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Mountain goat population ecology and habitat use along the Juneau Access road corridor, Alaska

Kevin S. White, David P. Gregovich, Grey W. Pendleton, Neil L. Barten, Ryan Scott, Anthony Crupi and Doug N. Larsen

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Alaska Department of Fish and Game Division of Wildlife Conservation

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ABSTRACT

The Alaska Department of Fish and Game (ADFG) conducted a mountain goat ecology study in the eastern Lynn Canal and the Berners Bay areas (ca. 1100 km^2) during 2005-2012. The primary purpose of this project was to acquire biological data necessary to manage local mountain goat populations in the event the proposed Juneau Access highway is constructed. The secondary purpose was to provide the Alaska Department of Transportation (ADOT/PF) with highway mitigation and design recommendations for reducing the likelihood of mountain goat-vehicle collisions. Specific project objectives included estimating mountain goat population size, vital rates, resource selection and movement patterns in the vicinity of the highway alignment. Data collection efforts focused on capture and monitoring of radio-marked mountain goats (n = 75 females, 84 males) deployed with Global Positioning System (GPS) and Very High Frequency (VHF) radio-collars (n = 135 GPS, 23 VHF). During capture biological data were gathered to assess nutritional status, diet composition, genetic identity and disease status. Aerial and ground-based survey monitoring of marked animals enabled determination of population size (via Bayesian mark-resight procedures), reproductive success and survival. Mountain goat GPS location data and GIS remote sensing data were used to develop resource selection function (RSF) models to characterize seasonal habitat use patterns.

Genetic analyses determined that the study area included three genetically distinct sub-populations that were divided by marine waters and/or flat, low elevation river valleys. In 2006, mountain goat abundance in the study area was considered moderate, relative to other areas in the region. However, study area-wide population estimates declined approximately 47% between 2006 (n = 1136) to 2010 (n = 604) following a succession of severe winters. Field data indicated that adult survival rates were negatively influenced by winter severity and survival of adult males was considerably lower than adult females. Most mortality occurred in late-winter (Feb-May), however significant mortality was also documented in October. Reproductive productivity was similar to mountain goat studies conducted elsewhere but is low relative to other northern ungulates resulting from a late age-at-first reproduction, frequent reproductive pauses and low twinning rates (i.e. 1-2%). Activity and movement patterns exhibited distinct seasonal patterns and were 3-4 times lower in winter as compared to summer. Movement rates of males increased significantly during the breeding season but activity rates were low (putatively due to mate-tending behavior). Parturient females reduced movement during the kidding season, presumably to accommodate limited mobility of neonates. Mountain goats exhibited elevational migrations from alpine summer ranges to low elevation forested winter ranges that coincided with the onset of high elevation snowfall events in autumn and the ablation of snow and, in the case of females, the parturition period, in spring. Resource selection function (RSF) modeling indicated that mountain goats selected for steep, rugged terrain in close proximity to cliffs with moderate-high solar exposure. Within this context mountain goats selected for low elevation ares in winter and moderate-high elevations in summer; mountain goats selected for lower elevation wintering areas in eastern Lynn Canal area as compared to animals that wintered east of Berners Bay.

The proposed Juneau Access highway alignment intersects important mountain goat wintering areas along eastern Lynn Canal. Implications of highway construction for local mountain goat populations include the potential for mountain goat-vehicle collisions, sub-lethal disturbance and increased human access. Such conditions (primarily those related to increased human access) will result in modification of mountain goat management strategies and will include changing existing registration hunts to a more restrictive limited-entry drawing hunts. Specific highway design and mitigation efforts are recommended to reduce the likelihood of mountain goat-vehicle collisions and disturbance (i.e. sub-lethal effects). Currently, based on the recent population decline harvest quotas should be reduced, relative to pre-2006 levels, and informed using demographic models based on data collected during this study. In addition, hunt area boundaries should be re-defined using mountain goat GPS location data and associated analytical outputs to ensure that hunt areas closely match mountain goat demographic boundaries.

INTRODUCTION

This report was prepared to meet the final reporting requirements for ADOT/PF. Funding for this project was made available in September 2005 and this report summarizes activities completed by December 30, 2011.

Background

In 2005, Coeur Alaska re-initiated development activities at the Kensington mine site, located a short distance northwest of Berners Bay. In addition, the ADOT/PF proposed construction an all-season highway between Echo Cove and the Katzehin River. In the context of these proposed industrial development activities, mountain goats were identified as an important wildlife species likely to be affected by mine development and road construction activities.

A small-scale study of mountain goats conducted in the vicinity of the Kensington mine by Robus and Carney (1995) showed that goats moved seasonally from high alpine elevations in the summer and fall to low, timbered elevations during winter months. One of the main objectives of the Robus and Carney (1995) study was to assess the impacts of the mine development activities on habitat use, movement patterns and, ultimately, productivity of mountain goats. However, the mine never became operational, thus these objectives could not be achieved, and by 1995 goat monitoring in the area wound down and eventually ended. In 2005, when the mine development activities were re-initiated the Alaska Department of Fish and Game maintained that many of the same concerns that prompted the Robus and Carney (1995) study were still valid and needed to be addressed. In addition, large-scale plans for development of the Juneau Access road raised new, potentially more substantial, concerns regarding not only the enlarged "footprint" of industrial development activities in eastern Lynn Canal, but also the cumulative impacts of both development projects on wildlife resources.

The potential effects of mining and road development activities on local mountain goat populations in the vicinity of the Kensington mine and eastern Lynn Canal have potentially important ramifications for management and conservation of the species in the area. Studies conducted elsewhere indicate that mountain goats can be negatively impacted by industrial development activities. Such effects include temporary range abandonment, alteration of foraging behavior and population decline (Chadwick 1973, Foster and Rahs 1983, Joslin 1986, Cote and Festa-Bianchet 2003). Consequently, information about the distribution of mountain goats proximate to the mine and road development corridor is critical for determining the extent to which populations may be affected by associated industrial activities. Information collected by Robus and Carney (1995), in the vicinity of Kensington mine, as well as Schoen and Kirchhoff (1982), near Echo Cove, suggest that spatial overlap between mountain goats and the proposed industrial activity will be most pronounced when goats are over-wintering in low-elevation habitats.

In response to the above concerns, ADFG, with operational funding provided by ADOT/PF, Federal Highway Administration (FHWA) and Coeur Alaska, initiated monitoring and assessment activities to determine possible impacts of road construction and mine development on mountain goats and identify potential mitigation measures, to the extent needed. Assessment and monitoring work included collection of vital rate, habitat use and movement data from a sample of radio-marked mountain goats in addition to conducting annual aerial population abundance and productivity surveys. These efforts are aimed at providing the ADFG with information necessary to appropriately manage mountain goats in the proposed areas of development.

Implementation of field objectives were initiated in 2005 and consisted of a 5-year monitoring program (2005-2011)jointly funded by ADOT/PF, FHWA, Coeur Alaska and ADFG. Beginning in 2007, the Alaska Department of Fish and Game committed additional annual funding for a complementary aerial survey technique development project within and adjacent to the project area. In 2009, the USDA-Forest Service (Tongass National Forest) also began contributing funding to further support aerial survey technique development data collection efforts. And, in 2010, Coeur Alaska reaffirmed their commitment to mountain goat monitoring near the Kensington Mine and adjacent areas and extended project funding for an additional 5 years (until FY2016). Consequently, project activities summarized in this report encompass a compilation of field data collection efforts achieved via financial support of multiple state, federal and private entities.

STUDY OBJECTIVES

Research efforts were designed to investigate the spatial relationships, vital rates and abundance of mountain goats in the Berners Bay and upper Lynn Canal area. The original intent of the study was to compare population responses in areas with and without road construction and development activity. However, over the time frame of the study, highway construction was not implemented as originally planned. Consequently, the ability to assess the effects of the highway and how mountain goat management strategies would need to be altered following construction was not conducted using the proposed control-treatment experimental design. The modified research objectives were to:

1) determine seasonal movement patterns of mountain goats in the vicinity of the Juneau Access road corridor;

2) characterize mountain goat habitat selection patterns in the vicinity of the Juneau Access road corridor;

3) estimate reproductive success and survival of mountain goats in the vicinity of the Juneau Access road corridor; and

4) estimate mountain goat population abundance and composition in the vicinity of the Juneau Access road corridor.

STUDY AREA

Mountain goats were studied in a ca. 1077 km^2 area located in a mainland coastal mountain range east of Lynn Canal, a post-glacial fiord located near Haines in southeastern Alaska (Figure 1). The initial study area was oriented along a north-south axis and bordered in the south by Berners Bay (58.76N, 135.00W) and by Dayebas Creek (59.29N, 135. 35W) in the north. Within this area, three separate study sites were delineated based on the actual or expected extent of industrial activity occurring in or near each locality (Figure 2).

An additional study area located east of Berners Bay was established in spring 2006 (Figure 2). This area was not originally included in the study design. However, recent information about road construction time lines resulted in a re-evaluation of the efficacy of conducting research activities in this area. Research effort in this area was relatively limited in scope, and low intensity sampling in this area was intended to provide managers with baseline information needed to assist future management efforts in light of the road construction, gravel crushing and/or stock-piling that is likely to occur in this area. Additional ADFG funding was allocated to partially offset costs associated with research activities in this area.

Elevation within the study areas range from sea level to 6300 feet. This area is an active glacial terrain underlain by late cretaceous-paleocene granodiorite and tonalite geologic formations (Gehrels 2000). Specifically, it is a geologically young, dynamic and unstable landscape that harbors a matrix of perennial snowfields and small glaciers at high elevations (i.e. above 4000 feet) and rugged, broken terrain that descends to a rocky, tidewater coastline. The northern part of the area is bisected by the Katzehin River, a moderate volume (ca. 1500 cfs; USGS, unpublished data) glacial river system that is fed by the Meade Glacier, a branch of the Juneau Icefield.

