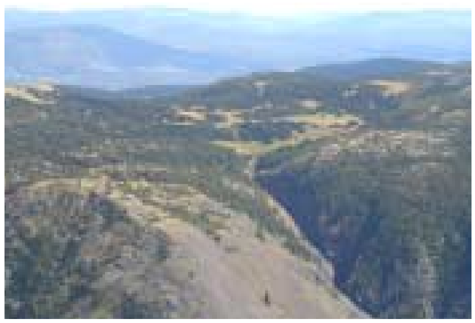


Photo 1. Morice Mountain.

Photo 2. Bob Creek Bluffs.

Photo 3. Dungate Creek Bluffs.

Photo 4. China Nose.

Photo 5. Foxy Creek Canyon.

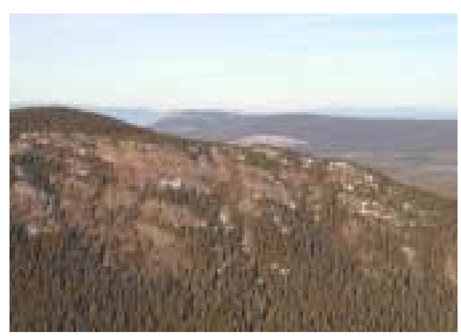


Photo 6. Klo Creek

Figure 2. Photographs of mountain goat use areas within the study area.

Methods

Aerial Telemetry

Mountain goats were relocated approximately once every four to six weeks, weather permitting. Both VHF and GPS collared animals were relocated in order to identify animal distribution, trends in habitat use and to monitor collar function. Standard aerial telemetry relocating techniques were followed, as outlined in *Wildlife Radio-telemetry: Standards for Components of British Columbia's Biodiversity* (RIC 1998b). A Cessna 206, equipped with two H-antenna and a Telonics VHF receiver was used. Relocations were completed by flying a continuously tightening circle of the area from which the collar signal appeared to be emitted in order to determine a bounded area in which the animal was located. The circle was focussed on an area based upon the transmitted signal strength and knowledge on mountain goat habitat preferences. Visual observation of radio-located animals was attempted to confirm the accuracy of each location, but avoidance of harassment of the collared animal was also considered during relocation.

Mountain goat locations and habitat data were recorded on project specific data forms. Major habitat attributes of each location that were recorded include habitat type (e.g. forest, meadow, rock), aspect, meso and macro slope position, canopy closure, structural stage, biogeoclimatic zone and broad ecosystem unit. Animal locations were recorded using a hand-help Garmin GPS 12 and a photo of the animal location was taken using an Olympus model C-3020 digital camera (2,048 x 1,536 pixel resolution). Upon return to the office, animal GPS locations were corrected (due to offset from flight) by comparing the field acquired photograph, diagrams and field mapped locations with digital ortho-photographs.

Mortality Investigations

During the summer and fall of 2003, four mountain goat collars were discovered to have entered into mortality mode during the telemetry flights, indicating that the collar was no longer moving and the animal was likely dead. Investigations of these collars were undertaken as soon as possible to try to determine the cause of death. Mortality investigations were undertaken by helicopter using a Telonics VHF radio telemetry receiver and a single H-antennae mounted on the nose, and ground telemetry methods using a HABIT Research HR2000X Osprey receiver and H-antenna. When the collar was located, an investigation of the area around the collar was conducted to look for evidence of the goat, and any indication of the cause of death. Notes were taken of the mortality site and in on instance a necropsy was performed to try to determine a cause of death.

DNA Analysis

DNA Extraction

DNA analysis was conducted by Wildlife Genetics International and the following summarizes the methods used for that work. All samples were extracted using QIAGEN's DNeasy Tissue kits, and following the manufacturer's instructions (http://www.qiagen.com/literature/genomlit.asp - dneasytissue). A total of 28 tissue samples were extracted, and 31 hair samples. For hair samples, an attempt was made to use 10 guard hair roots where available (n=29). When underfurs were used (n=2), entire clumps of whole underfur were extracted rather than clipping individual roots.

Marker Selection

Initially, 21 microsatellite markers on 14 tissue samples were tested. Most of the markers were taken from standardized sets that are used for parentage analysis in cervids, although many were originally developed in cattle. Advice was sought from Curtis Strobeck and Dave Coltman (University of Alberta), about which specific markers were known to be variable in Alberta populations of mountain goats. To reduce costs, the selection of markers was restricted for those that primers were already available. For the test of hair samples, the three most variable markers found from the tissue analysis were used. The heterozygosity of the ten effective markers for the tissue samples and three markers for the hair samples was recorded in an Excel spreadsheet.

Collar Recovery and Re-Capture

Recovery of selected GPS collars was attempted prior to their scheduled timed release through the use of the remote release mechanism (Lotek Wireless Inc. 2001b). To release the collar, a helicopter was used to locate the collared animal using a Telonics VHF radio telemetry receiver and H-antennae. Once a collared animal was located, it was approached by helicopter to within 200 m and a radio transmitter was used to trigger the remote release mechanism of the collar buckle. Release was attempted for three animals, with no success, and was abandoned for the other animals due to budget and time constraints. The timed-release mechanism was used for all but three collars, and location of the collars completed using both helicopter and ground-based telemetry techniques.

Three GPS collars that failed to release by either the remote or timed-release mechanisms were collected through aerial telemetry and net-gunning techniques. Mountain goats were located using a VHF radio telemetry receiver and H-antennae and were captured by aerial net-gun, using a hand-held net gun and a Hughes 500D helicopter. The capture crew consisted of the helicopter pilot and a net-gunner/animal handler, both experienced in capturing and collaring mountain goats. Accepted guidelines for animal capture and handling were followed during the procedure (CCAC 1984, CCAC 1997, RIC 1998a, RIC 1998b). All efforts were made by the capture crew to minimize capture related stress and trauma to the subject animals. The welfare of the captured animal was considered of greatest importance, and if necessary the capture and handling procedures were aborted and the animal was released prematurely if injury to the animal or handlers appeared imminent. A more detailed description of the animal handling procedures followed can be found in *Mountain Goat Capture and Handling Protocols* (Blume and Turney 2002). Once captured, mountain goats were immobilized through a minimal amount of physical restraint and the capture net was removed. Hobbles were then placed on the front and hind legs, the goat was blindfolded to provide a calming affect and rubber horn guards were fitted to prevent injury. During the entire capture and handling process, the condition of each animal was monitored for signs of respiratory distress and shock.

