Mountain Goat Winter Range Mapping for the North Coast Forest District

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EXECUTIVE SUMMARY

In December 2000, Acer Resource Consulting Ltd. was contracted to map mountain goat winter range within the Land and Resource Management Planning area of the North Coast Forest District. Mountain goat winter range was to be identified using a two tiered approach considering known and suspected patterns in sub-regional and stand level winter habitat selection. South facing, steep slopes with elevational connectivity to summer ranges were identified at the sub-regional scale on 1:50,000 mapping. Areas with a high probability of containing winter range were then examined in detail using aerial photographs and 1:20,000 TRIM maps to identify escape terrain. Historical, anecdotal, and concurrent aerial survey information was used to identify areas with known winter mountain goat use. Completed maps were provided to for digitization.

In total, 288 winter range units were identified on 122 1:20:000 TRIM maps. Winter range is not distributed evenly through the planning area. The Hecate Lowlands ecosection shows few areas with appropriate winter habitats and evidence suggests low goat densities in practically all locations where information exists. Difficult immigration conditions and poor growing season habitats appear to be the limiting factors. Habitat quality and goat densities in the southwestern Southern Boundary Range ecosection appear to be similar to most of the Hecate Lowlands with no growing season habitat and low topographic relief. In the northern portion of this ecosection however, large areas occur with good winter range and goat presence has been confirmed. The Mezeadin Mountains ecosection also contains good quality winter range. The only possible limiting factor for populations in this area is the high snow loading and the influence of the Cambria Icefield. The Kitimat Range ecosection contains the best quality winter range habitat in the planning area. Population centres appear to be associated with extensive alpine and subalpine complexes. Recommendations made provide priorities for future surveys to fill data gaps and confirm mountain goat winter occurrence.

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INTRODUCTION

A Land and Resource Management Plan (LRMP) is under development for the North Coast Forest District (NCFD). During table discussions, different land management scenarios will be assessed based on their impacts on biodiversity, economic stability, and sustainability. As with any planning process, the collection of relevant inventory information is the first step in developing a defensible plan. Confident strategy development for ungulate winter range is currently limited by inadequate inventory data. Incidental information is available but there is no coherent summary of existing knowledge.

Initiated in November 2000, the objective of this project was to document historic information and identify and map mountain goat winter range areas within the NCFD. The mountain goat winter range maps were required as a stand-alone product for table interpretation; however, the reliability of the information and the repeatability of the process require a thorough documentation to identify the assumptions, methodology and the results. Sufficient detail is provided on mountain goat life history to assist with interpretations of management options. Recommendations are also provided to focus future inventories where more information is required.

Interpretation of impacts and recommendations for appropriate management of mountain goat winter range were beyond the scope of this project. While this project was completed in combination with moose winter range mapping, this report addresses only the mountain goat winter range mapping. This project was managed through the Ministry of Water Land and Air Protection (WLAP) office in Smithers, BC.

STUDY AREA

The NCLRMP area includes most of the NCFD with the exception of Princess Royal Island, the Nisga'a Core Lands, and the Municipalities of Prince Rupert and Stewart. The NCFD is located in northwestern British Columbia and forms the western most District in the Prince Rupert Forest Region. It stretches along the western edge of the Coast Mountain Ecoprovince and is bounded to the east by the Coast Range and to the west by the Pacific Ocean. Its northernmost boundary lies at 55^0 25' north latitude and the southern boundary is at $52^0$26' north latitude. The study area includes WLAP's Management Units 6-3, 6-10, 6-11, and 6-14.

The NCFD is in the Coastal Gap Ecoregion which includes by the Kitimat Range, Southern Boundary Range, Mezeadin Mountain, and the Hecate Lowland ecosections. The biogeoclimatic zones in the study area include Coastal Western Hemlock (CWH), Mountain Hemlock (MH), and Alpine Tundra (AT). Steep mountains rising from floodplains or fiords characterize the mainland, while offshore islands have varying topographical features with limited alpine elements. Sheltered inlets and exposed coastline are also characteristic of the area. The Broad Ecosystems Units identified in the study area include: Cedar-Shore Pine Bog, Coastal Hemlock-Western Red Cedar, Amabilis Fir-Western Hemlock, Mountain Hemlock-Amabilis Fir, Sitka Spruce-Cottonwood and Wetlands. A location map of the study area is provided as Figure 1.

Figure 1: Location map of the study area.

LIFE HISTORY

Mountain goats belong to a small group of antelopes whose closest relatives live in Europe and Asia. A diurnal species most commonly found on steep and rocky terrain, these animals can be found throughout mountainous environments in the province with the exception of Vancouver Island and the Queen Charlotte Islands. Mountain goats use a variety of habitats throughout the year depending on the environmental conditions. The following provides an overview of the available literature concerning mountain goat life history and habitat selection in areas similar to the study area.

Reproduction

The rut is initiated in late October and usually runs to early December (Geist 1964 and Macgregor 1977). There is no specific rutting areas and it can occur anywhere mountain goat fall or early winter range (Foster 1982). In more restricted ranges, such as canyons of the Stikine River, it may be more localized (Foster and Rahs 1985). At birthing, the female will search for the most forbidding, isolated terrain available within the landscape (McFetridge 1977 and Chadwick 1983). There are no specific "kidding areas", but birthing is contagiously distributed within the landscape (Foster 1982) and is associated with available security habitats. Locally, most kidding occurs between late April and mid June (pers. observ.).

Mother and kid will remain together for 10 days before joining the rest of the herd (Macgregor 1977 and Chadwick 1983). The juvenile will eat grasses and sedges within a week but require an additional five to seven weeks before being completely weaned (Banfield 1974 and Chadwick 1977). The kid will follow within 10-20 m of the mother for the next 11 months before being adopted into a nursery group with other juveniles (Geist 1964 and Chadwick 1977). Young will remain in these nurseries with one or two dominant females and other mixed age juveniles for 2.5 years (Nichols 1980). The size of these nurseries is highly dependent on season, population density, and range productivity, with winter usually the time of largest group size (Petocz 1973, Smith 1977, and Fox et al. 1989).

Young males increase their independence as they age, leaving the nursery group in the summer of their third year (Chadwick 1977). As adults, the males are generally solitary or move within small, well distributed bachelor groups of 2 or 3 animals (Chadwick 1977 and Nichols 1980). Males show less specific habitat selection than females and they are often relegated to substandard habitats at the edge of better range (Chadwick 1977).

Females reach reproductive age at 27 months on productive coastal ranges (Houston and Stevens 1988). Reproductive ability has been associated with a minimum weight of 70 kg although sexual success is largely dependent on social status and size (Geist 1964 and Houston and Stevens 1988). This female dominance also provides access to better winter habitat and provides a competitive advantage when food supplies are lowest (Petocz 1973 and Festa-Bianchet et al. 1994). Mountain goats have been known to live up to 16 years in the wild, but have an average age of 7 in British Columbia populations (Petticrew and Munro 1979).

Habitat Selection

Security

Mountain goats require escape terrain within their home range during all seasons to avoid and escape predators. It is considered the single most important habitat feature in range selection (Russell 1974, McFetridge 1977, Chadwick 1977, Foster 1982, Fox et al. 1982 and Gilbert and Raedeke 1992) and the primary determinant of winter range (Fox et al. 1989). Two studies in Alaska indicated that 90% of year-round habitat use occurred within 400 m of escape terrain (Schoen and Kirckhoff 1982 and Smith 1985). One single description for all escape terrain is not appropriate given the variability between parent materials, bedding angles, hillslope position, site gradient, weathering, and glacial history. In general, however, escape terrain can be described as steep, broken surfaced slopes with rock outcroppings (Gilbert and Raedeke 1992). Cliffs with rounded contours and few ledges, such as are found on some weathered coastal sites, are used less than cliffs with sharp contours, ledges, and overhangs (Russell 1974). Preferred escape terrain gradients vary by season but are generally within the 40^{o} to 65^{o} range (Smith 1977, Foster 1982, and Fox et al. 1989).

Summer Range

Mountain goats summer in upper elevation alpine and subalpine ecosystems. As the snow starts to retreat in the late spring and early summer, mountain goats move upslope following the emergence of fresh vegetation while limiting their distance from escape terrain (Fox et al. 1989, and Fox 1991). South facing aspects, especially those with alpine meadows, receive the highest use (Hebert and Turnbull 1977, and Foster 1982), although sub-alpine forests and shrubland habitats may also be used (Fox et al. 1989). Fidelity to southern exposures is reduced in the summer with all aspects utilized, but southern, southeast, and southwest aspects are preferred (McCrory and Blood 1977, Foster 1982, and Fox et al. 1989). This may be a reflection of varying growing conditions and subsequent variations in available forage (Hjeljord 1973) but could be associated with heat regulation. Mountain goats are known to use forest cover (Foster 1982 and Cichowski et al. 1994), shade from topographic structures (Fox 1977 and Nichols 1980), and dust baths (Foster 1982) to control heat prostration.