The maritime climate in this area is characterized by cool, wet summers and relatively warm snowy winters. Annual

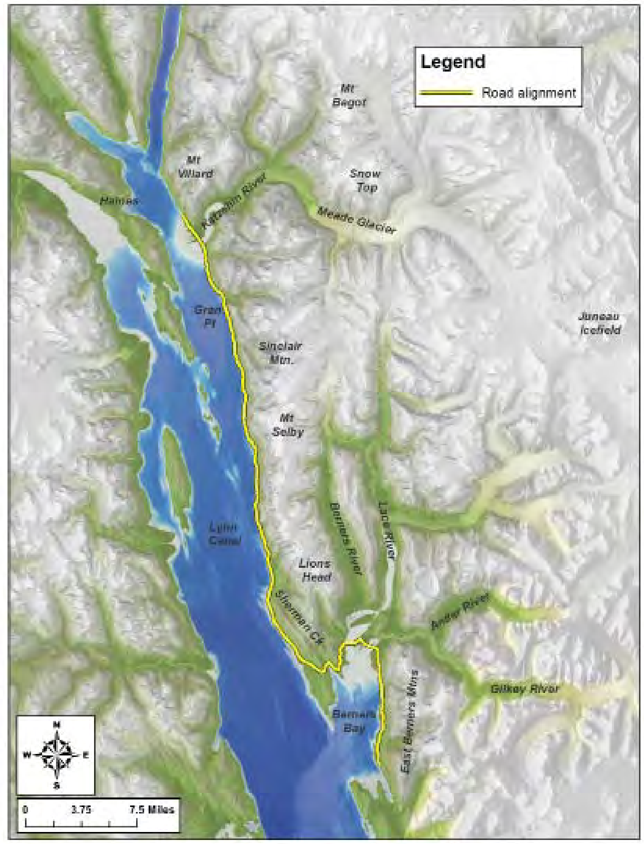

Figure 1: Map of the Lynn Canal and Berners Bay area. Local place names referenced in this report are identified. Mountain goats were studied in this area during 2005-2011.

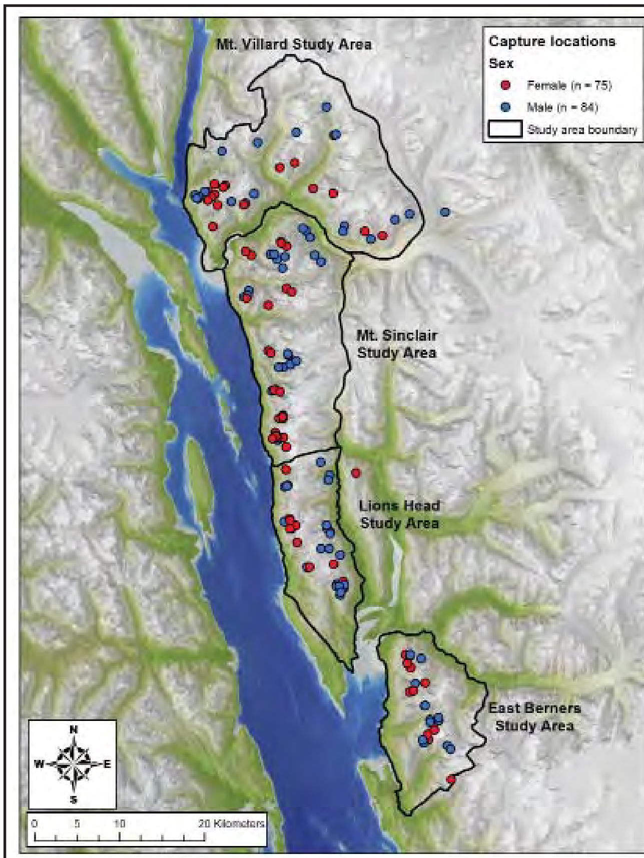

Figure 2: Locations of mountain goats captured and subsequently monitored in the Lynn Canal study area, 2005-2011.

precipitation at sea-level averages 55 inches and winter temperatures are rarely less than 5º F and average 30º F (Haines, AK; National Weather Service, Juneau, AK, unpublished data). Elevations at 2600' typically receive ca. 250 inches of snowfall, annually (Eaglecrest Ski Area, Juneau, AK, unpublished data). Predominant vegetative communities occurring at low-moderate elevations (<1500') include Sitka spruce (*Picea sitchensis*)-western hemlock (*Tsuga heterophylla*) coniferous forest, mixed-conifer muskeg and deciduous riparian forests. Mountain hemlock (*Tsuga mertensiana*) dominated 'krummholtz' forest comprises a subalpine, timberline band occupying elevations between 1500-2500 feet. Alpine plant communities are composed of a mosaic of relatively dry ericaceous heathlands, moist meadows dominated by sedges and forbs and wet fens. Avalanche chutes are common in the study area, bisect all plant community types and often terminate at sea-level.

METHODS

Mountain Goat Capture

Mountain goats were captured using standard helicopter darting techniques and immobilized by injecting 3.0 - 2.4 mg of carfentanil citrate, depending on sex and time of year (Taylor 2000), via projectile syringe fired from a Palmer dart gun (Cap-Chur, Douglasville, GA). During handling, all animals were carefully examined and monitored following standard veterinary procedures (Taylor 2000) and routine biological samples and morphological data collected. Following handling procedures, the effects of the immobilizing agent was reversed with 100mg of naltrexone hydrochloride per 1mg of carfentanil citrate (Taylor 2000). All capture procedures were approved by the State of Alaska Animal Care and Use Committee.

GPS Location Data

Telonics TGW-3590 GPS radio-collars (Telonics, Inc., Mesa, AZ) were deployed on most animals captured. Telonics MOD-500 VHF radio-collars were been deployed on a subset (n = 23) of animals to enable longer-term monitoring opportunities. During 2009-2011, animals were simultaneously marked with GPS and lightweight (Telonics MOD-410) VHF radio-collars (370g). Double-collaring animals was conducted to extend the period of time individual animals could be monitored (lifespan, GPS: 3 years, VHF: 6 years), thereby increasing the long-term opportunity to gather mountain goat survival and reproduction data and reducing the frequency in which mountain goats must be captured. The combined weight of radio-collars attached to animals comprise 1.2% of average male body weight and 2.0% of average female body weight and is well within the ethical standards for instrument deployment on free-ranging wildlife.

GPS radio-collars were programmed to collect location data at 6-hour intervals (collar lifetime: 2-3 years). During each location attempt, ancillary data about collar activity (i.e. percent of 1-second switch transitions calculated over a 15 minute period following each GPS fix attempt) and temperature (degrees C) were simultaneously collected. Complete data-sets for each individual were remotely downloaded (via fixed-wing aircraft) at 8-week intervals. Location data were post-processed and filtered for "impossible" points and 2D locations with PDOP (i.e. position dilution of precision) values greater than 10, following D'Eon et al. (2002) and D'Eon and Delparte (2005).

Diet Composition

Fresh fecal pellets were collected from live-captured animals during the summer-fall period (late-July to mid-October). Fecal pellet samples were also collected opportunistically during winter reconaissance and snow surveys. Samples were sent to Washington State University (Wildlife Habitat Analysis Lab, Pullman, WA) for dietary analyses. Specifically, microhistological analyses of plant cell fragments in pellet samples were conducted to provide an estimate of diet composition for individual mountain goats and a composite winter sample. Data were subsequently summarized by sex-class to determine whether diet composition varied between males and females. These analyses do not account for differential digestibility of each dietary food item identified in diets. Nonetheless, while results do not necessarily provide an accurate estimate of actual diet intake patterns they do provide a reliable estimate of relative differences in diet composition between males and females and seasonal trends.

Habitat Selection, Activity and Movement Patterns

Activity.—Activity sensor data were summarized at daily intervals for each individual GPS radio-collared mountain goat. Estimates for each individual were then categorized based on animal sex in order to derive a sex-specific estimate of average activity level for each day of the calendar year. This procedure allows for determination of seasonal patterns in mountain goat activity for males and females separately.

Movement Patterns.—Planimetric (i.e. horizontal) distance between consecutive GPS locations for each individual was estimated using the Geospatial Modeling Environment (GME), a GIS software program. Estimates were then standardized by including only consecutive locations separated by 6-hour intervals. Movement distances were then summarized by individual animal, sex and day in order to estimate sex-specific average daily movement rates.

Wintering Strategies and Elevational Distribution.—GPS locations were intersected with the SRTM digital elevation model using GME in order to determine elevation for each GPS location. Average daily elevation was then estimated for each individual animal and summarized by individual animal, sex and day in order to estimate sex-specific average daily elevation. These data were then used to describe seasonal patterns in distribution, specifically to determine when animals conducted elevational migrations between summer and winter ranges.

Habitat Selection and Modeling.—Resource selection function (RSF) models (i.e. Boyce 2002) were developed using mountain goat GPS location data and remote sensing covariate data layers in a GIS framework in order to describe where important winter and summer habitats occur in the study area. A resource selection function can be defined as: a model that yields values proportional to the probability of use of a given resource unit (Boyce et al. 2002). Specifically, we employed a logistic regression-based "used" vs "available" study design to estimate resource selection patterns at the population-level (i.e. 1st-order selection, Johnson 1980). In order to estimate resource availability in the study area, we randomly selected locations throughout the study area at a density of 30 locations per km^2, a density determined to reliably describe resource availability patterns in our study area (D. Gregovich, unpublished data). Mountain goat GPS locations (ie. "used") and "available" locations were then intersected (using GIS) with a suite of biologically relevant remote sensing data layers (Table 1, Appendix 8). These data were then analyzed using logistic regression (GLM function, stats package, Program R, ver. 2.13.1) to derive selection coefficients for each covariate by individual animal. The average inter-individual coefficient value (and confidence interval) was computed for each covariate (ie. the "two-stage" modeling framework; Fieberg et al. 2010) and stratified by season (winter vs. summer) and study area (East Berners vs. Lions Head/Sinclair/Villard). Stratification by study area was deemed appropriate because animals in the East Berners study area wintered at slightly higher elevation than those along Lynn Canal. Covariates considered to be significant were evaluated by examining whether confidence intervals for a given covariate include zero. Significant coefficient values were then multiplied by respective covariate remote sensing data layers in GIS using the following equation:

$$w(x) = \exp(\beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n) \quad (1)$$

Where, w(x) represents a resource selection function (RSF) that is proportional to the probability of use of variables $x_1 + x_2 + \ldots + x_n$. The resulting output was then categorized (using the quantile function in ArcGIS10) to characterize areas across the study area that differ in their relative probability of use by mountain goats. The predictive performance of RSF models was validated using k-fold cross validation (Boyce et al. 2002).

