



# 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 attributes, 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.

## Habitat Use by Mountain Goats Near Nadina Mountain

### Site Investigations of GPS Collar Locations



Fraser Lake Sawmills



## Introduction

Various resource agencies and forest companies in the Morice and Lakes Forest Districts have expressed concern over the potential effects of timber harvest activities on mountain goat (*Oreamnos americanus*) populations and habitats in the area. With support from the Ministry of Environment, Lands and Parks (now the Ministry of Water, Land and Air Protection) mountain goat use of isolated but relatively widespread non-alpine rocky bluff habitats has been studied by the authors of this project since 1996. Studies since 1997 have concentrated on a population of animals located at Nadina Mountain, approximately 40 km south of Houston, British Columbia. This work has expanded over the last three years to include non-alpine mountain goat habitats throughout the Morice and Lakes Forest Districts. Completed work has included the following (see Turney *et al.* 1999, 2000, 2001 and 2002):

- observations of habitat use by mountain goats at Nadina Mountain and related satellite sites under various seasonal and weather conditions (in 1997 and 1998);
- study of mountain goat movements along a trail from Nadina Mountain to a mineral lick, using infrared activated data loggers with remote cameras (in 1999, 2000 and 2001);
- permanent mountain goat sign removal transects on 16 sites in the Morice Forest District, to quantify and compare habitat use between sites (in 1999 and 2000);
- population inventories of Nadina Mountain and Morice Mountain (in 1999 and 2000);
- inventories of non-alpine mountain goat habitats throughout the entire Morice Forest District (in 2000) and Lakes Forest District (in 2001);
- inventory of alpine mountain goat habitats throughout the entire Morice Forest District (in 2002); and,
- GPS collaring of three mountain goats on Poplar Mountain, to study movement patterns and forested habitat use (in 2001).

This summarizes the work conducted in 2002, and provides an evaluation of the progress of the project and recommendations for future studies (Blume *et al.* 2003). During 2002, work included recovery of the GPS collars deployed in 2001, completion of site investigations at a sample of the GPS locations obtained from the collars, analysis of the GPS locations for habitat attributes and home range analysis. The study of movement patterns on the mineral lick trail was not continued in 2002, as three years of pre-harvest movement data have been gathered and proposed harvest in the area was postponed.

Another mountain goat project funded by the IFPA was a ground assessment and an analysis of mountain goat use of forested bluffs (Project #431.05b, see Mahon *et al.* 2003). As well, Forestry Innovation Investment research project was initiated south of Houston, to place GPS and VHF radio collars on up to 30 mountain goats and study their habitat use and movement patterns over the next three years (see Turney *et al.* 2003).

## Project Objectives

Within the framework of the goals established for the Morice and Lakes IFPA, this project supports the initiatives of developing socially acceptable sustainable forest management practices, conservation of environmental values and improvement in the knowledge base to achieve specific forest management objectives.

The particular objectives of this study are to:

- evaluate the effectiveness of using GPS collars as a method of studying mountain goat habitat use in this study area;
- identify any potential movement corridors between Nadina Mountain and the satellite sites;
- add to the current knowledge of mountain goat habitat use and more specifically, forested habitat use; and,
- provide recommendations to guide management of forest harvest activities so that conservation of mountain goat habitat and populations is considered.

## Study Area

The Nadina Mountain study area is located approximately 40 km south of Houston, BC in the northwestern portion of the province. Administratively, the study area is in the Morice Forest District of the Ministry of Forests' Prince Rupert Forest Region and in the Skeena Region of the Ministry of Water, Land and Air Protection. The study area is within the Bulkley Basin Ecoregion of the Fraser Plateau Ecoregion within the Central Interior Ecoprovince (Demarchi, 1995).