Foraging in summer range includes a variety of food items. In coast ecosystems summer diet includes 53% shrubs, 23% grasses and sedges, and 24% mixed forbs including mountain arnica (*Arnica latifolia)*, black twinberry (*Lonicera involucrata)*, and partridgefoot (*Leutkea pectinata*) (Hebert and Turnbull 1977). Food habits change throughout the summer as the goats move upslope following the receding snow line. *Epilobium spp*. and mountain sagewort *(Artemesia arctica*) are used in the early to mid summer at lower elevations (Singleton 1976 and Hjeljord 1977). As summer progresses, higher elevations are used to access stonecrop (*Sedum spp*.) and lupine (*Lupinus nootkatensis*). As winter approaches, sedges and grasses make up a larger part of the diet (Hjeljord 1977) until snow forces mountain goats downslope.

Winter Range

In the winter, coastal mountain goat populations have been identified using a wide range of habitats varying from alpine ridges to forested sites adjacent to tide water. This variety is necessary to fulfil their requirements for food accessibility and reduced mobility costs. In contrast to summer range selection where there are less specific associations, factors such as aspect, forest cover, adjacency to escape terrain, and elevational connectivity provide good indicators of winter range quality. Southern aspects are used almost exclusively (Hebert and Turnbull 1977, Smith 1977, Foster 1982, Fox et al. 1989, and Smith 1994) although, in context of the study area, Fox (1977) suggests that there is a reduced affinity in areas with consistently inclement weather.

Use of closed canopy forest cover in winter is well documented in coastal populations (Hjeljord 1973, Schoen et al. 1980, Foster 1982, Fox and Smith 1988, Fox et al. 1989, and Smith 1994). Coastal groups will move into these forested areas to avoid heavy wet snows (Hebert and Turnbull 1977, Foster and Rahs 1985, Fox and Smith 1988 and Smith 1994). Smith (1986) suggests that 50% of winter foraging occurs in commercial old growth forests in southeastern Alaska primarily because of their snow interception characteristics. However, these areas are only used if adjacent to escape terrain (Foster and Rahs 1985 and Fox et al. 1989). Russell (1974) indicates that in Knight Inlet winter thermal cover used by mountain goats requires a canopy closure of 60-80%, but does not specify an age class or structural stage. Crown closures exceeding 70% significantly limit browse production. Studies in the West Kootenays indicate that 35% of goat winter sign occurred within productive old growth stands and that 65% occurred in immature and mature stands (Poole and Mowat, 1997). Personal experience in climatic and vegetative conditions similar to the study area suggests that some stands as young as 60 years old can provide the necessary crown closure and browse production. Single open grown trees or small copses are often used by individual goats or small nursery groups (pers. observ.). These variations in spatial snow interception based on stand densities and ages, limits the applicability of forest cover mapping for identifying stands with good winter snow interception properties.

Mountain goats preferred winter escape terrain gradients vary but are generally steeper than in summer and range between 50^{o} and 65^{o} (Smith 1977, Foster 1982, and Fox et al. 1989). The increase in gradient is unlikely to be associated with increased predator protection and is more plausibly a reflection of the better snow shedding qualities of these steeper slopes (Smith 1977, Foster 1982, and Fox et al. 1989). Slopes less than 25^{o} are rarely used (Schoen and Kirchhoff 1982) and there is no use when slopes exceed 65^{o} (Foster 1982).

Dispersion from escape terrain is also reduced in winter with studies suggesting that 95% of winter goat use occurs within 250 m of escape terrain (McFetridge 1977, Fox 1983, cited in Fox et al. 1989). In coastal environments snow depths and quality can change dramatically in the course of a few hours. To best cope with these changing conditions, mountain goats must be able to change elevations quickly without risking increased predation. Consequently, linear escape terrain features that include large elevational changes tend to have higher concentrations of wintering mountain goats. While this has only been implied in several articles (Russell 1974 and Foster 1982), it is consistent with personal experience throughout the study area and on adjacent slopes in the Kalum Forest District.

Winter foods of coastal populations mirror available sources under different snow conditions. When snow first covers the ground in their summer alpine habitat, the goats move downslope into the MH parkland zone. Here they feed on *Vaccinium spp*., mountain heather (*Phyllodoce spp*.), partridgefoot, deer fern (*Blechnam spicant*), lady fern (*Athyrium filix-femina*), fescue (*Festuca spp*.), sedge (*Carex spp*.), *Ribes spp*., and coast red-elderberry (*Sambucus racemosa*) (Hjeljord 1973). Deeper snows drive them downslope into MH forests and the lower elevation CWH zone where their forage shifts to less nutritious foods. Work done by Fox and Smith (1988) indicates that coniferous trees make up 22% of their diet, with lichens (19%), forbs (18%), and mosses (16%) also used. When snow depths increase further, the forbs are no longer available and intake levels of the other, less nutritious foods increase. Among the tree species, mountain hemlock, western hemlock and yellow cedar were identified as preferred. Other authors support the importance of coniferous browse in the winter diet of coastal populations (Foster 1982, Foster and Rahs 1985, Fox et al. 1989, and Gilbert and Raedeke 1992). As snow levels decrease, mountain goats will increase their elevation and start to disperse (Hjeljord 1973). Food habits will not change, however, until green-up occurs in the sub-alpine.

Dispersal and Seasonal Movement

Dispersal between different mountain ranges and new habitats is highly variable and several authors suggest different scenarios. Geist (1971) suggests that most of this inter mountain dispersal occurs in the fall as females move through the valley bottoms to other areas. Fox et al. (1989) also suggests that it occurs in the fall, but that it is the males that disperse more commonly. Festa-Bianchet et al.

(1994) indicate that inter mountain dispersal occurs in the spring and that 2 year old goats of both sexes are involved. This migration away from natal ranges is suggested to mitigate the impact of eruptive population overshoots and crashes (Houston and Stevens 1988).

Mountain goats use traditional seasonal migration routes between summer and winter range (Russel 1974, Foster 1982, Smith and Raedeke 1982 and Nichols 1980). This may include traveling up to 24 km (Nichols 1980), but studies in Pacific coast ecosystems suggest a mean slope distance of 1.2 km between summer and winter range (Schoen and Kirchhoff 1982). In most cases, seasonal movement was primarily elevational with some habitat overlap between seasons (Russell 1974, Chadwick 1977, Smith 1977, and Foster 1982). It has also been noted that in winter the largest, most southern south aspect slope on a large block of mountains will collect the majority of animals that summer in that block (pers. observ.). Mountain goats are poor to moderate swimmers (Banfield 1974) as their fur quickly becomes saturated making swims greater than 1 km difficult (Hazelwood, pers. comm.).

METHODOLOGY AND ASSUMPTIONS

General Approach

Mountain goat winter range mapping is primarily a subjective process. While several modeling approaches have been considered in northwestern BC, escape terrain, one of the primary determinants of winter range, has yet to be captured effectively in existing databases. Smith (1994) developed a method that predicted use within a 2.6 ha cell 83% of the time but relied on a measure of adjacency to cliff habitat. Cliff and or escape terrain habitat is one attribute that is not consistently identified through forest cover mapping, terrestrial ecosystem mapping, or terrain classification mapping. Consequently, to develop large scale predictive habitat mapping it is necessary to first map the escape terrain. Since mapping escape terrain is largely a subjective process, any approach that incorporates it to predict winter range use should also be considered as primarily professional opinion.

This mapping process approaches winter range distribution at two scales in order to capture a variety of factors suspected to influence mountain goat winter habitat selection. Initially, the study area is examined from a landscape scale using 1:50:000 National Topographic Series (NTS) maps. Local and documented information, as well as the results of overview flights, are summarized and transferred onto these maps. In addition, other factors more suited to a sub-regional perspective, such as aspect, slope, access and adjacency to summer range, are identified and marked. The final phase of this process is to select large areas, generally extensive and continuous slopes, where all the necessary landscape conditions occur to support a population of wintering mountain goats. These large areas are identified as High Probability Polygons (HPP).