Once captured and restrained, the old GPS collar was removed from the animals and in two instances, a replacement GPS collar was deployed. One GPS 2000 and one GPS 2200 collar with store-on-board memory, were used to replace the recovered collars. Each collar was fitted with a 30 week timer-released mechanism. Collars were programmed before deployment following the manufacturer's instructions (Lotek Engineering Inc. 1999, Lotek Wireless Inc. 2001a). GPS collars stored not only animal location at the pre-programmed time intervals, but also fix mode (2-dimensional or 3-dimensional), number of satellites received and positional dilution of precision (PDOP). The GPS 2000 collar also recorded animal activity, ambient temperature and satellite signal strength. The programming parameters for each GPS collar type are summarized in Table 1

Table 1. GPS collar programming parameters.

Programming Parameter	GPS 2000 Collar	GPS 2200 Collar
GPS fix schedule	4 fixes/day	
VHF beacon schedule	0800 – 1800 daily	
Mortality signal	Activate if no movement in 48 hours	

Home Range and Movement Analysis

Analysis of the movements of mountain goats was completed using the GPS collar data only and the *Animal Movement* extension for ArcView® GIS (ver. 2.04) (Hooge and Eichenlaub 1997). For each day with one or more fixes, a fix was chosen randomly and the distance calculated between that GPS fix and the fix chosen from the preceding day. If the preceding day did not have a fix, then that daily movement was not calculated. SPSS for Windows© (ver. 11) was used to analyse the daily distance moved and to determine if there were any differences in daily movements between sexes, between adults and juveniles, between months and seasons, and between capture locations. Statistical tests were considered significant at $P < 0.05$.

Lotek collars are programmed by the manufacturer to store fixes only if DOP is less than 12 and 3D fix locations where DOP is less than 5 are likely to be within 20 m of the actual location (Gyulay *pers. comm.*). Raw GPS data were not filtered by fix status or DOP value. D'Eon *et al*. (2002) found that there is no quantifiable relationship between DOP and fix accuracy and cautioned against the use of DOP to censor raw data. Several studies have also noted that in censoring raw data, a bias in the resulting data may be introduced, as habitats with a lower likelihood of fix acquisition (e.g. high canopy closure, steep terrain) would be underrepresented (Poole 1998, Bowman *et al*. 2000, D'Eon *et al*. 2002, Taylor 2002). This effect would appear to be more pronounced in studies of mountain goats, given the habitat types that this species tends to frequent.

The mountain goat locations acquired by the GPS collars were stored as latitude and longitude. These coordinates were converted to Universal Transverse Mercater (UTM Zone 9) and BC Albers projections to be compatible with available digital mapping and digital ortho-photographs. Additional information stored by the GPS collars and used in data analysis included the date of fix acquisition, fix status (2D or 3D), and on the GPS 2000 collars activity levels and ambient temperature.

Seasonal home range estimates for the individual animals were calculated using the kernel method (Worton 1989). The kernel method was selected because it does not overestimate home range size and is not significantly biased by outlier effects (Gallerani Lawson *et al*. 1997). The kernel method also takes advantage of the number and the relative density of locations distributed across the study area. A 95% and a 50% kernel home range were completed using the combined GPS and VHF locations for each animal. Based on an initial exploration of the GPS location data and date, two general seasons were identified for a preliminary seasonal home range analysis. A winter and a growing season were determined by examining the dates of the GPS locations and their relative positions on the landscape, along with a comparison of monthly home range sizes. The adaptive kernel home range estimate was produced using the *Animal Movement* extension for ArcView® GIS (ver. 2.04) (Hooge and Eichenlaub 1997).

Results

VHF Telemetry Relocations

Thirteen mountain goats were captured and fitted with VHF collars in January 2003, and an additional six were fitted with VHF collars in March 2003. Both VHF and GPS collars were relocated during 16 telemetry sessions from January 27th 2003 to January 17th 2004. A total of 381 telemetry points were mapped from these flights. Landscape position and habitat information were all recorded for most telemetry locations. Four mortalities were recorded during the flights: three VHF collared goats and one GPS collared nanny. Mortality investigations occurred for all of these goats. A summary of the mountain goats that were captured and collared is provided in Table 2.

Table 2. Summary of VHF and GPS collared mountain goats by capture location.

Capture Area	Collar Type	Male	Female	Total
Morice Mtn	VHF	4	2	6
Bob Creek	GPS	1		1
	VHF	3	3	6
Dungate	GPS		3	3
	VHF	1	1	2
Klo Creek	VHF	2	1	3
China Nose	GPS	2		2
Foxy Creek	GPS	1	1	2
	VHF		2	2
Total		**14**	**13**	**27**

DNA Analysis

An initial test of 21 markers was conducted on 14 mountain goat tissue samples. Eleven markers were found not to amplify (A = 0), fixed for a single allele (A = 1), were otherwise insufficiently variable, or were too difficult to score and were not used for further testing (Table 3). The remaining 10 markers were tested on the remaining 14 tissue samples and obtained hetero-zygosity values (H_O) ranging from 0.36 to 0.86 (mean

Table 3. Summary of results of genetic analysis on mountain goat tissue samples.

Marker	*N*	*A*	H_O	Origin	Marker	*N*	*A*	H_O	Origin
BM203	28	8	0.86	Cow	CSSM041	14	1	-	Cow
BM4107	28	4	0.36	Cow	Rt5	28	4	0.54	Caribou
BMC1009	28	5	0.71	Cow	Rt7	14	0	-	Caribou
BM6506	14	2	-	Cow	BM4028	14	2	-	Cow
BM888	14	0	-	Cow	Rt6	14	1	-	Caribou
BM3507	14	0	-	Cow	Rt9	28	3	0.54	Caribou
FCB193	14	2	-	Cow	Rt13	14	0	-	Caribou
BL42	14	1	-	Cow	Rt27	28	3	0.46	Caribou
INRA107	28	2	0.64	Cow	Rt1	28	3	0.54	Caribou
Rt24	14	0	-	Caribou	BM1225	28	5	0.64	Cow
BM4513	28	5	0.75	Cow					

N = samples tested, H_O = observed heterozygosity, *A* = number of alleles

= 0.60) and the number of alleles (A) amplifying ranged from 2 to 8 (mean = 4.2). An analysis of level of power (using the number and variability of the markers) was conducted to determine the potential of using these markers to detect individuals from the population of mountain goats in the study area. Using six of the markers with the highest number of amplified alleles (A > 3), a plot of the distribution of genotype similarity for the 28 tissue samples indicated that the two most similar pairs of genotypes matched at only four of the six markers, suggesting that perfect six-locus matches between individuals would be very rare in this population.