The biogeoclimatic ecosystem classification system classifies elevations in the study area above 1,700 m as the treeless Alpine Tundra zone (AT), and elevations from 1,100 m to 1,400 m are within the forested 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 1,400 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. Below 1100 m in elevation is the Sub-Boreal Spruce dry cool subzone (SBSdk), which differs from the SBSmc2 by being somewhat drier and warmer with a longer growing season and shorter duration of snowpack (Banner *et al.* 1993)

During the 2002 study year, work was concentrated at Poplar Mountain on exposed rock habitats and forest areas generally within the ESSFmc subzone. Poplar Mountain, located approximately 6 km southwest of Nadina Mountain, is a large rolling bluff feature with numerous areas of cliff and rock outcrop. The upper portion of Poplar Mountain is classified as alpine tundra and is dominated by sparsely vegetated rock outcrops and subalpine fir in krummholtz form. No significant cliff or steep rock bluffs are found in this zone on the mountain. Middle slopes are forested, with a mix of subalpine fir, hybrid white spruce and limited amounts of

lodgepole pine. Several large expanses of northeast and north-west-facing cliff are found in these middle slope areas. The base of Poplar Mountain is made up of mature forests and talus slope, with areas of previous forest harvesting ranging from 12 to 15 years old

## Methods

### Mountain Goat Capture, Collaring and Collar Recovery

Three mountain goats were captured in 2001 using baited Clover traps. Each animal was fitted with a GPS collar (Lotek GPS collars fitted with remote release mechanisms), marked with ear tags and had a hair and tissue sample taken. Details of the methods used for capture and collaring can be found in Turney *et al.* (2002). Recovery of the GPS collars was accomplished by locating the collared animal using a radio telemetry receiver and antenna mounted on a helicopter, then sending a radio signal to the collar to cause it to release. The released collar was recovered and the data retrieved using a computer.

### Habitat Use Assessment

GPS collar location data was downloaded to computer and data points were plotted over digital mapping and air-photos of the study area using ArcView® geographic information system (GIS) software. To select areas for habitat assessment, 30 collar location points were randomly selected from each month of data (total = 360 points, approximately 5% of the total location points) and placed within a 50m x 50m grid of sampling cells superimposed over the study area. A total of 140 cells containing the collar location points were selected for sampling, with many cells containing more than one collar location point.

Habitat plots consisting of a 400 m<sup>2</sup> area were completed at each sample cell, preferably where mountain goat sign was observed. In sample cells where no mountain goat sign was found, habitat plots were completed in an ecosystem representative of the sample cell. In sample cells where more than one distinct ecosystem occurred, habitat plots were completed in each ecosystem type. Ground assessments included vegetation estimates using the methods outlined in the *Field Manual for Describing Terrestrial Ecosystems* (BC Ministry of Forests 1998), and recording evidence of mountain goat use.

### Habitat Use Data Analysis

Habitat plot data was entered into the Ministry of Forests GRAVITI database and summarized into an MS® Excel output. Plot habitat information that was used for summary analysis included BEC zone, site series, structural stage, elevation, slope, leading tree species and crown closure. A comparison of the predicted digital habitat map attributes of mountain goat locations to the actual habitat plot attributes was also completed, using ArcView® GIS and MS® Excel.

The mountain goat GPS locations were plotted in ArcView® GIS over a habitat map developed from predictive ecosystem mapping (PEM), slope, aspect and forest cover data. The habitat information

at these plotted points were analysed to provide a description of habitat use. Habitat attributes analysed included biogeoclimatic (BEC) zone, site series, slope class, leading tree species, projected age class, projected height class (projected classes to 2001) and crown closure class. Summary analysis was performed on these attributes using MS® Excel.

A 95% Kernel home range of the each of the two mountain goats with year-round data was calculated for early winter, late winter, spring, summer, and fall seasons. The adaptive kernel home range estimate was produced using the animal movement extension for ArcView® GIS (ver. 2.04) (Hooge and Eichenlaub 1997). A Chi-square analysis for habitat selection was completed using the points within the seasonal home ranges.