The second phase of this winter range mapping incorporates stand level features. Information collected on the NTS maps is first transferred to 1:20,000 TRIM-based forest cover maps. The escape terrain within the HPP is then mapped using the most current aerial photographs. Areas with suitable slopes, escape terrain connectivity, appropriate vegetation, and range connectivity are circumscribed as mountain goat winter range. Two types of winter range were identified: those areas with known mountain goat winter use, and those areas with suspected use. The following documents the methodology in detail and defines the assumptions used and their basis in the literature or through personal experience.

Winter Range Definition

For the purposes of this mapping project, mountain goat winter range is defined as those forested areas that have the capacity to support populations during the dormant season, which ranges from October to April in most of the study area.

Landscape Mapping

Background Information

Personal interviews were conducted with a total of 31 people, including forest industry personnel, government employees, helicopter and float plane pilots, First Nations, and consultants. Interviews ranged from a short phone call to a detailed discussion of sightings with references to a 1:600,000 map. Information on local mountain goat distribution and habitat selection was also collected from literature, internal government reports, and consultant reports. The relevancy of both the written and interview data varied but the majority of information was very general. See the personal communication reference list for a complete record of contacts.

All historic information was added to the NTS maps using reference numbers to indicate the source of the information. There was no standardization between survey intensities, survey methods, or presentation of results. Consequently, in an effort to standardize the results, a three class rating scheme was developed. All sightings were translated into either high density, moderate density or low density. These classes consider the information source, the level of intensity, the season of survey, and the existence of confirming information.

Overview Flights

Overview flights were completed throughout the study area between February 9 and March 8, 2001 with a total of 20 hours flight time. See Table 1 for flight details. Both mountain goat and moose overview flights were combined to reduce shuttle times. The intent of these flights was not to establish the demographics of local populations, but to establish the general distribution of animals through the study area and to confirm seasonal habitat quality. Consequently, no specific survey patterns were flown, and no sightability or search effort information was developed. These flights did not meet the criterion established within Resource Inventory Committee standards for aerial ungulate surveys (RIC 1997). All flights occurred in a Bell Jet Ranger 206.

Table 1: Summary of flight paths and areas examined during overview flights.

Flight #	Date	Flight Path/Locations
#1	02/09/2001	Alder Creek, Khtada Creek, Scotia Creek, Big Falls, Hayward Creek and north shore of Skeena River
#2	02/12/2001	Nass Bay, Observatory Inlet, Anyox River, Belle Bay Creek, Marmot River and Maple Bay
#3	02/14/2001	Hawkesbury Island, Goat Harbour, Triumph River, Tag Creek, Kiltuish watershed and Alan Reach
#4	02/27/2001	Nass Bay, Stagoo, Alice Arm, Kitsault River, and Illiance River
#5	03/08/2001	Port Simpson, Union Lake, Quottoon Inlet, Work Channel, Khyex River, Pitt Island, and Quaal Inlet

Flight coverages were selected based on available information, current development pressure, and the need to coordinate moose and goat areas of interest into the same flights. Areas identified in the overview mapping as having a high probability of wintering goats were given the majority of search effort although approximately 20% of the time was used to confirm absence in low probability areas. Areas with limited background or conflicting information were given the highest priority for aerial review. Winter flights were selected under the assumption that the majority of sightings would represent animals in their winter range. Budgets did not allow a thorough review of all locations within the study area.

Two observers were present on each flight. Each area was approached from the base of the slope upwards in an effort to limit disturbance. In general, elevations from valley bottom to ridge crest were flown in areas with suitable habitat. While visibility of goats and goat tracks was excellent on cliffs and exposed rock, identifying use within forested stands was more problematic. Even in heavily forested areas however, tracks could often be identified and followed. One observer acted as navigator and marked mountain goats and goat track densities on the appropriate NTS maps and used a reference number to identify corresponding notes. The second observer noted the reference number and any relevant information on habitat quality or track density. All flights occurred on relatively clear days with an unlimited ceiling. Snow conditions over the days preceding the flights were visually noted so that tracks could be aged. This was considered in the estimation of density and assisted in the identification of habitats selected during varying snow conditions.

Following the overview flights, track locations and densities were added to the winter range mapping. As discussed earlier, sightings were classified as low density, moderate density, or high density and a reference number was used to identify the flight number. Additional comments such as no goats seen, poor tracking conditions, and poor visibility were also added where environmental conditions constrained confidence. Original field maps and associated notes are available from the author.

High Probability Polygon Mapping

Once background and overview flight data was recorded, the maps were reviewed to determine where appropriate distributions of goat winter range features occurred. In order of relative importance, these features included appropriate slopes, aspects, appropriate vegetation, accessibility, and adjacency to summer range. These features were considered within the spatial context of 1:50,000 mapping and generally applied to entire slopes of a mountain range. Table 2 identifies the criteria used to identify suitable landscape areas for wintering mountain goats.

Table 2: Landscape features and assumptions used in 1:50,000 mapping for mountain goat winter range.

Landscape Feature	Mapping Assumptions	Supporting Literature
Slope	Mountain goats winter on slopes between 30° and 65°.	*1, *2, *4, *6
Aspects	Mountain goats winter on aspects between 135° and 250°.	*2, *3, *4, *5, *6, *7,
Vegetation	Mountain goats winter in or beside coniferous stands older than 60 years.	*6, *7, *8, *9, *10, *11,
Accessibility	Mountain goat population movement is limited by extensive icefields or water.	*12, *13
Adjacent Summer Range	Mountain goat winter habitat is connected elevationally to suitable summer range.	*2, *14, *15

*1 - Schoen and Kirchhoff 1982
*2 - Foster 1982
*3 - Hebert and Turnbull 1977
*4 - Smith 1977
*5 - Fox 1977
*6 - Fox et al. 1989
*7 - Smith 1994
*8 - Hjeljord 1973
*9 - Schoen et al. 1980
*10 - Smith 1985
*11 - Fox and Smith 1988
*12 - Hazelwood, pers. comm.
*13 – Banfield 1974
*14 – Russell 1974
*15 - Chadwick 1977

Using these assumptions, large slopes with appropriate conditions were circled on 1:50,000 maps. These large areas were considered HPP. In areas where the slope and aspect features occurred, but one of the other features was absent or of low quality, the area was included but marked accordingly.

Three abbreviations for these limiting factors were used on the 1:50,000 maps including: NTC – no thermal cover, PEC – poor elevational connectivity, and LSR – limited summer range. These areas were included as HPP to ensure they received a better review at the stand level mapping. In areas where no summer range occurs, the NSR abbreviation is marked but a HPP is not assigned.

Winter Range Mapping

Escape Terrain Mapping

The detailed mapping phase of the methodology is designed to locate and map escape terrain within the high probability polygons as a prerequisite to locating mountain goat winter range. First, all information collected on the NTS maps, including HPP, historic information, overview results, and limiting factor coding, were transferred to the 1:20,000 TRIM maps. Some minor adjustments were made at this stage to reflect the more detailed topographic mapping.

Aerial photographs were then used to identify all escape terrain within the previously delineated HPP. Using a definition of steep, broken surfaced slopes with rock outcroppings (Gilbert and Raedeke 1992), coupled with professional opinion, areas with suitable escape terrain were delineated. When escape terrain was clumped into continuous areas with less than 200 m between individual sites, the entire area was collectively marked as a single polygon. When these collective escape terrain polygons reached above the timberline, they were closed off to avoid unnecessary mapping in areas with no potential for winter range habitat. These polygons were then transferred by manual restitution using identifiable features on the 1:20,000 map.

Other relevant limiting factors, identifiable only on aerial photographs, were also noted on the maps. This included areas where snow levels may be higher than would be expected due to local shading, adjacency to icefields, or poor elevational connectivity to summer range. These features were marked on the maps using the abbreviations SH, HS, and PEC, respectively.

Winter Range Mapping

The 1:20,000 maps with the HPP, background information, limiting factors, and escape terrain were used as the basis for interpretations of mountain goat winter range. As suggested earlier, winter range mapping is highly subjective and relies on identifying suitable escape terrain features within forests that could provide snow interception or otherwise limited snow depths. Several other factors were considered but their relative importance was weighed against the level of confidence available for a particular area. Other factors included the spatial distribution of escape terrain, the relative elevation, and isolated weather and topographic effects.