Analysis of the hair samples found that although the signal strengths were weaker than from the tissue samples (see Figure 3), all samples produced complete three-locus data, and each individual had a unique multi-locus genotype. Based on the analysis of hair samples, determining an individual from hair samples within this population was considered to be very likely.

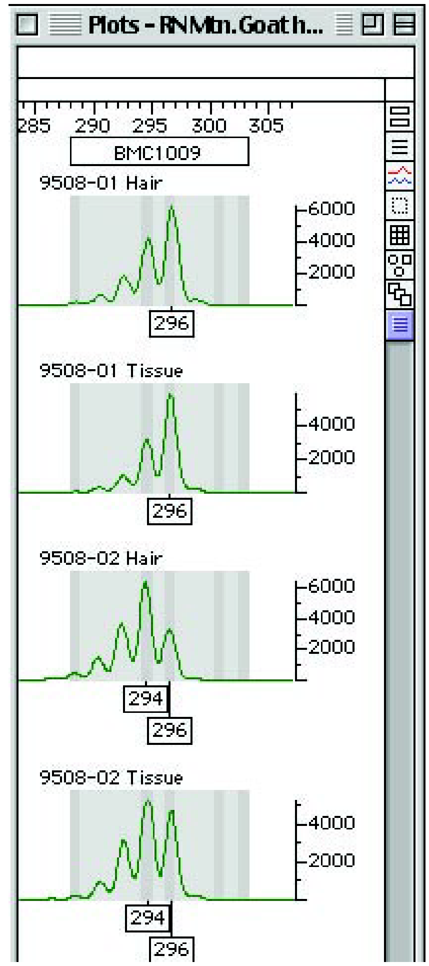


Figure 3. Comparison of hair and tissue samples for marker BMC1009.

Mortality Investigations

Table 4 summarizes the four mountain goat mortalities in the summer and fall of 2003. Due to the length of time from when the animals were captured it was assumed that none of these mortalities were capture related.

Mountain goat collar 151.309 was found at the base of a small rock bluff on a wildlife trail along the side of a creek (See Photo 7 of Figure 4). As well, there was a goat bed nearby, along the trail. All of the meat was gone from the carcass; however, the hair and most of the large bones were present, but scattered and the bones were somewhat chewed on. It could not be definitively determined from the remains how the animal had died.

Table 4. Summary of mountain goat mortalities in the summer and fall of 2003.

General Area Found	Frequency	VHF or GPS	Sex	Age	Estimate Date of Mortality	Mortality Investigation
Dungate	151.309	VHF	F	7 – 8	June 18 – 25	July 16
Morice Mtn.	150.840	VHF	F	2 – 3	Early Sept.	Sept. 22
Equity	148.410	GPS	F	3 – 4	Sept. 1	Oct. 1
Klo	151.270	VHF	M	4 – 5	Sept. 25 – 30	Oct. 1

There was evidence in scat that was found nearby that a bear had fed on the goat. As well, there were scuffle marks on the slope above where the goat was carcass was found, a bear bed, scat, and bear hair that indicated that it was a black bear that had fed on the goat carcass.

Mountain goat collar 150.840 was found on Morice Mountain, along a goat trail, in the subalpine forest. Other than the collar, there was no evidence of the goat or how the animal may have died. It possible that another animal may have moved the collar after the goat died.

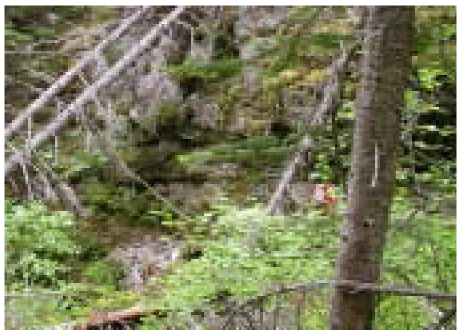


Photo 7. Collar 151.309 near Dungate.

Photo 9. Collar 148.410 near Equity.

Photo 8. Goat 151.270 near Klo.

Figure 4. Photographs of mountain goat mortality sites within the study area.

Mountain goat collar 151.270 was found along a creek in the Klo creek bluff area. The goat was intact, lying on its side with no obvious sign of trauma or mortality agent. A field necropsy revealed only slight bruising on the left elbow and left haunch, but not enough to indicate a severe fall. As well, the animal was in good condition with lots of fat stores, healthy looking organs, no broken bones, and a thick, new winter coat. There were no puncture wounds in the hide and the collar was sized correctly. A wildlife biologist with the Ministry of Water, Land, and Air Protection collected muscle and organ tissues for analysis, unfortunately they were not analyzed, prior to disposal. Investigation of the surrounding area indicated that the animal had recently spent some time nearby. There was a well dug out bed adjacent to where the animal was found (See Photo 8 of Figure 4), scat, and a trail leading up the forested slope to a pine stand nearby. During telemetry flights, this goat was often located in the gully along this creek and in the forested areas adjacent.

Mountain goat collar 148.410 was found in a relatively open, flat, submesic ESSFmc subalpine fir forest (See Photo 9 in Figure 4). This goat had been collared on the Dungate bluffs and moved to this forested area by the September 2, 2003 telemetry session. Based on the activity readings from the collar the animal likely died on Sept. 1st, and had been dead for 4 weeks, when the investigation took place. Only the hair and bones of the goat were found, well scattered and chewed, very little of the carcass found at the time of investigation. From the pattern of carcass dispersal, it was considered likely that wolves were the mortality agent or that they had fed on the carcass after mortality.

