April 2004
Summary No.37

Morice & Lakes Innovative Forest Practices Agreement

Project Summary

Ecosystem Management

Forest Productivity

Public Involvement

Adaptive Management

The ecosystem management component of the Morice & Lakes IFPA has embarked on several projects that assess biodiversity, ecological attibutes, and fish and wildlife habitat. These projects will provide important ecological data that will be used in learning scenario development for the IFPA's Sustainable Forest Management Plan.

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

Summary of 2003/2004 Activities

Introduction

Approximately 30,000 ha of potential mountain goat habitat is found in the Nadina Forest District 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, or only used on a periodic basis (Turney *et al.* 2000, Mahon *et al.* 2002). The reasons for this use pattern are unclear and there are concerns from resource managers that the loss of mountain goats from these features may be permanent, and may affect overall mountain goat population dynamics.

In order to increase the level of knowledge of mountain goat forested habitat use upon which informed management decisions can be made, a multi-year study was initiated in the of fall 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:

- 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.
- Monitor the differences in habitat use and movement patterns of mountain goats in areas with and without proposed forest harvesting activities.
- Determine a sightability factor for mountain goats in forested habitats during winter and summer.
- 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.
- Provide management recommendations to forest and wildlife managers to minimize impacts from forest harvesting activities on mountain goat habitats and populations.

Fraser Lake Sawmills

Summary of Past Activities

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.

Study Area

The study area consists of non-alpine cliff and canyon features located in north western 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, 2001 and 2002).

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).

The photos in figure 2 show the general areas used by the mountain goats in this study. Morice Mountain (Figure 1, Photo1) is a large, complex mountain feature located approximately 20 km southwest of Houston, BC on the east side of the Morice River. The Bob Creek Bluffs (Figure 1, Photo 2) are found approximately 10 km south of Houston, BC, and is a tributary to Buck Creek that contains several south and west aspect cliffs that provide good escape terrain. The Dungate

Creek Bluffs (Figure 1, Photo 3) are found approximately 10 km southeast of Houston, BC and this feature consists of a complex of middle elevation north, south and east facing cliffs clustered over a stream valley. China Nose (Figure 1, 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. Foxy Creek Canyon (Figure 1, Photo 5) is located between Maxan Lake and the Equity Mine site, about 35 km southeast of Houston, BC. This feature is a continuous canyon approximately 13 km long, containing numerous cliff and cave features. Klo Creek Bluffs (Figure 1, Photo 6) are located approximately eight 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.

Methods

Aerial Telemetry

Mountain goats were relocated approximately once every four to six weeks, with both VHF and GPS collared animals relocated 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), using a Cessna 206, equipped with two H-antenna and a Telonics VHF receiver. Mountain goat locations and habitat data (major habitat attributes, aspect, slope position, canopy closure, structural stage, biogeoclimatic zone and broad ecosystem unit) was collected. 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. Animal locations were recorded in a Geographic Information System (GIS) for future analysis.

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 1. Photographs of mountain goat use areas within the study area.

Mortality Investigations

During the summer and fall of 2003, four mountain goat collars entered into mortality mode and investigations were undertaken to try to determine the cause of death. Mortality investigations were undertaken using aerial and ground telemetry methods. 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 and notes taken.

DNA Analysis

DNA analysis was conducted by Wildlife Genetics International in Nelson, BC following standardized methods. All samples were extracted using QIAGEN's DNeasy Tissue kits, 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 collected.

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. To reduce costs, the selection of markers was restricted to those where 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 a radio-controlled remote release mechanism (Lotek Wireless Inc. 2001b). To release the collar, a helicopter was used to locate the collared animal using standard aerial relocation techniques. Once a collared animal was located, it was approached by helicopter and a radio transmitter 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 back-up timed-release mechanism was used for all but three collars, and the collars located 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. The capture crew consisted of the helicopter pilot and a net-gunner/animal handler, both experienced in capturing and collaring mountain goats. All efforts were made by the capture crew to minimize capture related stress and trauma to the subject animals. Once captured and restrained, the old GPS collar was removed from the animals and in two instances, a replacement GPS collar was deployed.

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 $P < 0.05$.

Seasonal home range estimates for the individual animals were calculated using the kernel method (Worton 1989). 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 and Discussion

VHF Telemetry Relocations

From January 27th 2003 to January 17th 2004, the 19 VHF and eight GPS collars were relocated during 16 telemetry sessions. A total of 381 telemetry points were mapped from the telemetry 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.

DNA Analysis

DNA analysis using 10 markers obtained heterozygosity values ranging from 0.36 to 0.86 (mean = 0.60) and the number of alleles amplifying ranged from 2 to 8 (mean = 4.2). An analysis of level of power (using the number and variability of the markers) indicated that the two most similar pairs of genotypes matched at only four of six markers chosen, 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 2), 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.