Escape terrain distribution is of primary importance. Mountain goats need elevational flexibility so vertically connected escape terrain often has high winter use. In addition, winter range must be connected by escape terrain to summer range. Isolated HPP without direct and suitable connectivity with summer range will have poor or no winter use. The horizontal distribution and density of winter escape terrain provides some measure of the potential use patterns in the area. Single linear features, such as a ravine, will have almost all of its use within a narrow band adjacent to the ravine. Alternatively, slopes with widely distributed escape terrain will likely show a more dispersed use pattern and several distinct travel corridors will likely be evident.

Beyond the escape terrain features and distribution, winter range will most likely be located near the lowest point in the vertically connected escape terrain. Because in most valleys within the Coast Ranges slopes less than 25^{o} occur only at and below the toe of the slope, the lowest usable winter range rarely incorporates valley bottom habitat. The lowest elevation is a relative term that varies between HPP. In hanging valleys, the lowest elevation may be 800 m above sea level (ASL) while in the main valley it may be 50 m ASL. The differences in elevation between the alpine and the lowest accessible escape terrain dictates the amount of habitat variability available to optimize foraging. Consequently, those sites at the lowest end of the vertically connected winter escape terrain with the greatest elevational range are more likely to receive higher use.

Personal observations have noted that in the majority of cases, HPP with a lake to the south have higher winter use and more predictable mountain goat winter use. It is believed that this is the result of the reflected solar radiation assisting with snow sublimation during cold outflow conditions. Most fresh water lakes at low elevations do not freeze in the study area due to the maritime influence. This association appears to be applicable to marine areas as well although a much smaller sampling of these areas was completed in this survey. If all other habitat attributes are equal, it is likely that winter goats will prefer the south facing slope above a lake or inlet.

Additionally, some areas show site specific topographic conditions that strongly suggests high snow levels. In some areas near large glaciers, extensive high elevation tundra, or confining topographic features, snow levels are higher than in adjacent areas. Identifying these features required a relatively good knowledge of the area and its distinctive patterns of late season snow. These sites and conditions were only considered in the designation of winter range when the aerial overview could confirm high snow levels.

Finally, shading can have a large impact on habitat selected by wintering mountain goats. In several locations where valleys have an east west alignment, are relatively narrow, and have steep slopes, the low elevation southern slopes get limited winter solar exposure. This can impact mountain goat use in two ways. Goats will either move to suitable sites across the slope into the sun, or they will winter above the shadowed area in mid elevation sites. These assumptions are based on observation only, so they were not considered unless distinctive shadows were seen on south facing slopes on air photographs taken in the growing season.

Winter range units were marked on the 1:20,000 maps as either blue or green polygons. The blue polygons have a historic record of wintering goats or goats were seen using the area during overview flights. Green polygons indicate that most appropriate habitat features occur but there is no supporting information to suggest that goats actually winter in the area.

RESULTS

In total, 288 winter range units were identified throughout the study area within approximately 180 HPP. Individual discussions of each winter range unit were considered too arduous so the results are presented by ecosection based on direction provided by WLAP. See Figure 2 for an ecosection and biogeoclimatic map covering the study area. Note that the Alaska Panhandle ecosection has been split into the Southern Boundary Ranges ecosection and Mezeadin Mountains ecosection since this project was initiated, and the available map does not distinguish these two new ecosections. The Southern Boundary Ranges ecosection includes most of the area formally known as the Alaska Panhandle but now excludes the drainages flowing into Alice Arm.

For each ecosection background information and overview flights are reviewed and interpreted. This is followed by a discussion of the implications for landscape distribution of habitats and populations considering known and suspected limitations. Finally, confidence levels are discussed and direction is provided for further overview and detailed surveys within that ecosection.

Figure 2: Study area map identifying the biogeoclimatic subzones and the ecosection boundaries**.**

A more detailed comparison of ecosections was initially envisioned but the absence of detailed descriptions of the geographic and climatic differences between ecosections limits this approach. The following discussion provides a summary description of the ecosections based on topographic and ecosystem maps. Consequently, interpretations based on these ecosection features should be viewed critically.

Hecate Lowland Ecosection

The Hecate Lowland ecosection is composed primarily of low elevation, well-weathered slopes with high exposure to the Pacific Ocean and associated precipitation events. The vast majority of these rolling slopes top out around 650 m with only a few peaks on Pitt Island and the adjacent mainland exceeding this height. Slopes include all aspects although main ridges appear to follow a north-south axis. Vegetation is dominated by the CWH very wet, hypermaritime (vh) subzone with very limited amounts of the MH wet hypermaritime (wh) subzone. Almost no alpine ecosystems occur within this ecosection. Snow levels are very low (Banner et al. 1993), with the mean annual maximum snow depth rarely exceeding 50 cm (Canada Department of Mines and Technical Surveys, 1957).

A review of background material on this ecosection provided very limited information on mountain goat distribution. Only one published count could be identified and it included adjacent areas of the Kitimat Range on the north side of the Skeena River. In 1993 the Wildlife Branch surveyed the area known as Skip Mountain and determined that densities in the western (Hecate Lowland) areas were half those in the eastern (Kitimat Range). This density variation was hypothesized to be the results of varying hunting pressure and poor habitat in the western edge (Schultze, 1993).

G. Hazelwood completed the first recorded winter track survey in 1969 during the development of Canada Land Inventory mapping. This survey indicated that no mountain goats or mountain goat tracks were detected west of either Work Channel or the Ecstall River. Several sets of tracks were noted along the eastern boundary of this ecosection though, including areas adjacent to Leverson Lake and areas with south aspects near the south end of Quottoon Inlet.

Discussions with groups and individuals did not reveal significant additional information. Rick Woodman had some of the most specific data based on 15 years of fixed wing flight in the area. Rick suggests that there are several small goat populations that summer in the uplands between Grenville Channel and the Ecstall River. Winter range in this vicinity is less than optimal with very limited elevational connectivity through escape terrain. However, given that this area would likely receive a minimum of snow, elevational movement may not play as important a role as it does further inland. Rick also indicated that he had heard several reports of mountain goats on Pitt Island. Several others interviewed suggested they had heard similar rumors but no one could designate the source. No other information was contributed regarding mountain goats or their habitats in the Hecate Lowland ecosection.

Three hours of helicopter time on the fifth overview covered areas within the Hecate Lowland ecosection. Effort in this ecosection was limited due to low probability of goat occurrence and the difficulty accessing many of the offshore areas. In the northern portion of the Hecate Lowland, between Portland Inlet and the mouth of the Skeena River, several areas on the Tsimpsean Peninsula and along the eastern shore of Work Channel were examined. Several steep areas with the most extensive high elevation habitat on the Tsimpsean Peninsula were given cursory examinations and no goats or goat tracks were identified. As suggested earlier, high elevation areas appear to provide poor growing season habitat and much of the exposed rock is smooth and well weathered. In addition, the slope gradients and general distribution of escape terrain limit elevational movement and general dispersal within possible summer range. The eastern side of Work Channel contained slightly better habitat with higher, more extensive summer habitat and steeper slopes. A single set of mountain goat tracks was positively identified on the south aspect slopes above the mouth of Ensheshese Creek.

Later in the flight, the western slopes of Skip Mountain, eastern banks of Grenville Channel, and eastern Pitt Island were surveyed. Survey conditions were highly variable with limited snow in many locations. Goats were identified only on the eastern slopes of Skip Mountain where densities of animals and tracks were moderate. No goats were seen anywhere else in the ecosection but tracks were identified in one location on Pitt Island adjacent to its largest peaks. Winter habitat was observed although forest stands did not appear to provide significant snow interception. This is less significant in this ecosection due to the lower snow levels compared to more interior ecosections. Summer habitat was highly limited however, with alpine and subalpine forests dominated by heath.

Mountain goat habitat and densities appear highly limited in this ecosection with few steep southern slopes, poor quality and elevationally disparate escape terrain, poor summer range and limited evidence of use. The distribution of winter range units is clumped with a band located directly west of the Kitimat Range ecosection boundary and a larger concentration associated with the highlands on the eastern edge of Pitt Island. Limitations to goat distribution and immigration into this ecosection are primarily associated with oceanic isolation. Most of the ecosection is composed of islands with varying distances from viable mainland population sources. Since those areas furthest from the mainland also have the most unsuitable habitat, it is highly improbably that extreme coastal areas within this ecosection support goat populations. The most conceivable immigration sources depend on the specific location within the ecosection but likely correlate with the mainland areas adjacent to Pitt Island and on the eastern side of Work Channel. At its narrowest, the channel between the mainland and Pitt Island (Grenville Channel) is approximately 500 m and a wolf pack has been seen crossing at this location (pers. observ.).