GPS Collar Recovery

Seven mountain goats were captured and fitted with GPS collars during January 2003 and an additional mountain goat was fitted with a GPS collar in March 2003. One collar (frequency 148.610) had stopped collecting GPS fixes by February 1st, 2003 due to an apparent GPS battery failure and only collected 25 fixes. During telemetry flights, this goat was consistently located in caves on steep rock faces in the China Nose bluffs, which made remote releasing the collar difficult. This collar eventually released using the timed-release mechanism on November 12th 2003 and was collected. A second GPS collar (frequency 150.100) started emitting a double beat September 29th, 2003, indicating a DPM failure. An attempt to remote-release this collar was unsuccessful and the timed release also failed. The goat wearing GPS collar (freq.) 148.410 died in mid-September and the collar was collected on October 1st, 2003. None of the remote-release mechanisms were successful; therefore we waited for the time-off release for the remaining GPS collars. Two collars successfully time-off released; however, three collars did not (including collar 150.100). The collars that were remaining on the mountain goats had faulty release mechanisms and these goats had to be recaptured for the collars to be removed on March 2nd, 2004.

GPS Collar Fix Acquisition

Seven GPS collars attempted to obtain a total of 11761 fixes while on the mountain goats, although one collar (freq. = 148.610) only obtained 20 fixes that were useable due to a failure of the GPS system. Another collar appeared to collect approximately 1500 fixes, but the data was unable to be recovered and was lost, possibly due to a battery failure during downloading. All other

Table 5. Summary of GPS collar fix acquisitions.

Collar Freq.	Fix Status						Total
	2D Fix		3D Fix		No Fix		
	N	% of Total	N	% of Total	N	% of Total	*N*
148.139	1189	47.3%	648	25.8%	677	26.9%	***2514***
148.179	1090	49.7%	367	16.7%	735	33.5%	***2192***
148.200	1131	51.7%	296	13.5%	759	34.7%	***2186***
148.410	462	33.2%	688	49.4%	242	17.4%	***1392***
148.610	13	54.2%	7	29.2%	4	16.7%	***24***
148.689	972	44.3%	205	9.4%	1016	46.3%	***2193***
150.151	503	39.9%	266	21.1%	491	39.0%	***1260***
Total	***5360***	***45.6%***	***2477***	***21.1%***	***3924***	***33.4%***	***11761***

collars obtained between 769 and 1837 useable fixes, with 45.6% of the total attempted fixes being 2D and 21.1% being 3D fixes (Table 5).

A total of 7837 useable GPS locations were collected on all collars from January 2003 to March 2004. The number and distribution of 2D and 3D fixes for the GPS 2000 and GPS 2200 model collars were different over the year, with the GPS 2200 collars collecting more useable fixes with more consistency on a monthly basis than the GPS 2000 collars (Figure 5). Differences in the length of time the different collar models collected data were a function of collar release timing and mortalities rather than the ability of the collar to sustain data collection.

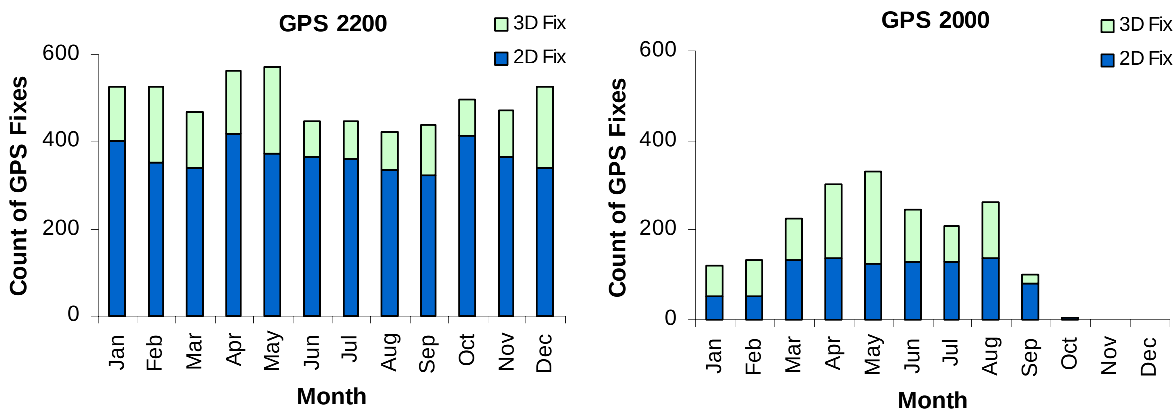
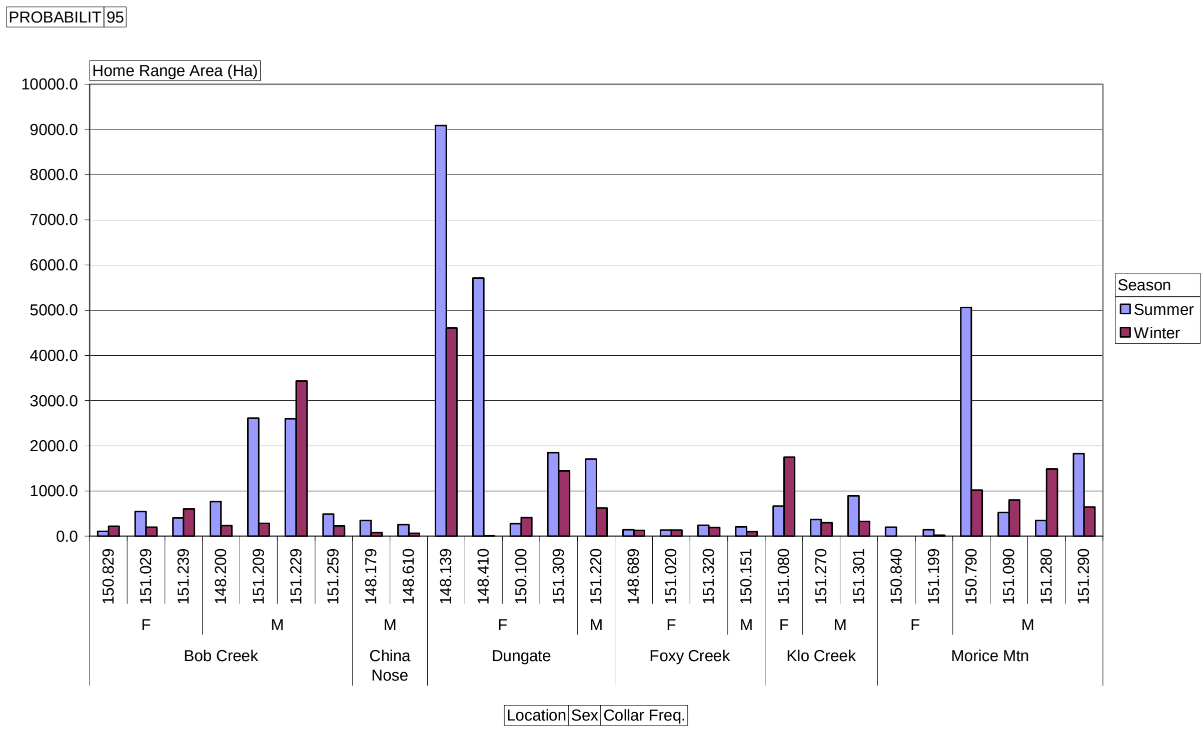