Figure 3: ADFG wildlife technician, Jeff Jemison, upon completion of a snow survey atop Echo Ridge, AK, 4/1/2011 (elev. = 2780 ft., snow depth = 206 cm/81 in)

Table 1. Remote-sensing covariates used to derive mountain goat resource selection functions, 2005-2011, Lynn Canal, AK

Variable	Definition	Source Data
Elevation	elevation (meters)	SRTM DEM[1]
Slope	slope (degrees)	SRTM DEM[1]
Distance to escape terrain	distance to areas with slope > 40 degrees	SRTM DEM[1]
Solar radiation (Jan 1)	solar radiation calculated for January 1	SRTM DEM[2]
Solar radiation (August 1)	solar radiation calculated for August 1	SRTM DEM[2]
VRM	vector ruggedness measure	SRTM DEM[3]

[1]Calculated using the Spatial Analyst Extension in ArcGIS 10

[2]Calcualted using the solar radiation algorithm in ArcGIS 10 (Fu and Rich 2002)

[3]Calculated using methods described in Sappington et al. (2007)

Winter Severity and Snow Modeling Data Collection

Winter distribution of mountain goats is strongly influenced by snow depth and distribution. Since patterns of snow accumulation vary at both small and large spatial scales it is often necessary to collect site-specific field data in order to accurately characterize these relationships within focal areas. Unfortunately, standardized snow depth monitoring information is extremely limited within the study area and additional information is needed in order to properly characterize spatial patterns of snow accumulation and, ultimately, mountain goat winter distribution. Consequently, in 2006 we initiated field efforts designed to create a snow depth database in order to generate spatially explicit snow depth models within the study area.

Standardized field surveys were conducted in order to estimate patterns of snow depth as it related to habitat type (i.e. forested/non-forested), altitude, and slope aspect (Figure 3). These efforts focused on four sites located in different mountain goat winter ranges in 2007 but consistent annual monitoring was conducted at only one site located on Echo Ridge, near Davies Creek. During surveys snow depth was measured at geo-referenced locations along an altitudinal gradient (beginning at sea level). Snow measurements were replicated at each sampling location (n = 5) and associated covariate information was collected. Sampling locations were spaced at regular (100-200m) intervals, depending upon terrain complexity. Steep (>35 degrees), exposed slopes were, generally, not sampled due to safety considerations. In addition, daily climate information for reference weather stations was acquired from the National Weather Service (Haines COOP Weather Station).

Reproduction and Survival

Kidding rates and subsequent survival were estimated by monitoring individual study animals during monthly surveys using fixed-wing aircraft (usually a Piper PA-18 Super Cub) equipped for radio-telemetry tracking or via ground-based observations (Figure 4). During surveys, radio-collared adult female mountain goats were observed (typically using 14X image stabilizing binoculars) to determine whether they gave birth to kids and, if so, how long individual kids survived. Monitoring kid production and survival was only possible during the non-winter months when animals could be reliably observed in open habitats. We assumed that kids did not survive winter if they were not seen with their mothers the following spring. Cases in which kid status assessments were equivocal were filtered from the data set and not used for subsequent estimates of kid survival.

Mortality of individual radio-collared mountain goats was determined by detecting radio-frequency pulse rate changes during monthly monitoring surveys. In cases where mortality pulse rates were detected, efforts were made to investigate sites as soon as possible via helicopter or boat. To the extent possible, all mortalities were thoroughly investigated to ascertain the cause of death and relevant biological samples collected. We determined date of mortalities via examination of activity sensor data logged on GPS radio-collars. Annual survival of radio-collared animals was estimated using the Kaplan-Meier procedure (Pollock et al. 1989). This procedure allows for staggered entry and exit of newly captured or deceased animals, respectively.

Population Abundance and Composition Estimation

Aerial Surveys.—Population abundance and composition surveys were conducted using fixed-wing aircraft (Helio-courier and PA-18 "Super Cub") and helicopter (Hughes 500) during August-October 2005-2011. Aerial surveys were typically conducted when conditions met the following requirements: 1) flight ceiling above 5000 feet ASL, 2) wind speed less than 20 knots, 3) sea-level temperature less than 65 degrees F. Surveys were typically flown along established flight paths between 2500-3500 feet ASL and followed geographic contours. Flight speeds varied between 60-70 knots. During surveys, the pilot and experienced observers enumerated and classified all mountain goats seen as either adults (includes adults and sub-adults) or kids. In addition, each mountain group observed was checked (via 14X image stabilizing binoculars) to determine whether radio-collared animals were present.

Population estimation.—The number of mountain goats in each study area was estimated using Bayesian procedures that involved statistically integrating survey-specific mark-resight estimates and modeled covariate-based survey-level estimates (White and Pendleton 2011). Briefly, logistic models were fit to predict average sighting probability for all goats in an area during a given survey as a function of survey level covariates that included: survey date, time of day, aircraft type, temperature, sky conditions, wind (median and maximum), and the number of observers (<=2 vs. 3); models were fit using Bayesian procedures with the program OpenBUGS. Bayesian models allowed for including results from each survey along with covariate-based sighting functions produced across many surveys to improve the precision of the population estimates (relative

Figure 4: Nanny kid group, including a GPS radio-collared female, observed during a activity sensor validation trial, July 2011.

to Lincoln-Petersen type estimates) and provide estimates when no marked goats were seen or when there were no marked goats in the area (with certain assumptions). These models also accounted for observed goats whose collar status could not be determined (i.e. cases where the view was insufficient to determine whether a goat was collared or not).

Sightability Data Collection.-During aerial surveys, data were simultaneously collected to evaluate individual- and survey-level "sightability". For accomplishing survey-level objectives, we enumerated the number of radio-collared animals seen during surveys and compared this value to the total number of radio-collared animals present in the area surveyed. To gather individual-based "sightability" data, we characterized behavioral, environmental and climatic conditions for each radio-collared animal seen and not seen (ie. missed) during surveys. In cases where radio-collared animals were missed, it was necessary to back-track and use radio-telemetry techniques to locate animals and gather associated covariate information. Since observers had general knowledge of where specific individual radio-collared animals were likely to be found (ie. ridge systems, canyon complexes, etc.), it was typically possible to locate missed animals within 5-15 minutes after an area was originally surveyed. In most cases, it was possible to completely characterize behavioral and site conditions with minimal apparent bias, however in some cases this was not possible (ie. animals not seen in forested habitats, steep ravines, turbulent canyons) and incomplete covariate information was collected resulting in missing data.

Ground Surveys.—Evaluation of ground-based techniques for estimating mountain goat population size and composition were conducted in a small portion of the Lions Head study area in June 2006, the Mt. Villard area during June 2007, the Mt Villard and Mt Selby areas during June-July 2008, and the East Berners Mountains in July 2009. Previous research has concluded that aerial surveys are often inadequate for providing accurate estimates of the proportion of adult males and females, as well as sub-adults during aerial surveys (Cote and Festa-Bianchet 2003); only the proportion of adults and kids in a population can be reliably estimated. As a result, ground-based survey techniques were tested to evaluate whether this method might serve as a reliable tool for classifying individuals of separate sex and age classes during survey efforts.

Additional field efforts involved collection of GPS-collar activity sensor validation data (Figure 4). In these cases, individual study animals were observed during pre-programmed activity sensor evaluation periods (i.e. 15 minute intervals following fix initiation events). During observation periods, detailed behavioral data were collected using focal animal sampling procedures (Altman 1974).

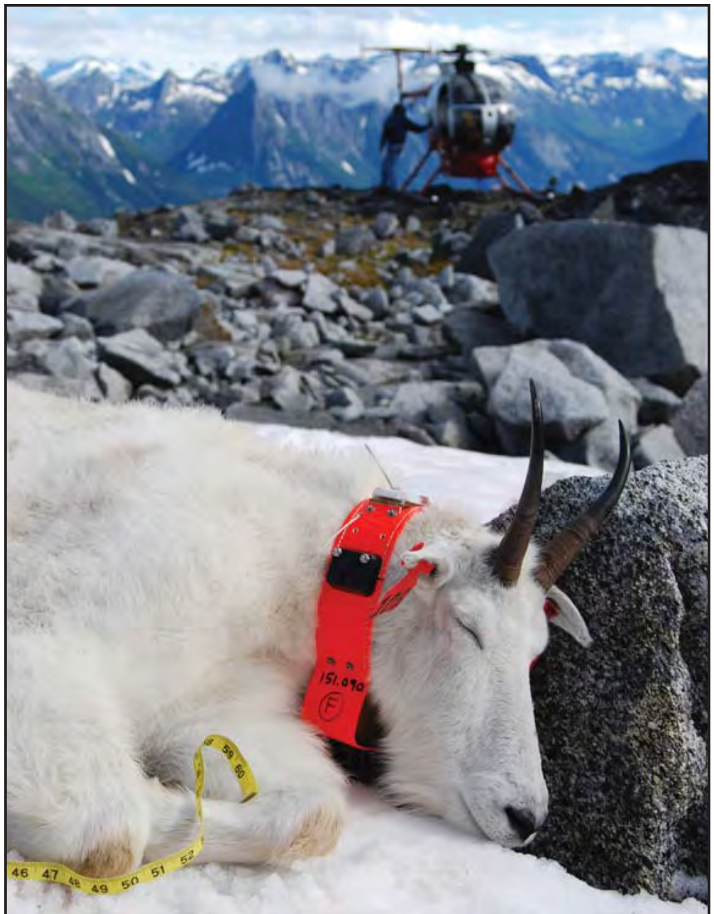

Figure 5: Photograph of an adult female mountain goat (LG-105) following deployment of a TGW-3590 GPS radio-collar, east Berners Mountains, AK. The Hughes 500D helicopter, used for capture, can be seen in the background.