In general, this ecosection offers poor year round mountain goat habitat. Mapping suggests that southern exposures are generally smaller and have slope gradients near the minimum requirements for use. However, the largest limitation to goat use in this ecosection does not appear to be associated with winter range. The lack of significant alpine environments suggests that summer foraging habitat, as is documented further from the ocean, is absent or much reduced. Without appropriate growing season habitat, it is highly unlikely that much of this ecosection could support mountain goats.

In total, 60 winter range sites were identified in the Hecate Lowlands. Of these, 11 were reviewed during helicopter overview flights. Evidence of goat use was confirmed in three winter range units. Given the low probability of large populations in the ecosection, with the possible exception of areas adjacent to the Kitimat Range ecosection, there is little confidence that all the winter range units identified would receive significant use. It is highly likely that as this ecosection is investigated more thoroughly, approximately 50% of the winter range units identified will be dropped. Further aerial investigations in this ecosection should focus in the Pitt Island and the areas between Douglas Channel and Grenville Channel.

Kitimat Range Ecosection

The Kitimat Range ecosection includes the granitic mountains that extend from the mouth of the Nass River south and occupies the eastern most slopes of the study area. Peaks generally range between 1400 and 2000 m with some exceeding 2700 m. Mountains have relatively smooth domelike shapes with north facing cirques (Holland 1976). Large coastal fiords and river valleys bisect this ecosection and are responsible for marine influences inland from the coast. Vegetation at lower elevations is dominated by the very wet maritime (vm) subzone of the CWH although small areas of the very wet hypermaritime subzone occur adjacent to Douglas Channel. Within the MH zone, the moist maritime (mm) subzone is far more common although the wet hypermaritime occurs on Hawkesbury and Gribble Islands. Alpine habitats are also more common than in the Hecate Lowlands with extensive upper elevation slopes centred near the Kiltuish watershed, at the headwaters of Scotia Creek, and in the upper Khyex and Kwinamass Rivers. Snow levels in this ecosection are known to be significantly greater than the Hecate Lowland ecosection with much of the annual precipitation coming as snow in upper elevations.

Historic research and surveys are most prevalent in this ecosection although limited numbers have occurred within the study area. The largest and most intense survey was completed by the Nisga'a Tribal Council between 1996 and 2000 and is summarized in Yazvenko et al. 2000. This survey focused on areas within the Nass Wildlife Area with limited flights in the eastern portions of the study area adjacent to the Kwinamass and Chambers drainages. Winter aerial surveys in 1998 indicated that several populations appeared to be utilizing the south and southwestern facing slopes near northern portions of the Chambers and Johnson watershed. No other areas within the study area received winter surveys but fall surveys indicated the existence of populations throughout the areas between Khutzeymateen Inlet and the Ishkheenickh watersheds including the Mylar Peninsula. Results of their habitat assessment suggest that moderate and high quality winter range occurs throughout much of this area although specific winter range areas were not identified.

The second largest survey was a by-product of the Khutzeymateen grizzly bear study completed by MacHutchon in 1993. As part of spring aerial surveys for tagged bears, incidental mountain goat surveys were completed. These surveys occurred in late spring so their results and their value as indicators of winter habitat use are limited. However, the location of the animals in spring provides some estimation of preferred wintering areas based on their proximity to quality winter range. Several concentration areas were noted near large, steep, south facing steep slopes above the Kateen and Khutzeymateen Rivers.

Several smaller surveys, usually watershed specific, have been completed in this ecosection. These include the McShane watershed (Turney and Taylor 1997), the Lachmach area (Schultze 1993), the upper Hayward drainage (Pollard 1996), the North Tsam development area (Pollard 2001a) and Gribble Island (Pollard 2001b). In the McShane watershed, mountain goat winter use appeared to concentrate near the marine interface but areas further upstream were not thoroughly investigated and specific locations were not mapped. In the Lachmach area, Schultze reported higher densities on the eastern slopes of Skip mountain and in other areas further inland. In the upper Hayward, mountain goats were seen on the south and southwestern slopes but no evidence of use was located on the eastern slopes near the upper watershed. In the North Tsam development area, no mountain goats or their sign were observed and field work suggests that few if any goats would winter within this north facing watershed. Most of Gribble Island was flown and several high elevation ridges bisecting the island were walked. No evidence of mountain goat use was identified. The lack of evidence and the isolation of this island strongly suggest that it does not currently support a mountain goat population.

Of those interviewed, most indicated that this ecosection supports moderate to large populations of mountain goats. Again, given the relatively large area, few people were able to specifically identify the locations or seasons of use. Most of the information available was for the Ecstall drainage and areas south of Douglas Channel. In the Ecstall, especially in the smaller east-west aligned valleys, year round mountain goat use was commonly cited. Several people also recalled seeing small groups in areas west of the Ecstall, on the border of the Hecate Lowland ecosection. Two pilots and S. Liepins indicated high density populations in the Khtada watershed, and high density use in the Goat Harbour and Bishop Bay area is relatively well known. Conversely, several pilots indicated that they had never identified mountain goats on the large islands within Douglas Channel.

This ecosection was flown more thoroughly than others due to accessibility, development pressure, and suspected higher densities. The first flight on February 9th surveyed the watersheds on the south side of the Skeena River to Ecstall Drainage and returned along the north side of the Skeena River from the Khyex River. Mountain goats and mountain goat tracks were identified in every habitat that had suitable gradients and aspects including areas in Alder Creek, Khtada Creek, Scotia Creek, Big Falls Creek, Carthew Creek, Hayward Creek, Ecstall River, and the southern slopes of McLean Mountain. No goats were identified around Sparking Creek but this reflects decreased visibility due to fog. Hazelwood (1969) also indicated that goats were present throughout the area with concentrations in areas such as Khtada Lake, the upper Khyex River, the headwaters of the Khutzeymateen, and Union Lake.

During the flight, most of the tracks and animals appeared to be on steep escape terrain below the tree line although several goats on McLean Mountain were well above it. Elevations varied between 100 m and 750 m. This variation does not appear to be directly proportional to the snow depth as lower elevations with lower snow depths and adequate escape terrain were underutilized compared to areas upslope. This may be a function of greater isolation within their protected range or it could reflect increased forage productivity in upper slopes.

During the third flight on February 14th, the southern portions of the Kitimat Range ecosection were examined. The flight originated on Hawkesbury Island and flew through many of the watersheds south and east of Douglas Channel. High and moderate densities of mountain goat sign were seen in Goat Harbour, in the pass to Triumph Lake, in mountains west of Tag Creek, and in several locations around Kiltuish Inlet, the Kiltuish River and Europa Lake. No goats were seen anywhere on Hawkesbury Island.

The areas around Goat and Triumph watershed show a different habitat type than many of the other areas investigated. These areas have a high marine influence but lie within the snow shadow of Gribble and Hawkesbury Island in the winter. These valleys are also wide enough that moisture-laden clouds tend to pass through without significant surface convergence-related precipitation. Summer range is limited but the MH areas appear to provide relatively rich forage associated with high quality escape terrain.

Based on the lack of goat evidence on Hawkesbury and Gribble Island, it is highly likely that these islands do not support populations of mountain goats. This is most plausibly due to several factors including isolation by Douglas Channel, poor summer range, and high snow depths in the winter. The minimum distance from these islands to mainland sites with known mountain goat populations is greater than 2.5 km. Given the currents and high winds that can occur in this channel, it is unlikely that mountain goats could cross successfully. The summer range is also limited to small isolated areas with alpine habitats. South facing escape terrain occurs throughout both islands but incidental winter surveys indicates that snow levels are deep at most elevations. While absence is difficult to prove, a second winter survey in these areas revealing no sign should provide a very strong argument for the absence on mountain goats on these islands.

The final flight on March 8 covered areas within the northern portion of Kitimat Range and included areas such as Union Lake, Quottoon Inlet, and the Khyex watershed. Limited evidence of mountain goat use was noted in Union Creek but several individuals and tracks were seen scattered through the southern and southwestern slopes at the head of the inlet and near the south side of the lake. In the Quottoon Inlet area, few tracks were seen but limited snow depths made tracking difficult. In the McShane watershed however, snow depths increased and low density tracks appeared near the mouth. Most of the southern exposures in the Toon watershed showed evidence of use. The highest densities occurred in upper elevations (400-700 m), although several individuals were noted along a gorge near the valley bottom (100 m). The Thulme watershed was also flown but no evidence of goat use were identified. The Khyex was flown extensively and moderate to high densities of sign were noted in several southern or southwestern aspects. However, no evidence was noted in several other areas of the Khyex with apparently reasonable winter habitat. It is possible that the clear warm day had encouraged them to take cover in areas where they would be more difficult to spot.