Figure 5. Number of 2D and 3D locations acquired for GPS 2200 and GPS 2000 collars for each month.

Home Range Analysis

The sizes of the 50% and 95% kernel seasonal home ranges varied by animal and their collared location (Figure 6). Two female mountain goats collared initially in the Dungate Creek area had the largest 95% kernel home ranges during the summer, along with a male from Morice Mountain. These same three animals had the largest 50% kernel summer home ranges as well, although one of the females from Dungate (Freq. 148.139) also had the largest 50% winter kernel home range. In general, winter home ranges were smaller than summer home ranges, which is similar to that observed by previous studies (e.g. Turney *et al.* 2002, Chadwick 1973, Stevens 1983). This change between seasonal ranges is probably related to snow accumulation in winter and melt in the spring, which affects the ability of animals to travel (Casebeer *et al.* 1950, Hebert 1967, Russell 1974, Stevens 1983). Previous studies have also observed that adult male ranges tend to be much larger than that of adult females and subadults of both sexes (Chadwick 1973, Schoen and Kirchoff 1982, Smith and Raedeke 1982). In this study, differences in male and female seasonal home ranges were variable, with no distinct trend.

Comparisons of the 95% seasonal home range sizes showed significant differences between the mean home ranges of the individual animals (ANOVA, $F_{0.05(1), 26,26} = 2.704$, $P = 0.007$). Comparisons of the mean home range sizes for summer and winter seasons, males to females, and adults to juveniles, were not found to be significant, while comparisons between locations (i.e. Bob Creek vs. Foxy Creek, etc.) were significant (see Table 6).



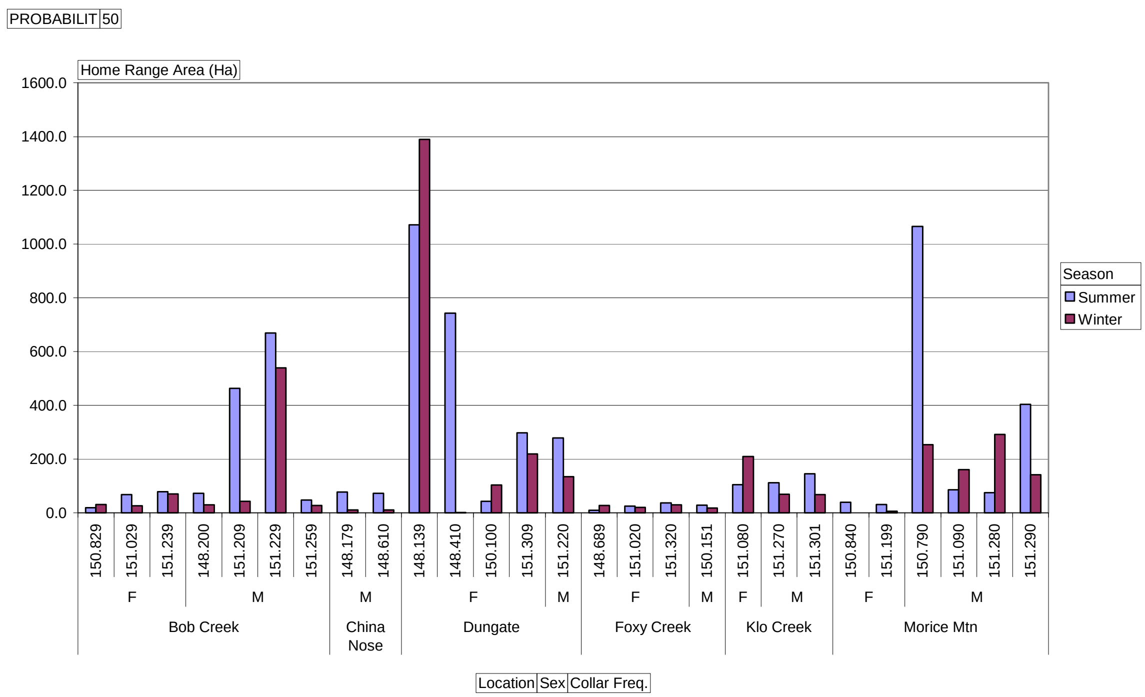


Figure 6. Comparison of seasonal mountain goat home range size probability, sex and location

Movement Analysis

Seven GPS collars had sufficient fix data on successive days to provide daily movement distances for analysis. Mean daily movement distances ranged from 299.9 to 1119.8 m (Table 7). Due to the low number of daily movement for collar 148.610, it was not used in any further analysis. Comparisons of the daily movement distances showed significant differences between individuals, but not between males and females or between adults and juveniles (Table 8). There were, however, significant differences in the daily movement distances between the individuals of different ages, between months, between summer and winter and between locations (Table 8).