RESULTS AND DISCUSSION

Mountain Goat Capture and Handling

Capture Activities.—Mountain goats were captured during 27 days in early-August to mid-October 2005-2011. Overall, 159 animals (75 females and 84 males) were captured using standard helicopter darting methods and included 7 re-capture events (Appendix 2). Most animals (n = 135) were deployed with Telonics GPS radio-collars (TGW-3590; Figure 5). However, 23 animals were deployed with conventional (i.e. non-GPS) VHF collars only. During 2009-2011, 29 animals were simultaneously marked with GPS and lightweight (Telonics MOD-410) VHF radio-collars (370g).

Helicopter captures were attempted during periods when mountain goats were distributed at high elevations and weather conditions were favorable (i.e. high flight ceiling and moderate wind speed). Additionally, captures were scheduled to avoid periods within 8 weeks of parturition in order to avoid unnecessary disturbance of adult females and associated neonates. Captures were attempted in areas where mountain goat access to dangerously steep terrain could be reasonably contained. As a result of these constraints, opportunities to capture mountain goats were fairly limited. Nevertheless, given the fairly large area of study and decent summer weather conditions, it was typically possible to capture approximately six mountain goats per day of effort.

Biological Sample Collection.—During handling procedures, standard biological specimens were collected and morphological measures recorded. Specific biological samples collected from study animals included: whole blood (4 mL), blood serum (8 mL), red blood cells (8mL), ear tissue, hair and fecal pellets. Whole blood, serum, red blood cells and fecal pellet sub-samples were either sent to Dr. Kimberlee Beckmen (ADFG, Fairbanks, AK) for disease and trace mineral screening or archived at ADFG facilities in Douglas, AK. During 2010, nasal and pharyngeal swab samples were collected from 5 animals to index prevalence of respiratory bacteria.

Genetic Analyses.—Tissue samples from all mountain goats captured since the inception of the study were genotyped by Aaron Shafer (University of Alberta, Edmonton, AB) and included in continent-wide analyses of mountain goat population genetics (Shafer et al. 2010). Shafer et al. (2010) indicated that substantial genetic structuring exists among mountain goats in southeast Alaska (and across the western North American range of the species). More recent analyses indicated that three genetically distinct mountain goat populations occur in our study area [east Berners mountains, Kakuhan range (including Lions Head and Sinclair Mountain), and Mt. Villard]; population boundaries generally coincide with our specific study area boundaries (Shafer et al. 2012). These findings indicate that gene flow between our study areas (with the exception of the Lion Head and Sinclair study areas, which are genetically indistinct) is limited. Additional analyses examined the extent to which mountain goat habitat selection characteristics and landscape configuration are linked to genetic relatedness across the study area (Shafer et al. 2012). Results from this analyses indicated that small- (i.e. distance to cliffs, heat load) and large-scale (i.e. river valleys and marine waterways) landscape features are key determinants of mountain goat gene flow across our study area (Shafer et al. 2012).

Disease Surveillance.—In 2010, a subset of captured animals (n = 5) were tested (Washington Animal Disease Diagnostic Laboratory, Pullman, WA) for prevalence of respiratory bacteria associated with incidence of pneumonia (specifically *Pasteurella trehalosi* and *Mycoplasma ovipneumonia*). However, even if such bacteria are found in the upper respiratory tracts of animals sampled it does not necessarily mean that a given animal has pneumonia, only that the potential exists. In fact, it is not unusual for reasonably high proportions of animals in a population to have pneumonia associated bacteria and never show adverse effects, particularly if animals are subject to minimal stress (ie. nutritional limitation, severe winters, etc.). Overall, none of the animals sampled in Lynn Canal tested positive for *Pasteurella trehalosi* or *Mycoplasma ovipneumonia*, although other species of respiratory bacteria were found. While sampling was limited, these results differ from those acquired for samples collected in 2010 from three other populations in southeast Alaska (Appendix 3). Until additional samples are collected, the overall findings must be considered preliminary.

Blood serum samples collected from captured animals were also tested for a suite of 15 different diseases relevant to ungulates (Appendix 4). Of particular interest was contagious ecthyma (CE), a viral disease previously documented among mountain goats in Haines and other areas of southeast Alaska. Common symptoms of CE include presence of grotesque lesions on the face, ears, and nose which can lead to death of animals, primarily those in young or old age classes; healthy adults commonly survive the disease. Of the 63 animals successfully tested for CE only one animal tested positive for CE-specific antibodies; a lower level of prevalence relative to other southeast Alaska populations tested in 2010 (n = 4), however sample sizes for some of the other populations were relatively low.

Overall, disease testing indicated that mountain goats in our study area exhibited limited exposure to nearly all of the 15 diseases assayed (Appendix 3). While such results indicate that animals in our study area are relatively free of disease exposure it is critical to recognize that such findings likewise suggest that our study populations are probably highly vulnerable to introduced pathogens, as previous exposure and apparent immunity appears to be low (K. Beckmen, ADFG Veterinary Services, Fairbanks, AK).

Trace Mineral Testing.—In 2010, whole blood and serum samples were analyzed to determine trace mineral concentration in 6 mountain goats in order to examine whether mineral deficiencies were prevalent in our study population (Appendix 5). However, limited comparable data are available to interpret our findings and documented deficiency threshold values are incomplete for mountain goats. Nonetheless, data collected in this study will be useful for future comparisons within and between populations.

GPS Location Data

GPS System Performance.—The performance of GPS radio-collars (Telonics TGW-3590) was evaluated for 124 collars deployed since the beginning of the study (Appendix 6). In general, the remote GPS data collection system used in this study worked as expected. Specifically, we did not encounter any significant problems with GPS collar performance, nor did any notable problems occur with remote data download attempts. This high level of success was achieved despite occasionally poor weather conditions and, in some cases, substantial download distances between aircraft and mountain goats (i.e. up to 3 miles). However, several pre-programmed bi-monthly GPS data download periods were missed due to weather conditions. Nevertheless, it was always possible to download missed GPS data on subsequent surveys.

Overall, 193,681 GPS locations were acquired from the 124 GPS collars deployed. This comprised 83% of the total possible GPS fixes attempted (n = 233,497); an acceptable fix success rate. Field testing during 2006 indicated that location dispersion (an index of accuracy) was lowest in open habitats (median = 20.1 m, mean = 28.3±3.0 m, n = 11), intermediate in cliff habitats (median = 46.8, mean = 50.7±15.4 m, n = 3) and highest in forested habitats (median = 40.6 m, mean = 69.7±15.1 m, n = 11). Since remote sensing data layers used for habitat modeling are typically refined to 30 m resolution, the level of accuracy of GPS locations is acceptable for routine applications.

Activity Sensor Validation.— Detailed behavioral data was collected for seven GPS radio-collared mountain goats in order to validate data collected by activity sensors imbedded in radio-collars. The activity sensor data calculates the percent of mercury tip-switch transitions over a 15 minute period commencing at pre-programmed times linked to GPS location acquisition attempts. Seventeen data collection trials were conducted in which actual animal behavior over a continuous 15 minute period was collected and later compared to activity sensor data (downloaded remotely from GPS collars). Overall, these data indicate that the percent of activity tip-switch transitions negatively correlated with percent of time animals are bedded ($r^2 = 0.77$) and positively correlated with the percent of time active ($r^2 = 0.85$; Appendix 7). Active behavior was proportionally comprised of feeding (0.46), vigilant (0.26), grooming (0.14), walking (0.13) and social interactions (0.01). In summary, the activity sensor validation results provide an important link between remote sensed activity sensor data (collected simultaneous with GPS locations) and actual animal behavior. Thus, these data provide a foundation for examining biological hypotheses related to factors governing mountain goat activity budgets (i.e. seasonality, sex, reproductive status) and habitat selection.

Diet Composition

Diet Composition.—Preliminary estimates of diet composition during the summer-fall period indicate that four major forage types were the most important constituents of

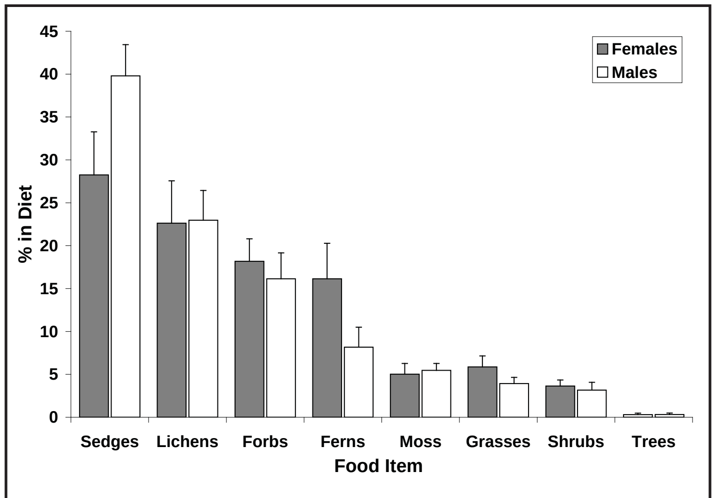

Figure 6: Percent diet composition of male and female mountain goats between late-July to mid-October, 2005-2006 in the Lynn Canal study areas. Estimates are not corrected for differential digestibility of food items.