## Results and Discussion

### GPS Collar Performance

The three collared mountain goats provided a total of 3,857 locations over a period of 671 collar deployment days. The collars of goats G1 and G2 functioned properly, while the collar of goat G3 failed after only nine days in the field. The GPS collars had a fix acquisition rate of approximately 72%, which was on par with that of other studies, but only 16-22% were of 3D fix status. For the two animals that were collared throughout the study period, fix acquisition was somewhat higher in spring and early summer than in fall and winter.

### Habitat Mapping Assessment of GPS Locations

Initial assessments of the GPS locations were conducted using non-statistical methods to identify trends and help describe habitat use patterns. These assessments showed that more than 84% of the GPS locations for each animal were in the ESSFmc zone, with the remaining locations being in the SBSmc2 zone. A higher proportion of the GPS locations were in mesic ESSFmc/01 sites (Bl-huckleberry-leafy liverwort) in winter and in drier, more open ESSFmc/04 sites (Bl-huckleberry-heron's bill) in spring/summer compared to other site types. GPS locations tended to be on steep slopes (41-60° slope) in early spring and summer, and on moderate slopes (21-40° slope) in winter. Forested GPS locations were dominated by subalpine fir/hybrid white spruce in early winter (November to February) and by lodgepole pine/subalpine fir during the late winter, spring and summer months. Winter GPS locations were most often found in mature forests (141-250 yrs) with tall trees (>28.5m) and high canopy closure (46-65%), while spring, summer and fall GPS locations tended to be in middle age class forests (81-140 yrs) with shorter trees (10.5-19.4 m) and moderate canopy closure (26-45%). Between 5 and 20% of GPS locations were also found in open canopied (0-25% canopy closure), young habitats (1-80 yrs) with short trees and shrubs (<10.4m) during the spring, summer and fall months.

Figure 1 displays the monthly distribution of all mountain goat GPS locations by a derived habitat cover value. Each location was given a low, moderate or high rating for their value as thermal cover and snow interception cover. The cover value of each location represents a combination of canopy closure, projected tree age and height (projected to 2001) and leading tree species composition. Higher crown closure, older age and taller height were considered to give better cover value. Stands dominated by spruce and sub-alpine fir were also considered to have higher cover value due to better shading and snow loading attributes of these species than lodgepole pine dominated stands or deciduous species. There was a distinct trend for GPS collar locations to be in high cover value habitats during the winter months.

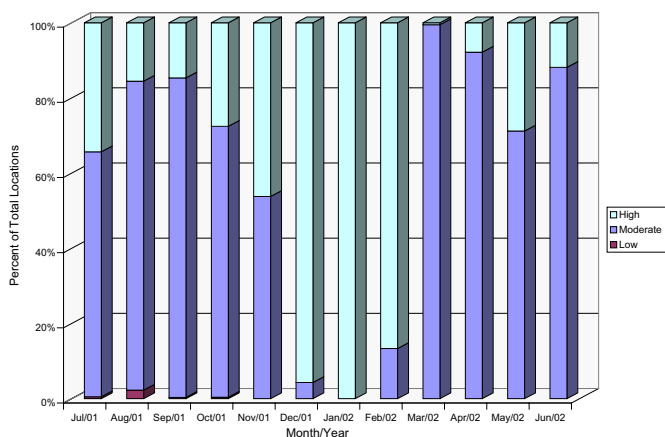


Figure 1. Summary of the monthly distribution of all mountain goat GPS locations by cover attributes<sup>1</sup>.