Limitations to goat distribution and immigration are few in this ecosection with adequate habitat throughout the area and few obstructions to dispersion. Based on anecdotal evidence, mountain goats can cross even large rivers such as the Skeena and the Ecstall. Only Douglas Channel or Gardner Canal could potentially act as significant obstructions to dispersal within this ecosection.

The Kitimat Range ecosection contains the best quality habitat and highest densities of mountain goat in the NCLRMP study area. Summer range is plentiful with large alpine summering areas and steep southern facing slopes for wintering. Distribution of suitable winter range areas is relatively consistent throughout the ecosection with small variations. Areas on Hawkesbury and Gribble Island are relatively small to reflect the short drainages and predominantly north south alignment of the mountains. A similar pattern of small and isolated winter range areas occurs west of the Ecstall River where slopes are generally short and winter ranges are more compact. Higher densities of winter range units occur in the conjunction with large south and southwestern slopes in the southern portion, east central portion, and northern portion of the ecosection.

In total, 163 winter range sites were identified in the Kitimat Range ecosection. Of these, 72 winter range areas were reviewed during helicopter overview flights. Evidence of goat use was confirmed in 30 winter range units, and 18 additional units were confirmed through background information. Confidence levels are moderately high in this ecosection due to background information and high overview survey effort. Further aerial investigations should focus on areas that received no flight coverage such as west of the Ecstall River and the mountains on both the north and south shores of the Skeena River. Overview surveys have previously established the general distribution of goats in this area so a more detailed approach may be required to confirm individual sites.

Mezeadin Mountains Ecosection

This ecosection is very new having been portioned out of the original Alaska Panhandle ecosection in the last year. It includes all drainages flowing west and south into Alice Arm. Peaks range between 1500 and 1800 m and slopes are steep and rugged with isolated basalt columnar formations. The Cambria Icefield is located at the headwaters of the Kitsault River and several smaller glaciers occur within the drainage itself. The location of this ecosection provides it with some protection from seasonal precipitation and the CWH wet submaritime (ws) subzone dominates lower elevation forests. The MHmm subzone occurs at higher elevations in bands below the alpine. Alpine ecosystems are extensive and dominate the western and northern portions of this ecosection. Snow levels are anticipated to be high given the more interior conditions and the cold influence of the glaciers on incoming wet fronts.

No literature was available concerning mountain goats in this ecosection. Large studies in the Nass did not include this area and the lack of recent development activities implies that few people have any recent knowledge of the area. The only information identified included incidental sightings of mountain goats in the areas around the old Alice Arm townsite. This was provided by helicopter pilots who have flown the area. This information was too general to establish the locations of these sighting.

This ecosection was reviewed during the fourth flight on February 7, 2001. The flight originated in Nass Bay and followed the south facing aspects of Alice Arm to the Kitsault River. The main channel of the Kitsault was then followed approximately 15 km upstream before the Illiance River was examined. A single pair of goats was identified although tracks were seen in several locations. The two adults were identified at the termination of the alpine ridge north of the Klayduc Creek, just above the Kitsault River. Tracks were identified in several other locations throughout the watershed but snow depths were low and there is little confidence that these sightings represented a realistic portrait of mountain goat densities or distributions.

Mountain goats have very few limitations to dispersal in this ecosection. While Alice Arm is likely too wide for mountain goats to swim, adequate steep slopes occur around the head of the fiord, and goats could easily circumscribe it. Large icefields could also restrict movement in the northern part of the ecosection. While mountain goats commonly utilize icefields, anecdotal evidence suggests they will rarely traverse large distances across open glaciers or snowfields.

The Mezeadin Mountains ecosection contains good to excellent year round mountain goat habitat. Possible habitat limitations would be associated with high snow depths and low forest cover in the northern portions of the ecosection. The rounded contours in the eastern half of the ecosection may also reduce the quality of summer range but this could not be confirmed during the overview flight. Winter range units are relatively small in the northern portions to reflect these habitat limitations, but are larger in the southern areas where the primary mountain alignment is east-west.

In total, 12 winter range sites were identified in the Mezeadin Mountains ecosection of which four were reviewed during a single overview flight. Goat use was confirmed in two areas but survey conditions were poor. Confidence in the position of winter range units is moderate but overall densities are difficult to speculate given the paucity of information. Further aerial investigations in this ecosection should focus on the smaller tributaries to the Kitsault River, especially in the upper watershed.

Southern Boundary Ranges Ecosection

This ecosection incorporates most of the area once identified as the Alaska Panhandle ecosection. It includes watersheds feeding Hastings Arm, Observatory Inlet, and Canadian tributaries to Portland Canal. In the southern portion of this ecosection, including Pearse Island, Wales Island, the Mylor Peninsula, and the southern portions of Ashington Range, mountains are well weathered and have maximum elevations in the 600-800 m range. Further north in the Burniston Range and in mountains adjacent to the Cambria Icefields, peaks are much higher (1400 m) and far more rugged. Watersheds are generally short and steep with no consistent alignment. Vegetation varies between southern portions and northern portions of this ecosection as well. In the south, CWHvh occurs in lower elevations and only small isolated areas of MHwh occur on the upper slopes. Alpine habitat is heath dominated and occurs only one location in the Ashington Range. In the northern and more protected areas, the CWH wet maritime (wm) subzone occurs in the limited range of forests between the subalpine and the ocean. The MHmm subzone is more extensive than in the south and most peaks are surrounded by large areas of alpine ecosystems. Snow levels are anticipated to be higher in the northern portions of this ecosection due to the influence of the glaciers, higher elevations, and more confining valleys.

Limited information was available on mountain goat distribution and habitat quality in this ecosection. No surveys or studies were identified. Limited recent development in this area also restricted contributions by pilots to the generalization that goats did occur in the area. A resident hunter indicated than Marmot Creek, just south of Stewart, had high densities of mountain goats (W. Topoleski, pers. comm.).

Both the second and fourth overview flights covered areas within this ecosection. On February 12, 2001, the flight passed north along Observatory Inlet to the Anyox watershed, than crossed the peninsula and flew north to Marmot Creek. The flight then flew south along the eastern shore of Portland Canal to Maple Bay and crossed over at Belle Bay before returning. While appropriate winter range was present throughout the area, low snow depths directly adjacent to the ocean limited confidence in tracking results. No evidence of mountain goats was identified along the northern edge of the Ashington range near Salmon Cove, even in relatively good habitat associated with cliffs and south facing aspects. In the Anyox drainage, four goats were observed in relatively low gradient habitat adjacent to a canyon on Bonanza Creek. Habitat adjacent to this canyon appears poor with limited forage due to the historic plume kill. The tracks suggested that these goats had moved south along the canyon from higher elevations in the last 24 hours. Goats were also identified in Bulldog Creek near Stewart in areas of excellent winter range. High densities of tracks were identified throughout the large, southwestern aspect, especially among the cliff faces. No goats were identified on the west facing slopes into Portland Canal or in the lower reaches of George River although moderate densities of tracks were identified along vertical ravines in upper East George River. The lower reaches of this system appeared to have reasonable quality habitat but poor elevational connectivity. No other mountain goat evidence was seen along Portland Canal and its tributaries until just north of Belle Bay on a west-southwestern slope. In this area, moderate densities of tracks indicated that goats had been moving down slope along two large avalanche tracks where there was exposed escape terrain. Unfortunately, in low elevation habitat adjacent to this area, low snow depths made confirmation of actual goat use in the winter range unit impossible.

The second overview flight on February 27, 2001 initiated in Nass Bay, flew along the eastern side of Observation Inlet to Alice Arm, and included the Stagoo and Kelskiist Creeks. Flying northward along the eastern side of Observation Inlet did not provide any indications of mountain goat use. Aspects in these areas are primarily east-southeast and west-northwest and there was limited summer range available. No goats were identified in the southern most tributary of Stagoo Creek but high densities of tracks were observed in the middle tributary along a large, south facing slope. These tracks occurred within forested areas and over the majority of this southern slope except near the upper portion of the watershed. While snow levels in this area may be higher, the habitat quality does not significantly change from lower in the watershed. In the Stagoo valley and Kelskiist Creek, a low elevation fog limited visibility and no goats were seen. Aerial photographs indicate that the main Stagoo valley has very similar habitats to its two other major tributaries with large south facing slopes and elevationally connected escape terrain from the alpine to the valley bottom.