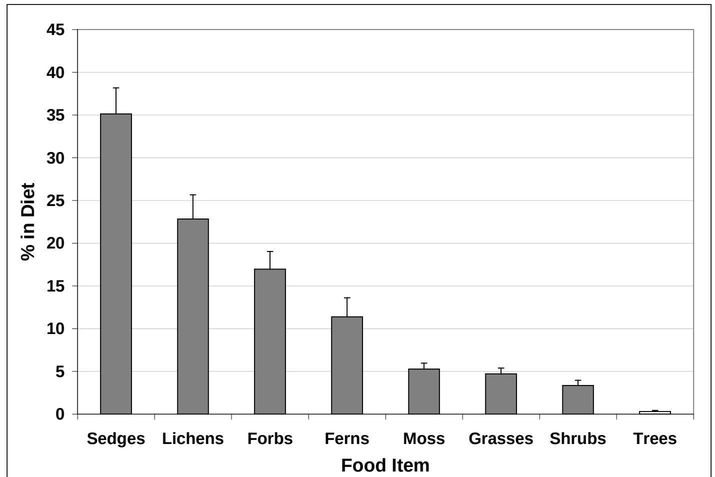

Figure 7a: Percent diet composition of all mountain goats (sexes combined) between late-July to mid-October, 2005-2006 in the Lynn Canal study areas. Estimates are not corrected for differential digestibility of food items.

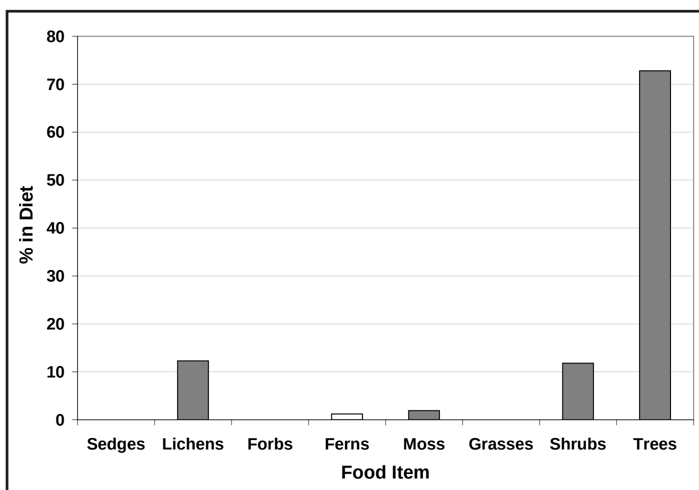

Figure 7b: Percent diet composition of mountain goats (unknown sex) in mid-February, 2006 in the Echo ridge area. Estimates are not corrected for differential digestibility of food items.

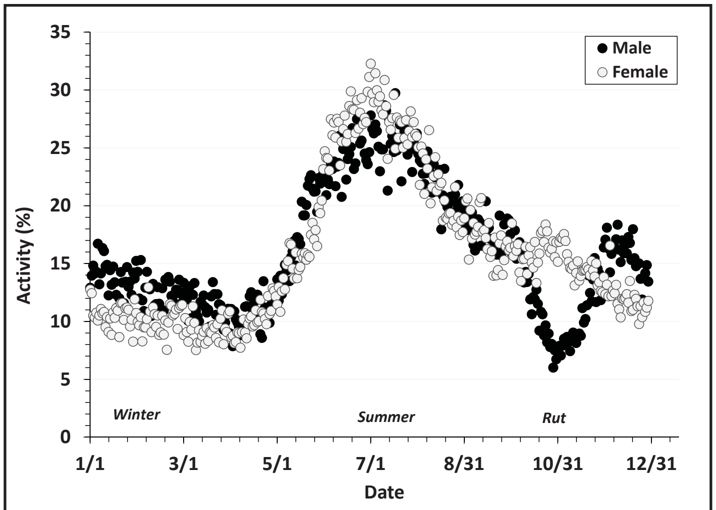

Figure 8: Relationship between mountain goat activity (% tip-switch transitions per 15 minutes) and time of year for GPS-marked male and female animals, 2005-2011, Lynn Canal, AK.

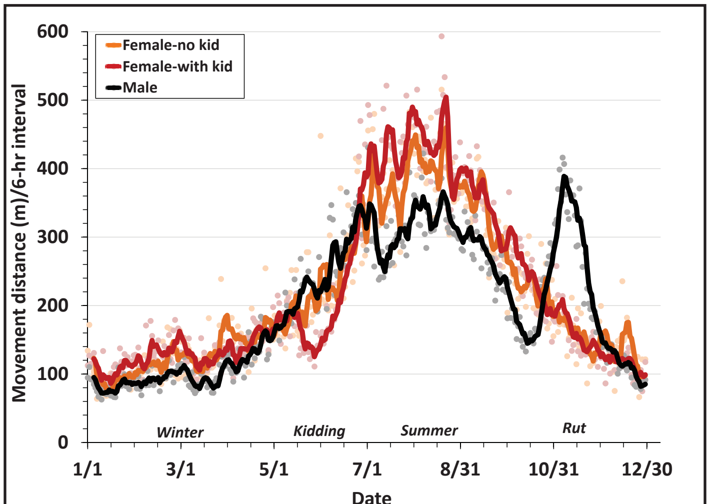

Figure 9: Relationship between mountain goat movement distance and time of year for GPS-marked male and female (with and without kids) animals, 2005-2011, Lynn Canal, AK.

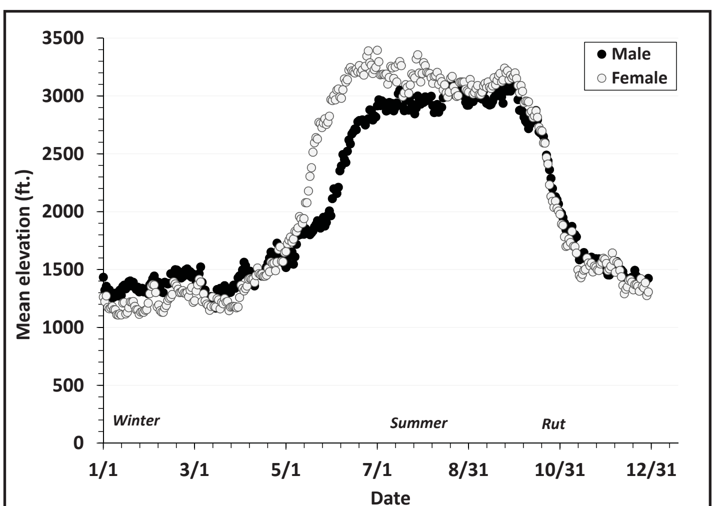

Figure 10: Relationship between mountain goat mean daily elevation and time of year for GPS-marked male and female animals, 2005-2011, Lynn Canal, AK. Elevation, 2005-2010.

mountain goat diets. Specifically, sedges/rushes, lichens, forbs and ferns (in order of decreasing importance) comprised 85% of diets. Interestingly, some differences in diet composition between the sexes was evident. In particular, preliminary evidence suggests that sedges/rushes were more common in male diets while ferns were more common in female diets (Figure 6). Overall, the most common individual food items in diets during summer-fall were *Carex* sp. (20.7%), *Luzula/Juncus* sp. (14.4) (sedges/rushes), *Cladonia* sp. (11.4)(lichen), *Lupinus nootkatensis* (8.6%)(forb) and unidentified fern rhizomes (7.4%) (Figure 7a). During winter, diets were overwhelmingly composed of conifer needles (*Tsuga* sp., 72.5%) and also included *Lobaria* sp. lichen (11.7) and *Vaccinium* sp. (9.9%)(Figure 7b).

Habitat Selection, Activity and Movement Patterns

Activity.—Mountain goat activity patterns demonstrated distinct seasonal patterns (Figure 8). In general, activity was lowest during December-April (ie. winter) and increased substantially during green-up and peaked in mid-summer (Figure 8). Activity gradually declined during late-summer into fall (Figure 8). Interestingly, activity declined substantially during late-October through early-December among males, but not females (Figure 8).

The reduction in activity among males during late-fall coincides with the breeding season, or rut. Geist (1964) and Mainguy et al. (2008) described a similar pattern among Canadian mountain goats. The reduced activity during the rut is specifically related to a decline in foraging and an increase in standing behavior (Mainguy et al. 2008). The reduction in foraging among males during the breeding seasonal is commonly observed in polygynous ungulates. This phenomena is not completely understood but may be related to production of scent marking compounds that physiologically result in appetite suppression (Miquelle 1990). The increase in standing behavior during the rut may be related to males investing time in looking for mates (and presumably monitoring reproductive receptivity) and competing males (Mainguy et al. 2008).

The reduction in activity during winter is likely related to senescence of deciduous vegetation and accumulation of snow. These factors result in significant reductions in forage quality and availability and increases in costs of locomotion. As a consequence, mountain goats, like other northern ungulates (i.e. Parker et al. 2009), experience a negative energy balance during the long winter season and engage in behavioral strategies designed to reduce energetic expenditures in order to conserve endogenous nutritional reserves.

Movement Patterns.—Mountain goat movement rates exhibited seasonal variation such that movement rates were low (ca. 100 m/6-hrs) during winter and 4-5 times higher during mid-summer (400-500 m/6-hrs)(Figure 9). Similar to activity patterns, movement rates generally increased during late-spring (ca. mid-May) and declined during fall (mid-Sept). Within this seasonal framework, sex- and reproduction-specific differences were evident. Specifically, parous females demonstrated a distinct 2-4 week depression in movement rates during the parturition, or kidding, season relative to females that did not have a kid (Figure 9). This pattern is likely related to the restricted mobility of neonates during the first few weeks of life. During the fall breeding season, male movement rates increased significantly relative to females (Figure 9). This pattern likely occurs because polygynous males are travelling widely during the breeding season in search of receptive females. During the winter, movement rates are severely restricted, similar to activity, and represent a behavioral strategy designed to reduce energetic costs in nutritionally depauperate, snowy winter ranges.