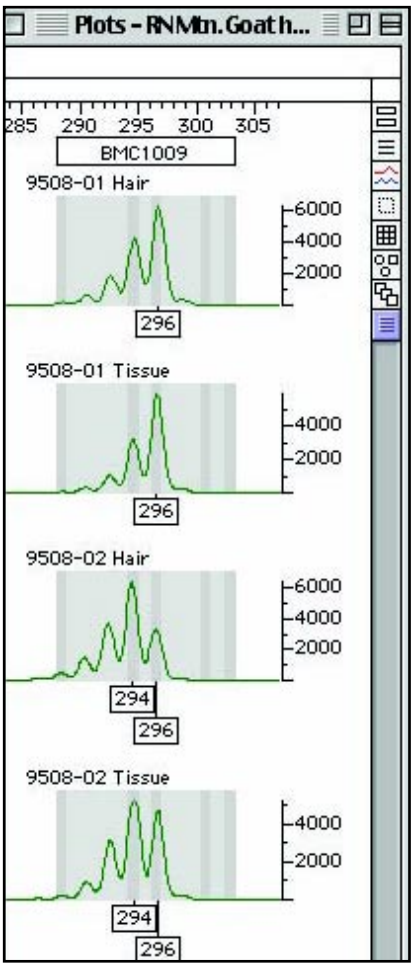

Figure 2. Comparison of hair and tissue samples for marker BMC1009.

Mortality Investigations

Four mountain goat mortalities were discovered in the summer and fall of 2003 and due to the length of time from when the animals were captured it was assumed that none were capture related. Three of the goats were female, and one was a male, and their ages ranged from three to eight years old. For two of the animals, there was evidence of predators (wolves and black bear) feeding or scavenging the bodies. One animal's remains were never found and one animal had died recently, but a necropsy revealed no obvious cause.

GPS Collar Fix Acquisition

A total of 11761 fixes and fix attempts were obtained by seven GPS collars. One collar (freq. = 148.610) only obtained 20 fixes that were useable due to a failure of the GPS system, while another collar appeared to collect approximately 1500 fixes, but the data was unable to be recovered. Between 769 and 1837 useable fixes were obtained by the working collars, with 45.6% of the total attempted fixes being 2D and 21.1% being 3D fixes.

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 3).

Home Range Analysis

The sizes of the 50% and 95% kernel seasonal home ranges varied by animal and their collared location. 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). Comparisons of the 95% seasonal home ranges showed significant differences between the mean home range sizes 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 1).

Table 1. 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.			

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 2). Comparisons of the daily movement distances showed significant differences between individuals, but not between males and females or between adults and juveniles. 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. 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. One of the more interesting movements was by an adult female (freq. = 148.139, age = 3 at capture), which travelled the longest distances of any of the collared animals from July to September. Her movements are outlined in Figure 4, and show that she travelled from Dungate to Foxy Creek, to China Nose to Equity.

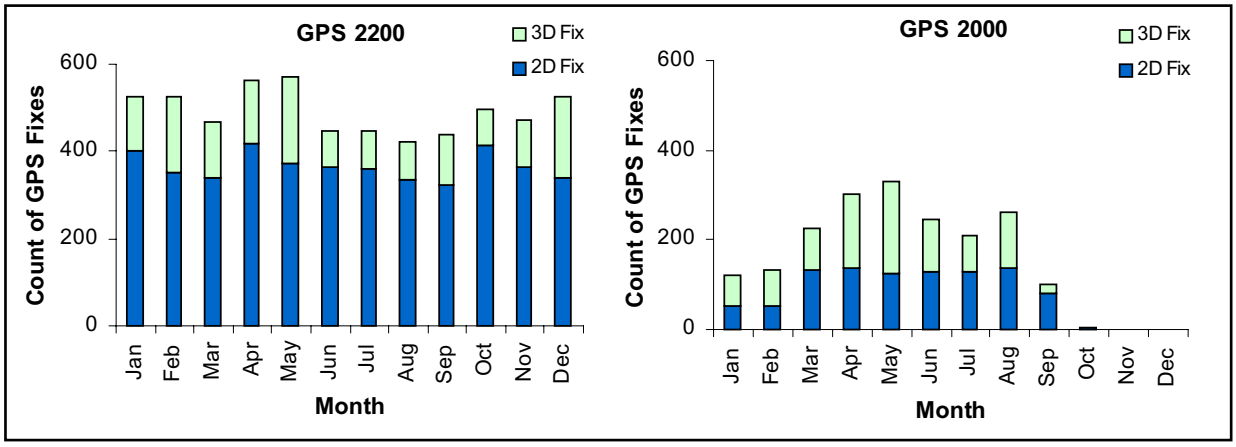

Figure 3. Number of 2D and 3D locations acquired for GPS 2200 and GPS 2000 collars for each month.