This ecosection contains several oceanic limitations to mountain goat dispersal. Portland Canal, Observatory Inlet, and Hastings Arm are all wide enough that they represent significant obstructions. In addition, the large glaciers associated with the Cambria Icefield could potentially limit northward movement. Consequently, most populations within this ecosection are relatively isolated from immigration.

The northern portion of this ecosection contains moderate year round mountain goat habitat with ample associated summer range. Habitat limitations in the northern portion would likely be associated with winter range habitats due to several factors including high elevational snow depth gradients, limited winter range sizes, and difficult migration conditions. In the southern portion of the ecosection, south of the Burniston Range, the lack of significant summer or winter range limits its potential to support mountain goats. There is no alpine habitat and the rounded and well-weathered slopes provide limited functional winter range habitats. Incidental flights in the spring of 2002 confirmed the absence of mountain goat evidence on both Pearce and Wales Island.

In total, 53 winter range sites were identified in the Southern Boundary Range ecosection of which 26 were reviewed during two overview flights. Goat use was confirmed in nine areas but survey conditions were poor, especially in low elevation areas directly adjacent to the coast. Confidence in the location of winter range units is moderate but speculation on overall densities is not possible given the lack of information. Further aerial investigations in this ecosection should focus on the southern portions of the ecosection to confirm absence, and in areas around the Ohl and Kshwan watershed where no information exists.

CONCLUSIONS

Using a multi-scale approach, mountain goat winter range was mapped for the entire NCLRMP study area. Almost three hundred winter range units were identified based on literature, historic surveys, anecdotal information, air photo review, and overview helicopter surveys. In the absence of more detailed inventories, the results of this mapping approach should be considered as the best available information on winter range habitats. Based on overview flight results and professional experience, it is estimated that a minimum of 95% of areas used by wintering mountain goats have been captured in HPP. Inadequate data is available to establish the accuracy of the winter range mapping although preliminary results are promising. Recognizing that a conservative approach was used, future field surveys will likely reduce the actual number of winter range units, especially in areas of the Hecate Lowlands. Alternatively, small adjustments may be necessary to include areas being used adjacent to the areas identified. Regardless of the estimated accuracy, maps should be considered a work in progress and be continuously supplemented or amended as better information becomes available. These maps are adequate as tools to aid in regional planning but interpretations for stand level developments should be supplemented with on-site reviews.

Mountain goats are found throughout most of the NCLRMP study area with the exception of exposed offshore areas. These offshore sites appear to be limited by the lack of adequate summer range, poor quality escape terrain, and limited access. Further inland, all adequate conditions occur to support mountain goats year round and relevant surveys have suggested moderate to high densities in most areas. Large oceanic channels and icefields likely isolate some populations in Douglas Channel and near Portland Canal although this requires further investigation. The Kitimat range ecosection has the highest densities in the study area compared to other ecosections, but is still likely lower than densities found in the adjacent Nass Range ecosection.

RECOMMENDATIONS

As suggested, mapping is based on a variety of assumptions and the more data available, the higher the reliability. Priorities for further surveys and their methods will depend on the goals of the survey. If the goal is to refine the current product and only limited budgets are available, preliminary aerial surveys, similar to those completed in this study, should be completed. The following areas need to be reviewed to establish the occurrence and distribution of mountain goats and winter range:

- Southern Pitt Island,
- Hawkesbury and Gribble Islands,
- Ashington Range
- Lakes area northwest of Hartley Bay, and,
- Boundary of Kitimat Range and Hecate Lowland south of the Skeena River.

If a measure of the accuracy is necessary, more quantitative counts should be established. Considering this goal, several areas with limited data should be checked. In these areas, comparisons should be made between identified winter range areas and adjacent slopes to establish differences in density. A variety of paired comparisons should be used to reduce site specific variations in habitat types and micro-climates. To reduce possible biases, areas selected should not have been previously reviewed. Suitable location include:

- Mountains along the north and south shores of the Skeena River,
- Kwinamass River watershed,
- Upper Kitkiata watershed, and,
- Anywhere in the Southern Boundary or Mezeadin Mountains ecosections.

Finally, more refined surveys to determine how well the winter range units actually capture the high winter use areas can be completed to establish that appropriate habitat has be captured. These surveys can occur in any of the winter range units identified where mountain goats are known to occur. The most appropriate sites should be those that are easily accessible given the higher relative cost of these ground-truthing surveys. Regardless of the survey type intended, all new information should be used to update existing maps.

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REFERENCES

Banfield, A. W. F. 1974. The mammals of Canada. Toronto University Press. Toronto. 437 pp.

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 parts 1 and 2. Land Management Handbook Number 26. Research Branch, B.C. Ministry of Forests, Victoria, B.C.

Canada Department of Mines and Technical Surveys. 1957. Atlas of Canada. Geographical Branch, Ottawa, 110 map sheets.

Chadwick, D.H. 1977. The influence of mountain goat social relationships on population size and distribution. In Sammuel and W.G. Macgregor **eds**. Proceedings, First international mountain goat symposium; 1977 February 19; Kalispell, MT. Victoria, BC: Province of British Columbia Ministry of Recreation and Conservation, Fish and Wildlife Branch: 74-91.

Chadwick, D.H. 1983. A beast the color of winter. San Francisco: Sierra Club Books. 208 pp.

Cichowski, D.B., D. Haas, and G. Schultze. 1994. A method used for estimating mountain goat numbers in the Babine Mountains recreation area, British Columbia. In Proceedings of the Ninth Biennial Symposium of the Northern Wild Sheep and Goat Council, **ed**. M. Pybus, Cranbrook, British Columbia. **9**:56-64.

De Vos, A., P. Brokx, and V. Geist. 1967. A review of social behavior of the North American cervids during the reproductive period. American Midland Naturalist **77(2)**:390-417.

Del Frate, G.G., and T.H. Spraker. 1994. The success of mountain goat management on the Kenai Peninsula in Alaska. In Proceedings of the Ninth Biennial Symposium of the Northern Wild Sheep and Goat Council, *Ed*. M. Pybus, Cranbrook, British Columbia. **9**:92-98.

Festa-Bianchet, M., M. Urquhart, and K.G. Smith. 1994. Mountain goat recruitment: kid production and survival to breeding age. Can. J. Zool. **72**:22-27.

Foster, B.R. 1982. Observability and habitat characteristics of the mountain goat (*Oreamnos americanus* Blainville, 1816) in west-central British Columbia. Masters Thesis: University of British Columbia. 134 pp.

Foster, B.R. and E.Y. Rahs. 1985. A study of canyon-dwelling mountain goats in relation to a proposed hydroelectric development in northwestern British Columbia, Canada. Biological Conservation **33**:209-228.

Fournier, F. and M. Festa-Bianchet. 1994. Social dominance in adult female mountain goats. Animal Behavior **49**:1449-1459.

Fox, J.L. 1977. Summer mountain goat activity and habitat preference in coastal Alaska as a basis for the assessment of survey techniques. In W. Sammuel and W.G. Macgregor **eds**. Proceedings, First international mountain goat symposium; 1977 February 19; Kalispell, MT. Victoria, BC: Province of British Columbia Ministry of Recreation and Conservation, Fish and Wildlife Branch: 190-199.

Fox, J.L., K.J. Raedeke, and C.A. Smith. 1982. Mountain goat ecology on Cleveland Peninsula, Alaska 1980-82. Final Rep. Pacific Northwest For. Range Exp. Stn. Contract PNW-Supp. 165-AO#2. USDA Forest Service For. Sci. Lab., Juneau, Alaska. 55 pp.

Fox, J.L. 1983. Constraints on winter habitat selection by mountain goats (*Oreamnos americanus*) in

Alaska. Seattle: College of Forest Resources, University of Washington; 147 pg. PH. D. dissertation.

Fox, J.L. and C.A. Smith. 1988. Winter mountain goat diets in southeast Alaska. J. Wildl. Manage. **52(2)**:362-365.

Fox, J.L., C.A. Smith, and J.W. Schoen. 1989. Relation between mountain goats and their habitat in southeastern Alaska. U.S. For, Serv., Gen. Tech. Rep. PNW-246. 25 pp.

Fox, J.L. 1991. Forage quality of *Carex macrochaeta* emerging from Alaskan alpine snowbanks through the summer. Am. Midl. Nat. **126**:287-293

Geist, V. 1964. On the rutting behavior of mountain goat. Journal of Mammology. **45(4)**:551-568.