Wintering Strategies and Elevational Distribution.—Along the Pacific coast, mountain goats exhibit elevational migrations from alpine summer range to low-elevation, forested winter ranges where snow depths are relatively reduced (Herbert and Turnbull 1977, Fox et al. 1989). This pattern contrasts with mountain goat populations in colder, drier (generally interior) climates where mountain goats typically winter at high elevations on windblown slopes. In our study area, nearly all animals exhibited migrations to low elevation habitats between 1000-1500 feet, on average (Figure 10). In some areas, particularly along Lynn Canal, mountain goats spent considerable time below 500 feet, including several cases where animals wintered in close proximity to high tide line. In contrast, in a few isolated instances mountain goats in specific locations (i.e. Meade Glacier, Antler Lake, Grandchild Peaks; n = 7 animals) wintered at high elevations. This is likely linked to colder, drier and windier climates in these areas and/or restricted access to warmer, less snowy coastal wintering habitats. Nonetheless, nearly 95% of the mountain goats monitored with GPS radio-collars wintered in low elevation forested habitats. Typically, migration from low elevation winter ranges to alpine summer range commenced in mid-May; females tended to initiate migrations ca. 2 weeks earlier than males, on average (Figure 10). Migration from summer range to winter ranges typically commenced in mid-October and coincided with the first significant alpine snowfall events (Figure 10).

Resource Selection Modeling.—Mountain goat resource selection was analyzed separately for the winter and summer seasons based on previously described differences in seasonal altitudinal distribution (Figure 10). In addition,

Table 2a. Resource selection function (RSF) coefficients for remote-sensing variables used to derive RSF models for mountain goats in the Lion Head/Sinclair/Villard study areas, 2005-2011, Lynn Canal, AK

	Winter			Summer		
Variable	Coefficient	LCI	UCI	Coefficient	LCI	UCI
elevation	-7.424985	-8.805059	-6.044912	1.606339	1.167352	2.045325
elevation^2	-2.946404	-3.644584	-2.248223	-3.326321	-3.640783	-3.011859
cliffs	-1.843572	-2.158784	-1.528361	-0.651351	-0.833230	-0.469473
slope	1.190326	0.974464	1.406187	0.599884	0.413313	0.786455
slope^2	-0.363247	-0.445018	-0.281475	-0.367023	-0.445540	-0.288505
solar (Jan 1)	0.541136	0.235795	0.846477	NA	NA	NA
solar (Jan 1)^2	-0.883769	-1.089006	-0.678532	NA	NA	NA
solar (Aug 1)	NA	NA	NA	0.221452	0.059737	0.383167
solar (Aug 1)^2	NA	NA	NA	-0.221750	-0.325468	-0.118032
VRM	0.722373	0.563777	0.880968	0.233641	0.151278	0.316004
VRM^2	-0.272687	-0.330349	-0.215025	-0.052771	-0.070885	-0.034657

Table 2b. Resource selection function (RSF) coefficients for remote-sensing variables used to derive RSF models for mountain goats in the East Berners study area, 2006-2011, Lynn Canal, AK

	Winter			Summer		
Variable	Coefficient	LCI	UCI	Coefficient	LCI	UCI
elevation	-2.812129	-4.650915	-0.973344	2.161979	1.764804	2.559154
elevation^2	-2.556290	-3.365947	-1.746633	-2.427439	-2.883036	-1.971843
cliffs	-5.235536	-7.275517	-3.195555	-2.436600	-3.431124	-1.442076
slope	-0.653048	-0.949059	-0.357037	--	--	--
slope^2	-0.233425	-0.441483	-0.025367	--	--	--
solar (Jan 1)	1.376696	0.586528	2.166864	NA	NA	NA
solar (Jan 1)^2	-0.438847	-0.861545	-0.016149	NA	NA	NA
solar (Aug 1)	NA	NA	NA	0.266072	-0.072772	0.604916
solar (Aug 1)^2	NA	NA	NA	-0.265269	-0.429749	-0.100790
VRM	0.173776	-0.174946	0.522499	--	--	--
VRM^2	-0.310421	-0.516873	-0.103968	--	--	--

apparent differences in winter range elevational distribution between the East Berners and Lynn Canal areas (Lions Head, Mt. Sinclair and Mt. Villard) justified derivation of separate resource selection functions for those two areas.

Overall, resource selection was modeled using five terrain variables (Table 1, Appendix 1), with the exception of the East Berners summer model which included three terrain variables (Table 2a, 2b). With the exception of the "distance to cliff" variable both linear and quadratic terms were used to describe selection functions for each variables. In a few cases, variable coefficients calculated for individual animals resulted in extreme values (i. e. <3 standard deviations of the mean), apparently due to unusual individual selection patterns. Such individuals were considered outliers and systematically removed from analyses. This procedure was necessary to ensure that models accurately represented selection patterns of a majority of animals and that final model coefficients were not unduly influenced by animals exhibiting atypical behavior.

In general, mountain goat selection patterns for most terrain variables were similar during winter and summer; elevation was the only variable for which seasonal selection patterns differed substantially (Table 2a-b, Appendix 8a-b, Appendix 9a-h). Overall, mountain goats selected for areas close to cliffs with moderately steep, rugged slopes that had moderate-high solar exposure. Within this context, mountain goats selected for low elevation areas during winter and moderate-high elevation areas during summer. Interestingly, mountain goats tended to winter at slightly higher elevations in the East Berners study area relative to the Lynn Canal study areas. In the Lynn Canal area steep rugged terrain often continuously extends from alpine areas to sea level. Whereas, on the east side of Berners Bay steep terrain often terminates at mid-elevation upland areas of moderate slope and less commonly extend to sea level.

Despite these general patterns in resource selection it is important to note that individual variation in resource selection was detected such that some individual animals demonstrated resource selection patterns that differed from the majority of animals. For example, the few marked animals in the upper Meade Glacier and Antler Lake areas wintered at high elevations, a phenomena that is probably linked to local climate and/or inaccessibility of low elevation forested winter ranges. Consequently, as described previously, it is important to recognize that our models represent “average” resource selection patterns and may not be representative for every animal and specific locality in the study area.

Model validation results indicated that resource selection models accurately predicted actual use patterns of GPS-marked mountain goats (Table 3). The Lynn Canal models tended to perform better than models for East Berners. Since the Lynn Canal models were developed with substantially more mountain goat GPS location data it is not surprising that the Lynn Canal models more accurately predicted actual use patterns than the East Berners models. The winter model for East Berners was characterized by the lowest performance (though validation results still indicated a significant relationship between actual and predicted use). This occurred because the model tended to under represent use in some areas (i.e. areas with low RSF scores were used more than predicted). Consequently, the winter modeling output for the East Berners area (i.e. Appendix 9)

Table 3. RSF model validation results for the Lynn Canal and East Berners areas relative to season. Cross-validated Spearman-rank correlations (r_s) between RSF bin ranks and area-adjusted frequencies for individual and average model sets reported below provide an indication of the extent to which RSF models accurately predicted actual use of iteratively witheld data from GPS-marked animals.

Lynn Canal	winter		summer	
Set	r_s	P-value	r_s	P-value
1	0.99	<0.001	0.99	<0.001
2	1.00	<0.001	1.00	<0.001
3	0.99	<0.001	0.99	<0.001
4	1.00	<0.001	0.99	<0.001
5	0.96	<0.001	1.00	<0.001
Average	1.00	<0.001	1.00	<0.001

East Berners	winter		summer	
Set	r_s	P-value	r_s	P-value
1	0.66	0.044	0.99	<0.001
2	0.88	0.002	0.61	0.066
3	0.19	0.608	0.96	<0.001
4	0.79	0.010	0.99	<0.001
5	0.94	<0.001	0.96	<0.001
Average	0.77	0.014	0.99	<0.001

Figure 11: Photograph of an adult female and kid during January 2012 illustrating use of extremely low elevation habitats along Lynn Canal during winter. The photograph was taken ca. 1 km south of the Gran Point sealion haul-out.

should be considered a conservative representation of actual mountain goat winter use and distribution in this area.

In summary, our analyses describe a strong affinity of mountain goats for areas with steep, rugged terrain in close proximity to cliffs, a pattern previously described for the species in southeastern Alaska (Fox et al. 1989) and elsewhere (Festa-Bianchet and Cote 2007). In fact, terrain characteristics can be considered a key prerequisite for predicting mountain goat habitat, irrespective of season. However, during winter, mountain goat selection is further constrained to include lower elevation habitats that are typically vegetated with closed canopy conifer forest. Such habitats have reduced snow depths (Kirchhoff 1987) and thus greater forage availability (Fox 1983, White et al. 2009) and reduced costs of locomotion (Dailey and Hobbs 1989). Nonetheless, snow shedding characteristics of steep terrain also reduces snow depth resulting in use of non-forested habitats in some cases (particularly if sites are characterized by high solar radiation). In locations where steep terrain continuously extends from high elevation summer range to sea level, such as along Lynn Canal, mountain goats will winter at extremely low elevations, including on cliffs immediately above high tide line (Figure 11). In eastern Lynn Canal, 25.3 km of the highway alignment intersect areas in the "moderate" to "high" RSF categories. However, in other localities, such as east of Berners Bay, steep terrain does not consistently extend to sea level and mountain goats winter at slightly higher elevations, on average.

Winter Severity and Snow Modeling

Snow Surveys.—Four field-based snow surveys were conducted within 3 days of April 1 during 2007-2008, 2010-2011 on Echo Ridge. Analyses of these data quantified the degree to which snow depth differs with increasing elevation between forested and non-forested sites (Appendix 10). Overall, these data quantify the extent to which snow depth varied relative to elevation and habitat type (i.e. open vs. forest). Specifically, snow depth was 30-40 inches deeper in open relative to forested habitats, on average. Further, snow depth increased 2.3-2.7 inches per 100 foot gain in elevation, on average.

Climate Data.—Daily climate data were archived from the National Weather Service database to characterize broader scale climate patterns. Mean daily snow depth and snowfall data were summarized from data collected at the National Weather Service station in Haines, AK (Appendix 11-12). Mean snowfall in Haines during the study period (2005-2011) was 126% of the long-term normal (i.e. 1999-2011). Overall, snowfall in Haines during 4 of the 6 winters of the study was above normal; the winter of 2006/2007 experienced the greatest amount of snowfall recorded in Haines (and also at the longer-term monitoring site at the Juneau airport, 1943-2011).

Table 4: Proportion of radio-marked adult females seen with a kid at heel, 2005-2011, Lynn Canal, AK.