Table 2. 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.

Future Work

When this project was initiated, 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. 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.

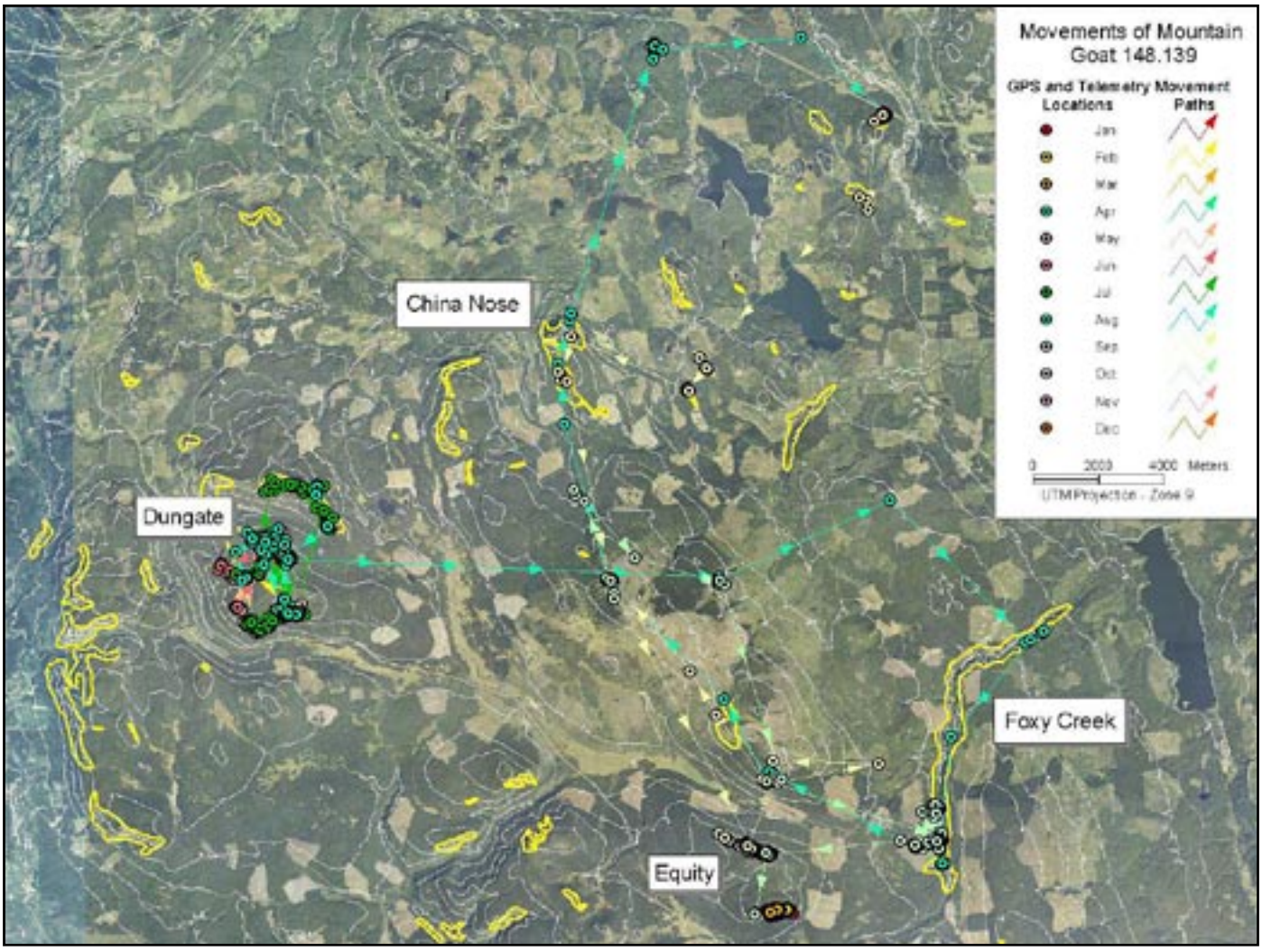

Figure 4. Movements of adult female mountain goat (freq. 148.139) within the study area.

Literature Cited

Banner, A., W. MacKenzie, S. Haeussler, S. Thomson, J. Pojar and R. Trowbridge. 1993. A field guide to site identification and interpretation for the Prince Rupert Forest Region. Min. of For. Victoria, BC. Land Management Handbook No. 26.

Chadwick, D.H. 1973. Mountain goat ecology-logging relationships in the Bunker Creek drainage of western Montana. Unpublished report for the State of Montana. 240pp.