Three mountain goats moved from their collaring locations during the year to other bluff complexes, while many goats moved extensively within and around the bluff complexes where they were captured. A juvenile male (freq. = 148.179, age = 2 at capture) was captured on China Nose and moved twice to a bluff complex to the west of China Nose called the Poison Bluffs. The first movement occurred from Sept. 26th to Oct. 24th, 2003 and the goat used a large portion of Poison Bluffs, while the second was Nov. 13th and 14th, 2003 and appeared to be in conjunction with a number of large distance movements from China Nose (see Figure 7).

Table 6. Evaluations of mountain goat seasonal home ranges using ANOVA.

Comparison	df (Between, Within)	F value	*P* Value
Individuals	26, 26	2.704	* 0.007
Summer vs. Winter	1, 51	1.933	0.170
Male vs. Female	1, 51	0.148	0.702
Adults vs. Juveniles	1, 51	1.189	0.281
Locations	5, 47	2.680	* 0.033

* Significantly different home range sizes.

Table 7. Summary of mountain goat daily movement distances.

Collar Freq.	Sex	Age	N	Mean Daily Distance (m)
148.139	F	Ad.	417	1119.8 ± 83.9
148.179	M	Juv.	354	846.3 ± 57.6
148.200	M	Ad.	357	884.7 ± 44.4
148.410	F	Ad.	231	1083.4 ± 96.4
148.610*	M	Ad.	5	299.9 ± 43.3
148.689	F	Ad.	332	615.8 ± 29.4
150.151	F	Ad.	206	763.3 ± 45.1

* Not used in further analysis.

Table 8. Evaluations of mountain goat daily movement distances using ANOVA.

Comparison	df (Between, Within)	F value	*P* Value
Individuals	5, 1891	8.802	* <0.000
Male vs. Female	1, 1895	3.290	0.070
Adult vs. Juvenile	1, 1895	3.449	0.063
Ages	3, 1893	14.410	* <0.000
Months	11, 1885	27.433	* <0.000
Summer vs. Winter	1, 1895	165.802	* <0.000
Locations	3, 1893	13.939	* <0.000

* Significantly different daily movement distances.

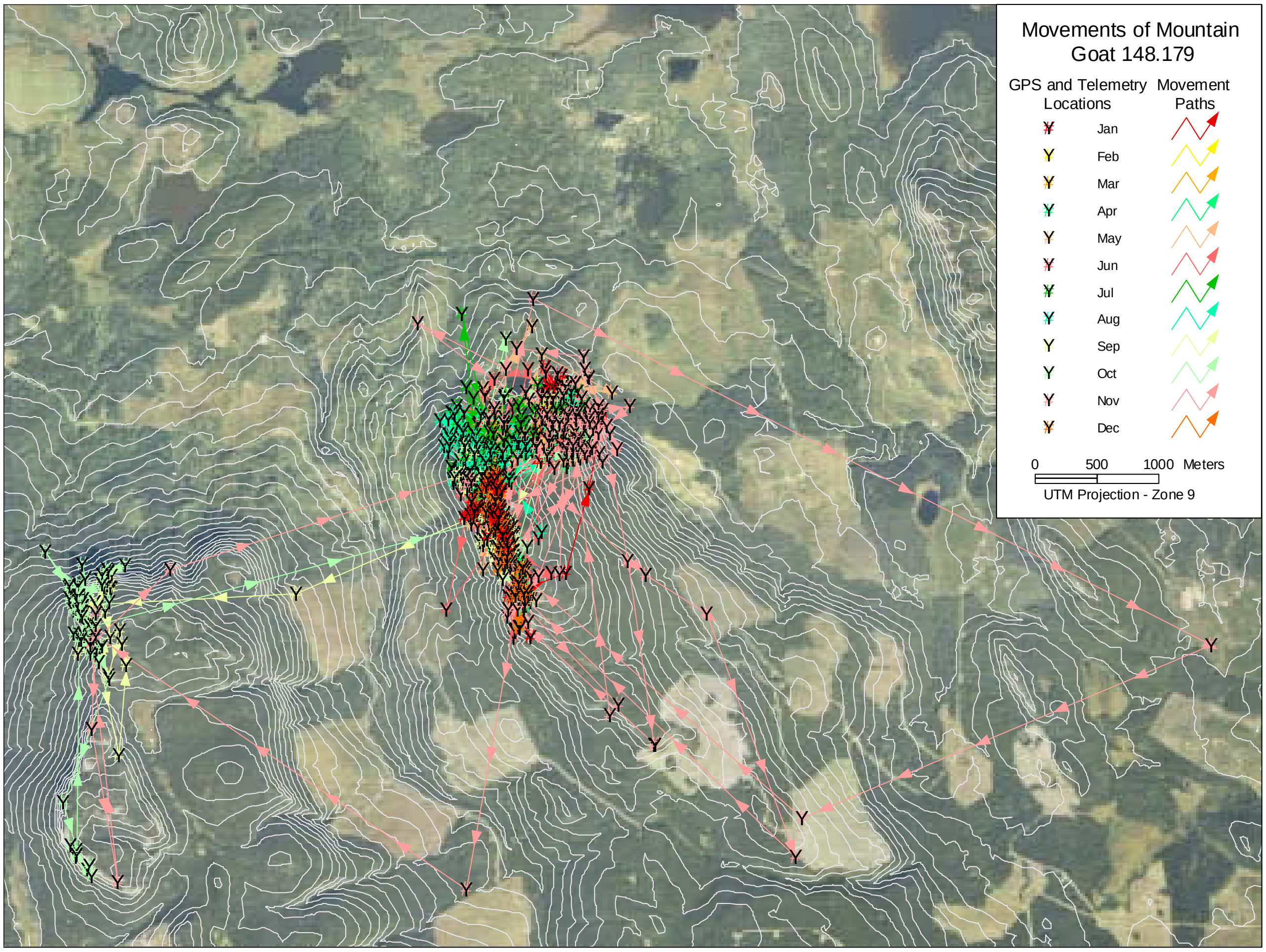


Figure 7. Movements of juvenile male mountain goat (freq. 148.179) near China Nose.