Year	Kid	No kid	n	Proportion with kid	SE
2005	8	4	12	0.67	0.14
2006	16	9	25	0.64	0.10
2007	20	12	32	0.63	0.09
2008	19	14	33	0.58	0.09
2009	15	10	25	0.60	0.10
2010	18	8	26	0.69	0.09
2011	15	6	21	0.71	0.10
All years	111	63	174	0.64	0.04

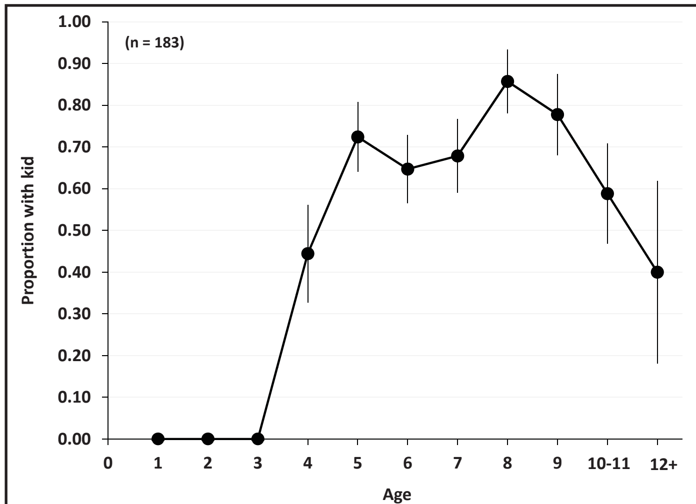

Figure 12: Proportion of radio-marked adult females observed with a kid at heel, by age, 2005-2011, Lynn Canal, AK.

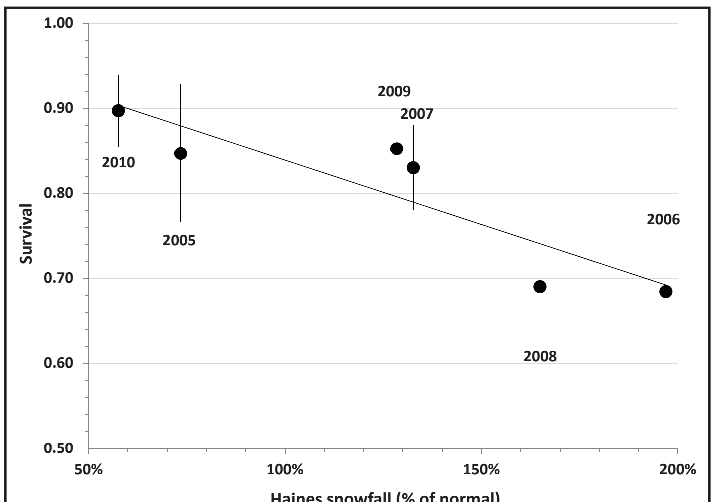

Figure 13: Relationship between mountain goat survival (males and females combined) in Lynn Canal and snowfall in Haines, AK, 2005-2011.

Reproduction and Survival

Kid Recruitment.—Kid recruitment of radio-marked female mountain goats was estimated by determining the percent-

Table 5: Estimates of mountain goat annual survival (Ŝ) for different sex classes during 2005-2011, Lynn Canal, AK. Mean winter snow depth and total snowfall recorded in Haines and Eaglecrest, AK is provided to index relative winter severity between years.

	Males				Females				Total				Haines		Eaglecrest	
													Snow Depth	Snowfall	Snow Depth	Snowfall
Year	At Risk	Died	Ŝ	SE	At Risk	Died	Ŝ	SE	At Risk	Died	Ŝ	SE	Mean (in)	Total (in)	Mean (in)	Total (in)
2005/2006	9.6	2	0.79	0.13	10.0	1	0.90	0.09	19.6	3	0.85	0.08	6	114	15	122
2006/2007	25.4	11	0.57	0.10	22.1	4	0.82	0.08	47.5	15	0.68	0.07	46	309	60	381
2007/2008	26.5	6	0.79	0.07	20.8	3	0.88	0.07	47.3	9	0.83	0.05	24	208	45	285
2008/2009	24.2	10	0.66	0.09	21.4	6	0.73	0.09	45.6	16	0.69	0.06	18	240	44	235
2009/2010	25.1	4	0.86	0.07	22.3	4	0.85	0.07	47.4	8	0.85	0.05	18	202	28	166
2010/2011	24.3	3	0.88	0.06	23.2	2	0.91	0.06	47.5	5	0.90	0.04	4	90	34	168
All years	133.3	37	0.76	0.03	117.8	21	0.84	0.03	251	58	0.79	0.02	19	194	38	226

At Risk = average number of animals monitored per month (per time period)

Snow Depth, Mean = calculated as daily mean between Nov 1-April 30

Eaglecrest, Elevation = 1200 ft.

age of radio-marked females seen with kids during May-June aerial telemetry surveys (Table 4). Since each radio-marked female was not observed daily during the kidding period, it was not possible to determine if kids were born and subsequently died prior to, or between, surveys. As such, estimates of kid production reported here are presumably lower than the actual percentage of females that gave birth. Nevertheless, our estimates of kid production were similar to estimates of kidding rates reported elsewhere (Festa-Bianchet and Cote 2007).

Past studies have documented late age at first reproduction for mountain goats, as compared to other ungulates (Festa-Bianchet and Cote 2007, Galliard et al. 2000). Consistent with these findings, we did not document any cases where females less than four years of age had kids at heel in summer (Figure 12, Appendix 13). Overall, kid production estimates varied with female age (range = 40-82%) such that younger and older females were generally less likely to have a kid at heel than prime-aged females (i.e. 7-9 years old; Figure 12). Annual estimates of kid production ranged from 58-71% between 2005-2011 (Table 4). Of 54 kids observed with radio-marked females during parturition and subsequently checked the following spring, between 23-57% were annually estimated to have survived (Appendix 14).

Survival.—Mountain goats were monitored monthly during fixed-wing aerial telemetry flights and/or via GPS-telemetry. Of the 153 animals monitored during 2005-2011, 58 animals died of various causes (Table 5). In general, most mortality occurred during late winter (February-May), however, substantially mortality also occurred during October, a period coinciding with the onset of winter conditions and migration to winter range (Appendix 15). Survival of males tended to be lower than females, a pattern previously documented in mountain goats (Festa-Bianchet and Cote 2007). Annual survival estimates varied between years and was negatively related to winter snowfall (Table 5, Figure 15), a finding that is consistent with a recently completed state-wide analysis (White et al. 2011). In general, the occurrence of relatively severe winter conditions over the last four years of study has resulted in lower than average survival rates, relative to other populations (Smith 1986, Festa-Bianchet and Cote 2007). The observed low rates of survival, particularly during severe winters between 2006-2009, have likely precipitated an overall decline in mountain goat populations in the study area, and elsewhere in the region.

Previous analyses have demonstrated that mountain goat population growth is highly sensitive to adult survival rates, particularly adult females, relative to other vital rate parameters (Hamel et al. 2006). The especially low survival rates observed during 2 out of 6 of the winters of study highlight the sensitivity of this population to natural environmental

Table 6. Categorical covariate summary, including proportion of animals seen under each sub-category, for mountain goat sightability trials conducted in southeastern Alaska, 2007-2011.

Variable	Category	Seen	Missed	Total	Prop Seen
Group Size	1	77	41	118	0.65
	2	46	24	70	0.66
	3	20	10	30	0.67
	4	14	2	16	0.88
	5	11	4	15	0.73
	6-10	20	0	20	1.00
	11-15	7	0	7	1.00
	16-20	3	0	3	1.00
	21-40	3	0	3	1.00
Behavior	Running	6	0	6	1.00
	Bedded	81	21	102	0.79
	Walking	45	22	67	0.67
	Standing	50	28	78	0.64
	Feeding	15	9	24	0.63
Landform	Mid-Slope	124	59	183	0.68
	Ridge	42	21	63	0.67
	Ravine	31	40	71	0.44
Slope	Flat	3	1	4	0.75
	Gentle	18	7	25	0.72
	Steep	72	31	103	0.70
	Moderate	76	35	111	0.68
	Very Steep	27	44	71	0.38
Terrain	Smooth	40	7	47	0.85
	Broken	125	66	191	0.65
	Very Broken	31	47	78	0.40
Habitat	Meadow	73	10	83	0.88
	Rocky	97	53	150	0.65
	Subalpine Conifer	13	21	34	0.38
	Thicket	9	22	31	0.29
	Snow	2	16	18	0.11
	Mature Conifer	0	3	3	0.00
Lighting	Sun	61	33	94	0.65
	High Overcast	101	67	168	0.60
	Shade	31	22	53	0.58
	Low Overcast	5	4	9	0.56
% Canopy Cover	0	121	63	184	0.66
	1-5	0	0	0	--
	6-25	3	3	6	0.50
	26-50	4	3	7	0.57
	51-75	6	8	14	0.43
	76-95	0	7	7	0.00
	95-100	0	19	19	0.00
Dist Terrain Obs (m)	0	3	3	6	0.50
	1-10	52	49	101	0.51
	11-25	35	10	45	0.78
	26-50	17	8	25	0.68
	51-100	16	3	19	0.84
	100-200	7	2	9	0.78

variation and suggest that resilience is relatively low compared to populations that experience less severe climatic variation. As such, its important to recognize that sustainable growth of mountain goat populations in the study area is likely to be more strongly affected by additive mortality factors, than would be expected in more productive populations.

Population Abundance and Composition

Aerial Survey Training Manual.—An aerial survey training manual was produced in order to ensure that moderately complicated aerial survey protocols could be consistently implemented by different observers. The manual focuses on describing specific field protocols, illustrating each habitat classification type and providing test cases to enable prospective observers to test their proficiency and calibrate their responses to other observers (White and Pendleton 2010). The manual is intended to be a working document and will be revised in the future as additional images and materials become available.