Hooge P.N. and B. Eichenlaub. 1997. Animal movement extension to arcview. ver. 1.1. Alaska Biological Science Center, U.S. Geological Survey, Anchorage, AK, USA.

Mahon, T., M. Nelligan, L. Turney and R. Blume. 2003. Inventory of mountain goats in non-alpine habitats in the Morice and Lakes Forest Districts - 2002 interim report and digital map coverages. Unpublished report prepared for Morice and Lakes Innovative Forest Practices Agreement. WildFor Consultants Ltd. and Ardea Biological Consulting, Smithers, BC. 12pp + append.

Resources Inventory Committee. 1998b. Wildlife radio-telemetry: standards for components of British Columbia's biodiversity No. 5. Ministry of Environment, Lands, and Parks, Resources Inventory Committee. Victoria, B.C. 112pp + append.

Stevens, V. 1983. Dynamics of dispersal in an introduced mountain goat population. Unpublished report submitted as a doctors thesis to the University of Washington. Seattle, Washington. 189pp + append.

Turney, L., R. Blume and T. Mahon. 1999. Habitat use by mountain goats near Nadina Mountain - final report. Unpublished report prepared for Min. of Env. Lands and Parks and Houston Forest Products Ltd. Ardea Biological Consulting, Smithers, BC. 32pp + append.

Turney, L., R. Blume and T. Mahon. 2000. Mountain goat populations and movement patterns near Nadina Mountain – 1999 summary report. Unpublished report prepared for Min. of Env. Lands and Parks, Houston Forest Products Ltd. and CanFor Ltd. Ardea Biological Consulting, Smithers, BC. 24pp + append.

Turney, L., R. Blume, A.M. Roberts and J. Murray. 2003. Non-alpine habitat use and movements by mountain goats in north-central British Columbia: Annual operational report 2002-2003. Unpub. rep. prep. for Forest Research Program, Forest Innovation Investment. Smithers, BC. 24pp + append.

Turney, L., T. Mahon, R. Blume and J. Farkvam. 2001. Mountain goat populations, movement patterns and habitat use in forested habitats near Nadina Mountain and Foxy Creek British Columbia – 2000 summary report. Unpublished report prepared for Min. of Env. Lands and Parks, CanFor Ltd. and Houston Forest Products Ltd. Ardea Biological Consulting, Smithers, BC. 33pp + append.

Turney, L., R. Blume, J. Farkvam and T. Mahon. 2002. Mountain goat movement patterns and forested habitat use near Nadina Mountain, British Columbia – 2001 summary report. Unpublished report prepared for Min. of Water, Land and Air Prot., Min. of Sust. Res. Man., CanFor Ltd. and Houston Forest Products Ltd. Ardea Biological Consulting and WildFor Consultants Ltd., Smithers, BC. 19 pp. +append.

Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164-168.

Contact

Laurence Turney, Owner
Senior Wildlife Biologist,
Ardea Biological Consulting,
2175 Millar Rd. Smithers, BC
V0J 2N6.
Ph. (250) 877-6705.
e-mail: laurence@ardea.ca

Acknowledgements

This project was funded by Houston Forest Products Co. using Forest Investment Account funds on behalf of the Morice and Lakes Innovative Forest Practices Agreement (IFPA). The IFPA is a partnership of Houston Forest Products Co., Canadian Forest Products Ltd., Babine Forest Products Ltd., Fraser Lakes Sawmills Ltd., L & M Lumber Ltd. and Decker Lake Forest Products Ltd. This project was supported by the Ministries of Sustainable Resource Management and Water, Land and Air Protection (WLAP). The authors would like to thank G. Schultze and M. Todd for their technical support and review of the study. The capture and collaring of mountain goats was conducted with the assistance of Bighorn Helicopters Ltd, C. Wilson and T. Vandenbrink. Fixed-wing support for animal relocations was provided by M. Blossom, L. Scott, V. Millar, and L. Frey of Northern Thunderbird Air, Smithers. Helicopter support was provided by R. Buchanan and P. Rooney (Highland Helicopters - Houston), who were always available and made accessing the study sites possible. We would also like to thank T. Mahon (WildFor Consultants Ltd.) and L. Vanderstar (WLAP) for helping with collar recovery, R. Marshall (WLAP) for help in mortality investigations and L. Rach (Ardea) for GIS and mapping assistance. Administrative support from the funding agencies was provided by J. van der Giessen of Houston Forest Products Ltd.

This activity summary was prepared by Laurence Turney.

For More Information...

Morice & Lakes IFPA

For more information on the Morice & Lakes IFPA, please contact:

Jim Burbee, RPF, IFPA Manager
c/o Tweedsmuir Forest Ltd.
3003 Riverview Road
Prince George, B.C. V2K 4Y5
Tel: 250-564-1518
e-mail: venturefc@telus.net

www.moricelakes-ifpa.com