<sup>1</sup>High cover: >40% crown closure; trees >140 years old; trees taller than 15 m; stands of Sxw and Bl  
 Moderate cover: 21-40% crown closure; 101-139 years old; trees 6-15 m tall; stands dominated by Sxw or Bl but with significant Pl  
 Low cover: <20% crown closure; trees <100 years old; trees < 5m tall; stands dominated by Pl and may contain deciduous

### Habitat Plots

Habitat plots were completed at 138 randomly selected GPS locations from two of the collared animals. Mountain goat sign was found in 98 of these plots, and the most common sign type observed were trails, followed by pellet groups and feeding sign. Other sign found included beds, tracks and hair clumps. Although plots were found in a wide variety of locations and habitat types, most plots were typified by mid to upper meso-slope position, moderate slopes (21-40°), cool aspects (285-135°) and mature forests. Plots were in a variety of BEC site types with the most common being ESSFmc mesic to subxeric sites (02, 03 and 04 sites making up 64.5% of all plots).

### Comparison of Habitat Mapping and Habitat Plots

Although habitat plot surveys were conducted to provide a description of the habitat types found at mountain goat locations and not for the intention of validating digital habitat mapping, a brief comparison of habitat plot data against PEM data, forest cover attributes and DEM derived attributes (slope and aspect) was completed.

The BEC classification of habitat plots in the field agreed with habitat mapping for 96.4% of all plots. When comparing the site series designation of plots in the field and that predicted by PEM, only 31.2% of the site series agreed exactly, although in most cases the difference in classification was within one moisture or nutrient regime (e.g. the PEM predicted an ESSFmc 03, while the habitat plot was an ESSFmc 04).

The leading tree species observed in the plots generally agreed with that predicted by habitat mapping, but the percent cover of each leading species did not agree between the habitat plots and habitat mapping. In many of the plots, disagreement occurred in percent species composition when the plot contained rock outcrop or talus. The canopy closure habitat plot field estimates generally did not agree with the canopy closure predicted by habitat mapping (only 27.8% agreement in all plots). Of the plots where field classification and habitat mapping did not agree in canopy closure class of plots, 90.7% were within one class difference (i.e. a plot given crown closure class of 2 in the field was classed by habitat mapping as a 3).

The slope reported by the digital habitat map tended to be less than that measured at the actual plot location, with 60.1% of habitat map slopes being shallower than measured slope. However, 48.2% of plots with underestimated slope and 60.9% of plots with overestimated slope by habitat mapping were within 5° of actual measured slope. The measured aspect agreed with the aspect reported by habitat mapping for 55.8% of all plots. Of the plots where measured aspect and habitat mapping aspect did not agree, 18% were within 5° aspect and 73.8% were within 25° aspect. When a comparison of measured aspect and habitat mapping aspect was completed using broader aspect classes (neutral, warm or cool) rather than aspect in degrees, there was a 91.3% agreement for all plots.

## Home Range Analysis

Five seasons were determined for the mountain goats for seasonal home range analysis: early winter, late winter, spring, summer and fall. The home range size (Table 1) for both mountain goats G1 and G2 were smallest in the winter and largest during the summer, which is a trend similar to that observed by previous studies (e.g. 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). The growing season ranges (spring, summer and fall) of the male goat G1 are smaller than that of the female G2, which appears to contradict the results of other studies (e.g. Chadwick 1973, Schoen and Kirchoff 1982, Smith and Raedeke 1982). During both the summer and the fall, the female (G2) had home ranges that were 4 to 12 times greater than the male's (G1) home range, although the reasons for the increased size is unclear.

Analysis of habitat selection within seasonal home ranges by the collared goats displayed similar trends in habitat use by both animals. In all seasons the collared goats selected habitats with moderate (21-40°) to steep (41-60°) slopes in pine or subalpine fir dominated stands of age class 7 (121-140 years old). These habitats were located in generally submesic to subhygric sites of the ESSFmc subzone. Non-forested or young age class forested habitats with gentle (0-20°) slope were avoided.

Table 1. Seasonal home ranges of GPS collared mountain goats.