An adult female (freq. = 148.410, age = 3 at capture) left the Dungate area on Jul. 17th, moving west to the Bob Creek complex for one day. On Jul. 18th she left Bob Creek and moved east traveling during the night towards Klo Creek where she moved between a number of small bluffs in the area until Jul. 26th. During that time, movements between 6.4 km over a 16 hour period and 7.4 km in a 12 hour period were recorded. The goat moved from the Klo Creek area toward the bluffs south of Equity Mine on Jul. 26th, spending time moving between the north and south facing bluffs in that area until Aug. 1st. The majority of August was spent within a low creek canyon to the east of Klo Creek, where she died of unknown causes on Sept. 1st, based on the activity monitors within her collar. Figure 8 outlines the movements of this animal within the study area.

An adult female (freq. = 148.139, age = 3 at capture) travelled the longest distances of any of the collared animals, moving from her capture location of Dungate Creek on Aug. 15th, 2003 eastwards towards the north end of a large burn between Equity and China Nose. She reached the north end of Foxy Creek on Aug. 16th and moved south along Foxy Canyon, leaving the south end of the Canyon on Aug. 20th. From Foxy Canyon, she moved northwest to China Nose, spending a number of days at China Nose and on small bluffs north and east of China Nose. By Sept. 5th, the goat had returned to China

Nose and moved south to a north-facing bluff, north of Equity Mine by Sept. 7th. She stayed at that site until Sept. 27th, moving into the burn towards China Nose, using a series of small bluffs and canyons until Oct. 6th, when she moved back to the south end of Foxy Creek. The goat stayed in the south end of Foxy Creek until Oct. 23rd, when she moved back to the bluffs overlooking Equity Mine until she was recaptured and the collar removed Mar. 2nd, 2004 (see Figure 9).

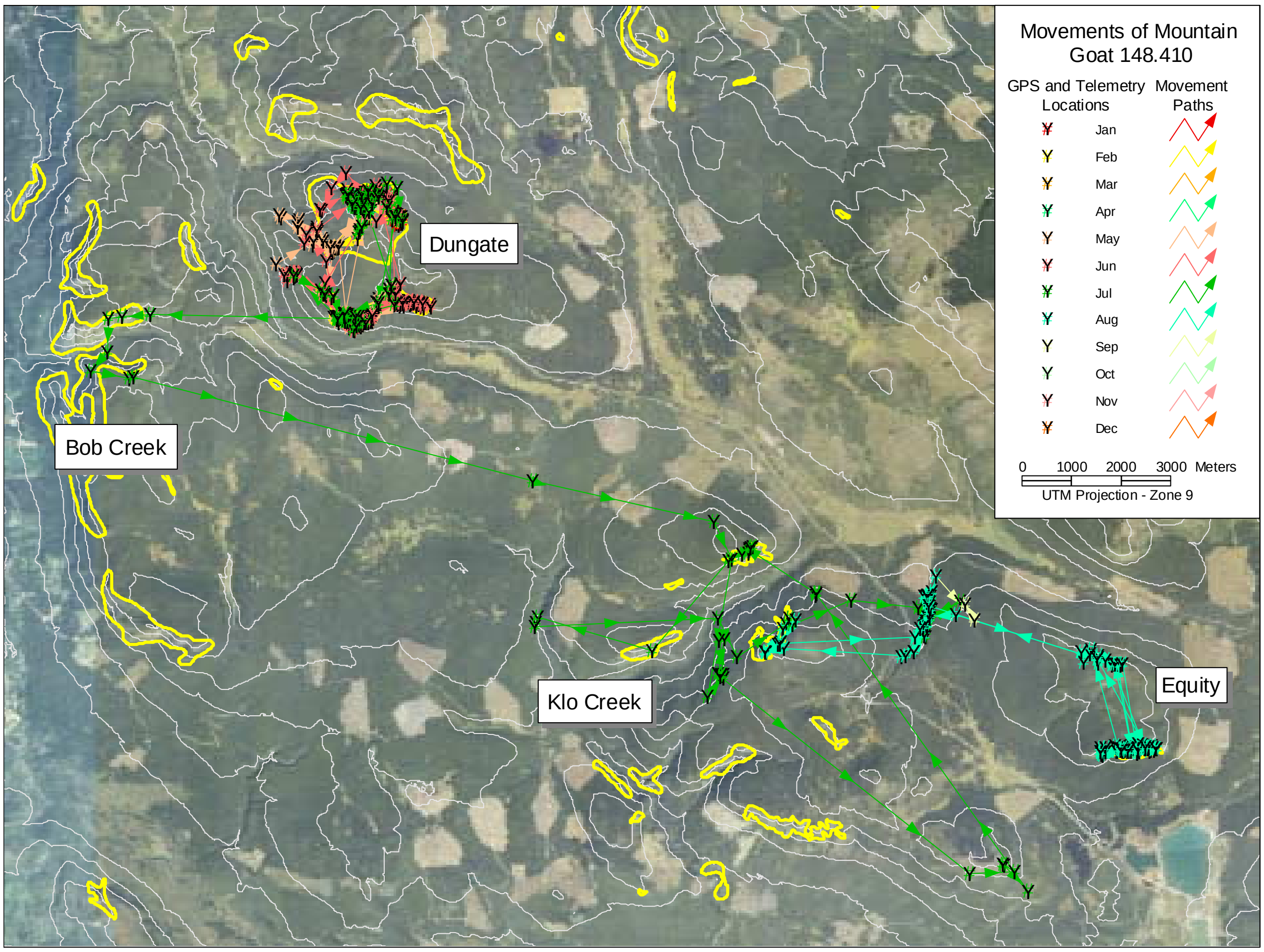


Figure 8. Movements of adult female mountain goat (freq. 148.410) near Klo Creek.