Geist, V. 1971. Mountain sheep: A study in behavior and evolution. Univ. Chicago Press, Chicago. 383 pp.

Gilbert, B.A. and K.J. Raedeke. 1992. Winter habitat selection of mountain goats in the north Tolt and Mine Creek drainages of the north central Cascades. In Biennial Symposium of the Northern Wild Sheep and Goat Council, Cody, Wyoming. **eds**. J. Emmerich and W.G. Hepworth. Wyoming Game and Fish Department, Cody. **8**:305-324

Hazelwood, G. 1969. Winter track count maps (1:250,000). Produced as preliminary maps for Canada Land Inventory Project, from G. Hazelwood's personal archives.

Hebert, D.M. and W.G. Turnbull. 1977. A description of southern interior and coastal mountain goat ecotypes in British Columbia. In W. Sammuel and W.G. Macgregor **eds**. Preceedings, First International Mountain Goat Symposium; 1977 February 19; Kalispell, MT. Victoria, BC: Province of British Columbia Ministry of Recreation and Conservation, Fish and Wildlife Branch: 126-146.

Hjeljord, O. 1973. Mountain goat forage and habitat preference in Alaska. J. Wildl. Manage. **37(3)**:353-362.

Holland, S.S. 1976. Landforms of British Columbia: a physiographic outline. British Columbia Department of Mines and Petroleum Resources. Bulletin 48.

Houston, D.B. and V. Stevens. 1988. Resource limitation in mountain goats: a test by experimental cropping. Can. J. Zool. **66**:228-238.

MacHutchon, A.G., S. Himmer, and C.A. Bryden. 1993. Khutzeymateen valley grizzly bear study; Final Report. Ministry of Environment, Lands and Parks and Ministry of Forests. Wildlife Report No. R-25, Wildlife Habitat Research Report No. 31, Victoria, British Columbia.

Macgregor, W.C. 1977. Status of mountain goats in British Columbia. In W. Sammuel and W.G. Macgregor **eds**. Proceedings, First international mountain goat symposium; 1977 February 19; Kalispell, MT. Victoria, BC: Province of British Columbia Ministry of Recreation and Conservation, Fish and Wildlife Branch: 24-28.

McCrory, W.P. and D.A. Blood. 1977. Mountain goat surveys in Yoho National Park, British Columbia. In W. Sammuel and W.G. Macgregor **eds**. Proceedings, First international mountain goat symposium; 1977 February 19; Kalispell, MT. Victoria, BC: Province of British Columbia Ministry of Recreation and Conservation, Fish and Wildlife Branch: 69-73.

McFetridge, R.J. 1977. Strategy of resource use by mountain goat nursery groups. In W. Sammuel and

W.G. Macgregor **eds**. Proceedings, First international mountain goat symposium; 1977 February 19; Kalispell, MT. Victoria, BC: Province of British Columbia Ministry of Recreation and Conservation, Fish and Wildlife Branch: 169-173.

Nichols, L. 1980. Mountain goat management technique studies. Final Report, projects W-17-9, W-17-10, and W-17-11. Alaska Department of Fish and Game, Juneau, Alaska. 47 pp.

Petocz, R.G. 1973. The effect of snow cover on the social behaviour of bighorn rams and mountain goats. Can J. Zool. **51**: 987-993

Petticrew, P.S. and W.T. Munro. 1979. Preliminary mountain goat management plan for British Columbia. Ministry of Environment. Victoria British Columbia. 26 pgs.

Poole, K.G. and G. Mowat. 1997. Mountain goat winter habitat requirements in the West Kootenay region of British Columbia. Unpubl. Rep. For Slocan Forest Products Ltd. Slocan, British Columbia. 22 pp.

Pollard, B.T. 1996. Fish and wildlife values in the Hayward drainage. Unpublished report for International Forest Products Ltd. 12 pg.

Pollard, B.T. 2001a. Pre-planning overview of wildlife and habitat values in the North Tsam Small Business Development Area. Unpublished report for the North Coast Forest District, Prince Rupert, BC. 17 pg. with map appendices.

Pollard, B.T. 2001b. Pre-planning overview of wildlife and habitat values in the Gribble Small Business Development Area. Unpublished report for the North Coast Forest District, Prince Rupert, BC. 20 pg. with map appendices.

Resource Inventory Committee. 1997. Version 1.0 Standardized inventory methodologies for components of British Columbia's biodiversity: aerial-based inventory techniques for selected ungulates bison, mountain goat, mountain sheep, moose, elk, deer, and caribou. Ministry of Environment, Lands, and Parks - Wildlife Branch, Victoria, British Columbia. 78 pgs.

Russell, D. 1974. Grizzly bear-mountain goat investigations in Knight Inlet, British Columbia. British Columbia Fish and Wildlife Branch, Nanaimo, British Columbia. 84 pp.

Schoen, J.W., M.D. Kirchhoff, and O.C. Walmo. 1980. Winter habitat use by mountain goats. Juneau, Alaska Department of Fish and Game; Federal Aid in Wildlife Restoration Project W-17-10, 11 and W-21-1,2; final report; job 12.4R. 67pp.

Schoen, J.W. and M.D. Kirchhoff. 1982. Habitat use by mountain goats in southeast Alaska. Juneau, AK: Alaska Department of Fish and Game; Federal Aid in Wildlife Restoration Project W-17-10, 11 and W-21-1, 2; final report; job 12.4R. 67 p.

Schultze, G. 1993. Mountain goat population survey for limited entry hunting area Management Unit 6-15 Zone L. Wildlife Branch, Skeena Region, British Columbia Environment, Lkands and Parks, August 1993, 7 pg.

Singleton, J. 1976. Food habits of wild ungulates in British Columbia: bibliography and plant synopsis. Environment and Land Use Committee Secretariat, Department of Environment, Victoria, B.C. pg. 4-9.

Smith, B.L. 1977. Influence of snow conditions on winter distribution, habitat use, and groups size of mountain goats. In W. Sammuel and W.G. Macgregor **eds**. Proceedings, First international mountain goat symposium; 1977 February 19; Kalispell, MT. Victoria, BC: Province of British Columbia Ministry of Recreation and Conservation, Fish and Wildlife Branch: 174-189.

Smith, C.A. 1986. Habitat use by mountain goats in southeastern Alaska. Juneau, AK: Alaska Department of Fish and Game; Federal Aid in Wildlife Restoration Project W-22-2; final report; job 12.4R. 58p.

Smith, C.A. 1994. Evaluation of a multivariate model of mountain goat winter habitat selection. In Proceedings of the Ninth Biennial Symposium of the Northern Wild Sheep and Goat Council, *Ed*. M. Pybus, Cranbrook, British Columbia. **9**:159-165.

Smith , C.A., and K.J. Raedeke. 1982. Group size and movements of a dispersed low density goat population, with comments on inbreeding and human impacts. Proceedings, Biennial Symposium Northern Wild Sheep and Goat Council; 1984 April 30-May 3; Whitehorse, YT. Yukon Wildlife Branch; 3: 54-67.

Smith, K.G., M.A. Urquhart and M. Festa-Bianchet. 1992. Preliminary observations of timing and causes of mountain goat kid mortality in west-central Alberta. In Biennial Symposium of the Northern Wild Sheep and Goat Council, Cody, Wyoming. *Eds*. J. Emmerich and W.G. Hepworth. Wyoming Game and Fish Department, Cody. **8**:293-304.

Turney, L., and S. Taylor. 1997. Summary of fish and wildlife inventories in the McShane Creek watershed. Contracted report for Boyle and Dean Logging Ltd., Terrace, BC, 12 pp.

Van Drimmelin, B. 1983. Report of a re-inventory of the Nass Range mountain goat populations. Fish and Wildlife Branch, Skeena Region, Ministry of Environment, Smithers, British Columbia. 22 pp.

Vogel, C.A., and J.M. Scott. 1995. Review and analysis of North American mountain goat (*Oreamnos americanus*) literature with emphasis on population dynamics. Unpubl. Rep., University of Idaho, Moscow. 46pp.

Wright, R. Undated. Mountain goats in British Columbia. Ministry of Environment Lands and Parks fact sheet. Province of British Columbia. Victoria, 5 pp.

Yazvenko, S.B., G.F. Searing and M.W. Demarchi. 2000. Wildlife habitat assessment in the Nass Wildlife Area – Final Report. Contracted report produced for Forest Renewal British Columbia and submitted by the Nisga'a Tribal Council. Aiyansh, British Columbia. 75 pg. with map appendices.