Season	Home Range Size (ha)	
	Mountain Goat G1	Mountain Goat G2
Early Winter 11 November to 23 February	0.9	0.5
Late Winter 24 February to 30 April	1.1	0.6
Spring 1 May to 30 June	35.8	53.2
Summer 1 July to 15 September	102.6	416.0
Fall 16 September to 10 November	55.3	670.7

## Conclusions

Several relationships between habitat parameters and the monthly distribution of GPS fix proportions were observed. These relationships may be the result of both fix acquisition potential as influenced by habitat factors and actual mountain goat habitat use and movement. GPS fix acquisition is affected to varying degrees by a variety of environmental factors (i.e. factors other than animal behaviour or habitat use) including vegetation, aspect, weather conditions and topographical relief. However, there were some distinct and contrasting habitat use related trends in monthly and seasonal rates of GPS fixes that are not likely due to successful fix acquisition rates alone. This project did not test GPS performance using fixed receivers under different habitat conditions, and so a comparison of the effects of different habitat types on successful fix acquisition cannot be made. Also, a comparison between mountain goat habitat use and habitat availability was not completed. Nevertheless, a full range of habitat types were available to the study animals, all in significant proportions, and included open alpine meadows and krummholtz, relatively open canopy subalpine forested habitats, bare rock and talus security habitats and more densely forested mid and lower elevation forested habitats. Therefore, some descriptive (i.e. not statistically derived) inferences on habitat use by specific mountain goats are considered justified, and are summarized below.

The results of the habitat analysis of GPS locations of goats G1 and G2 were strikingly similar when plotted on a monthly basis against various habitat descriptors, such as BEC zone, site series, canopy closure, structural stage, etc. This habitat use included a high proportion of locations in ESSFmc/01 sites in the winter months of December to February, a high proportion of locations in ESSFmc/04 sites during the period of March to September and low proportion of locations in the SBSmc2 zone during winter. Of significance was a marked trend in the use of habitats in winter with characteristics that promote qualities of thermal cover and snow interception. Use of habitats dominated by subalpine fir and spruce was higher in winter, and these tree species generally provide better thermal cover and have better snow loading capability than lodgepole pine or deciduous tree species. Use of mature forest and stands with higher tree height also appeared to be greater during winter. Forest with these attributes tend to provide better thermal cover habitat and lower snow levels than younger forest with shorter trees. The most powerful indication of seasonal habitat selection was the tendency of these animals to use forest with higher canopy closure in winter. In fact, use of open habitats occurred only during the summer and fall months. Degree of canopy closure is a direct indicator of thermal cover value and snow interception.

## Recommendations

The movement and habitat use data collected on three mountain goats is not considered sufficient to make any substantial recommendations regarding forest management within the study area. It is apparent that some mountain goats in the study area use forested habitats to a greater extent than previously known, especially during the winter months. It is considered a strong possibility that harvest operations conducted within the study area will have impacts on the mountain goat populations using Poplar Mountain. The main source of these negative effects will likely be the presence of access roads. Significant portions of Poplar Mountain and forested areas in close vicinity to other mountain goat habitat in the greater Nadina Mountain area contain merchantable timber. These forested areas are also used by mountain goats so timber harvesting in these locations may also impact mountain goat habitat. In order to provide a larger sample size upon which to base comprehensive forest management recommendations, further attempts should be made to fit more mountain goats in the study area with GPS and VHF collars in order to determine detailed habitat use patterns and population movements at the broader landscape scale.

Significant portions of Poplar Mountain and forested areas in close vicinity to other mountain goat habitat in the greater Nadina Mountain area contain merchantable timber.

Harvesting of the proposed block at West Nadina Bluff was initially scheduled for the winter of 2001/2002, but this was postponed and has not been completed. Three years of mountain goat trail monitoring have been completed, which has resulted in the collection of a significant amount of baseline data on seasonal and daily pre-harvest trail use patterns. The delay in harvesting, however, has not allowed the study of trail use under post-harvest conditions to proceed. Once harvest has occurred, trail use should be monitored for at least one year from mid to late May until late October. It will then be possible to compare pre-harvest and post-harvest trail use data and establish detailed management recommendations for the Nadina Mountain study area.

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