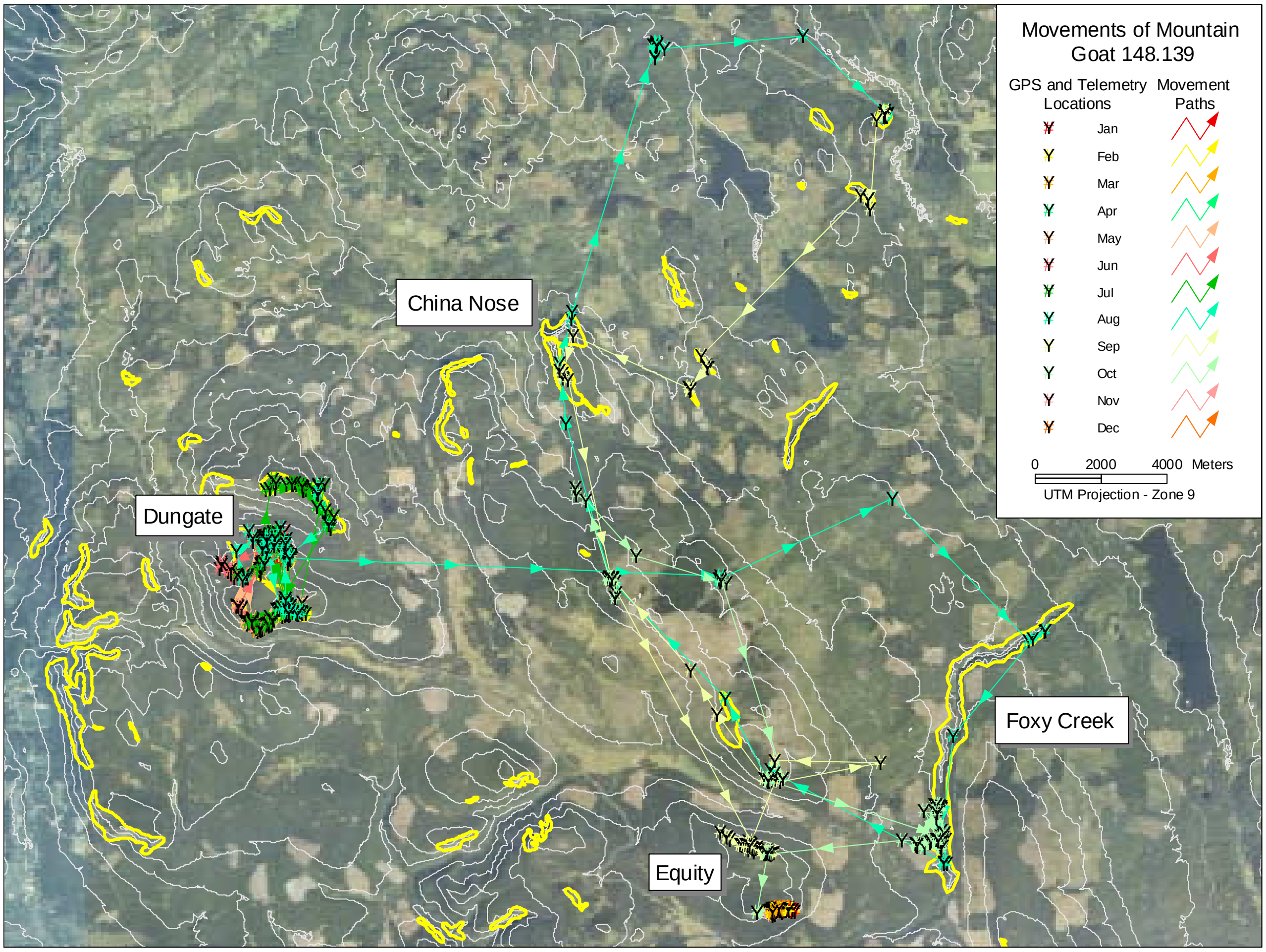


Figure 9. Movements of adult female mountain goat (freq. 148.139) within the study area.

Discussion

The results of the telemetry and GPS location data indicates that the mountain goats are using extensive portions of the study area, with large home ranges shown by many animals in both summer and winter. The significant differences in the home range sizes of individuals was not unexpected as differently aged male and female mountain goats would be expected to have different habitat needs and abilities to exploit them. Movement patterns detected by the telemetry and GPS data were very interesting, with three of the 26 collared animals exhibiting movements between bluff/canyon complexes, suggesting that interactions between the groups of animals may be quite common. It should be noted that the GPS collars were much more effective at showing the movement patterns than the VHF collars, due to the significantly increased sampling rate of the GPS collars. Based on the telemetry data, it was known that three of the goats had moved from their initial collaring locations, but the extent and timing of the movements was not detected. It should also be noted that the GPS collars were relatively reliable for the collection of data in steep and forested habitat conditions such as Foxy Creek and China Nose. Problems and increased costs due to collar release failures were significant in this study, however, and further investigation of alternative release mechanisms is required.

The analysis of DNA from tissue and hair samples was very encouraging from the stand-point of using non-invasive hair sampling techniques as a method for population and individual sampling. Based on the results of the genetic analysis, it appears that the individuals in this study area can be reliably distinguished using hair samples. This opens up the potential for using hair sampling for monitoring movement and meta-population parameters, provided an effective monitoring and sampling strategy can be developed. Further work is required to develop an effective sampling method as well as further work on development of genetic markers, and investigation of the genetic variability of populations across the range of mountain goats.

The detection of four mortalities in a collared population of only 26 animals, suggests a possible mortality rate of 15%, which is larger than the mortality rate used by resource managers for their population carrying capacity estimates (R. Marshall, pers. comm.). Three animals were known to have died in late August to late September, with one animal showing no apparent signs of trauma or disease when investigated. Two of the three animals showed evidence of feeding by predators, and although it was not possible to determine if they were the cause of death, it was considered likely. The two mortalities that showed evidence of predator feeding were also found in areas that did not have immediately available escape terrain. It is likely that the use of these forested habitats for movement between escape terrain carries an increased predation risk.

When this project was initiated in late 2002, the 2003-2004 project year was to be the mid-point of a three year study to look at the habitat use and movement patterns of mountain goats in forested habitats where forest harvesting operations were occurring. Cuts in funding from the initial funding agency required that the project objectives and tasks be changed and new funding sources found. Houston Forest Products Co., using Forest Investment Account funding provided financial assistance for this field season, allowing the continuation of telemetry flights, genetic analysis of tissue and hair samples, and recovery of GPS collars. Unfortunately there was insufficient funding for a complete analysis of the GPS and telemetry data, especially to be completed an in-depth habitat or movement analysis. The results presented are a cursory look at the data to provide some information to project researchers and managers, but is not intended to be a comprehensive review of the data available from this project. Further funding is required to continue the monitoring of the remaining 16 VHF and two GPS collars, and to complete more habitat use field-work and analyses.

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