Aerial Surveys.—Overall, 60 aerial surveys were conducted during August-October 2005-2011 (Appendix 16). Due to weather constraints, complete surveys of pre-defined survey routes were conducted in 51 out of 60 instances; the remaining 9 surveys were incomplete and thus data should not be considered directly comparable to other surveys. During nearly all surveys, data were collected for purposes of developing individual-based and population-level sighting probability models (exceptions occurred when surveys were conducted prior to marking). In addition, complementary aerial surveys were conducted in areas outside of the study area (Haines, Baranof) where mountain goats were marked as part of independent studies. Collection of data in other areas enabled acquisition of additional sightability data resulting in opportunity to more accurately parameterize sightability models; however, a majority of the data used to develop models was collected in the Lynn Canal/ Berners Bay study areas.

Individual-based Sightability Data Collection.-During 2007-2011, habitat and behavioral covariate data were collected for 328 marked mountain goat observations during aerial surveys (Table 6). These data were paired with records of whether animals were either seen or not seen during routine surveys in order to compile a database suitable for determining factors related to mountain goat survey sighting probability.

In order to further examine patterns in these data, we fit logistic models to predict sighting probability as a function of the individual covariates listed in Table 6; models were fit using Bayesian procedures with the program OpenBUGS. Data for all of the covariates were not collected for each marked goat (i.e., some covariates were included only in later surveys), making the comparison of effects among the covariates somewhat more complex. Overall, the most important variables for predicting sighting probability are habitat (lower probability for all habitats relative to alpine meadows), group size (as a continuous variable), terrain (lower probability for very broken), and behavior (lower probability for bedded).

Table 7. Estimated number of mountain goats in the East Berners, Lions Head, Sinclair Mtn., and Mt. Villard study areas, 2005-2011. Estimates were derived using Bayesian methods and integrate survey-specific mark-resight estimates and modeled covariate-based survey-level estimates.

Year	Population Estimate	SE	LCI	UCI	# surveys
East Berners					
2005					0
2006	208	17	179	245	2
2007	264	18	232	304	3
2008	241	16	213	275	1
2009	137	7	125	152	1
2010	168	10	150	190	2
2011	250	18	218	288	1
Lion's Head					
2005	128	13	104	156	2
2006	164	9	149	182	4
2007	102	4	94	110	5
2008	133	7	120	149	2
2009	112	9	97	131	1
2010	124	7	111	140	2
2011	171	9	153	190	1
Sinclair Mtn.					
2005	383	33	326	454	2
2006	426	20	389	467	3
2007	211	11	191	235	3
2008	289	14	264	318	2
2009	--	--	--	--	0
2010	151	9	134	170	2
2011	171	2	167	176	1
Mt. Villiard					
2005	263	17	233	300	1
2006	338	26	291	393	2
2007	276	19	243	317	3
2008	444	31	384	504	1
2009	131	11	111	155	1
2010	161	14	137	190	1
2011	391	38	324	471	1

Survey-level Sightability Data Collection and Analyses.- During 2005-2011, 55 aerial surveys were conducted that provided adequate data for estimating survey-level sightability. Overall, survey-level sighting probability estimates ranged between 0.25-1.00, however sample sizes were generally small for meaningful comparisons between individual surveys. Nonetheless, the mean sighting probability among all surveys combined was 0.61, which likely provides a more reasonable estimate of mountain goat sighting probabilities during routine aerial surveys.

In addition, we fit logistic models to predict average sighting probability for all goats in an area during a survey as a function of survey level covariates including survey date, time of day, aircraft type, temperature, sky conditions, wind (median and maximum), and the number of observers (<=2 vs. 3) ; models were fit using Bayesian procedures with the program OpenBUGS. Bayesian models allow for including results from each survey along with covariate-based sighting functions produced across many surveys to improve the precision of the population estimates (relative to Lincoln-Petersen type estimates) and provide estimates when no marked goats were seen or when there were no marked goats in the area (with certain assumptions). These models also account for observed goats whose collar status could not be determined (i.e., the view was insufficient to determine whether the goat was collared or not); the prevalence of goats with unknown status was greatly reduced in later surveys through changes to field methods. The most important survey level covariates for predicting sighting probability are aircraft type (lower probability for surveys from a Helio Courier relative to a Hughes 500 helicopter or Piper PA-18 supercub), time of day (higher probability earlier in the day), and sky condition (lower probability when clear).

Population Estimates.-The number of mountain goats in each study area was estimated using Bayesian procedures (as described above) during 2005-2011 (Table 7). This method statistically integrates survey-specific mark-resight estimates and modeled covariate-based survey-level estimates resulting in a more precise estimate than either method could independently derive. In the future, it may be possible to further refine estimates by including individual-based sightability model estimates and, possibly, demographic modeling information (i.e. vital rates).

Overall, surveys were flown and estimates were derived for all study areas and all years, with the exception of East Berners in 2005 and Sinclair Mountain in 2009. In most cases, multiple surveys were flown in each area during each year. While interannual variation is evident in our estimates, precluding precise determination of population trends over time, results suggest that mountain goat populations in the study areas declined following the severe winter in 2006/2007 but appear to have modestly increased by 2011. Notably, study area-wide population estimates declined approximately 47% between 2006 (n = 1136) to 2010 (n = 604). These findings are consistent with estimates of mountain goat survival during the same period. Specifically, as described previously, mountain goat survival was particularly low during 2006/2007 (and also 2008/2009) but was substantially higher in 2010/2011 (Table 5).

SUMMARY

1. ADFG conducted a mountain goat population ecology study in the eastern Lynn Canal and Berners Bay areas during 2005-2012. This study focused on estimating mountain goat population size, vital rates, movement patterns and resource selection. The primary purpose of the research is to provide population-specific information necessary to manage the population in the event the proposed Juneau Access highway is constructed.

2. Genetic analyses determined that the study area was composed of three genetically distinct sub-populations that were divided by marine waters and/or flat, low elevation river valleys (i.e. east of Berners Bay, Kakuhan Range and north of the Katzehin River).

3. At the initiation of the study the mountain goat abun-

dance in the study area was consider moderate, relative to other areas in the region. However, study area-wide population estimates declined approximately 47% between 2006 (n = 1136) to 2010 (n = 604) following a succession of severe winters.

4. Adult mountain goat survival rates were negatively influence by winter severity. In addition, survival of adult males was considerably lower than adult females. Most mortality occurred in late-winter (Feb-May), however significant mortality was also documented in October.

4. Mountain goat reproductive productivity is low relative to other northern ungulates resulting from a late age at first reproduction, reproductive pauses and very low twinning rates (i.e. 1-2%).

5. Mountain goat activity and movement patterns exhibited distinct seasonal patterns. Activity and movement patterns were 3-4 times lower in winter as compared to summer. Movement rates of males increased significantly during the breeding season but activity rates were low (putatively due to mate tending behavior). Parturient females reduced movement during parturition, presumably to accommodate limited mobility of neonates.

6. Mountain goats exhibited elevational migrations from alpine summer ranges to low elevation forested winter ranges. Downslope migrations in autumn appeared to coincide with the onset of high elevation snowfall events. Spring migrations coincided with snow ablation and, in the case of females, the parturition period.

5. Resource selection function (RSF) modeling indicated that mountain goats select for steep, rugged terrain in close proximity to cliffs with moderate-high solar exposure. Within this context mountain goats select for low elevation ares in winter and moderate-high elevations in summer. Mountain goats selected for lower elevation wintering areas in eastern Lynn Canal area as compared to animals that wintered east of Berners Bay.

6. The proposed Juneau Access highway alignment intersects important mountain goat wintering areas along eastern Lynn Canal.

7. Implications of highway construction for local mountain goat populations include the potential for mountain goat-vehicle collisions, sub-lethal disturbance and increased human access. Such conditions may result in modification of mountain goat management strategies and include changing the existing registration hunt to a more restrictive limited-entry drawing hunt.

RECOMMENDATIONS

Mountain Goat Population Management

Population Size and Productivity.—The Alaska Department of Fish and Game and the Board of Game have constitutionally mandated obligations to manage mountain goat populations in Berners Bay and eastern Lynn Canal areas for sustained yield. Data from this study indicate the mountain goat populations in this area occur a moderate density, relative to other areas in southeastern Alaska, but declined by approximately 47% in recent years following a series of severe winters. Winter snowfall is an important factor that exerts strong effects on mountain goat survival and population dynamics (White et al. 2012). This study area was characterized by relatively severe winter conditions during most years and local populations are likely to experience periodic depressions in productivity, survival and population growth in the future. As such, local populations are likely especially sensitive to other factors that have potentially negative effects on mountain goats (i.e. disturbance factors, predation, disease) and should be managed carefully and conservatively. In recent years, harvest in these populations has been effectively managed via registration hunts and occasional use of emergency order closures in certain areas (i.e. Mt. Villard). Nonetheless, based on the recent population decline documented in this study harvest quotas should be reduced, relative to pre-2006 levels, and informed using demographic models based on data collected during this study. Further, use of the detailed mountain goat movement data gathered during research investigations should be used to redefine hunt area boundaries to more closely match mountain goat demographic boundaries.

Human Access.—The construction of the Juneau Access highway would result in increased human access to areas determined to be high value mountain goat habitats. Increased human access (i.e. recreational and industrial) will increase the potential for disturbance of mountain goats, particularly in low elevation wintering habitats. However, perhaps more importantly, large numbers of hunters from Juneau (population: ca. 30,000) will be afforded unprecedented access to high quality mountain goat range. Such access will result in difficulties managing harvest quotas under existing (registration hunt) regulations; similar to outcomes resulting from construction of the Skagway-White Pass highway in the 1970's (Ryan Scott, pers. comm.). Following road construction, hunting opportunities in this area should be regulated using more restrictive limited-entry drawing hunts in order to avoid overharvest. In addition, smaller more geographically distinct hunt areas should be created to avoid localized depletion of mountain goats. Finally, a specific management strategy should be considered for areas in the vicinity of Haines in order to respect and to maintain traditional harvest patterns.

Post-construction Highway Effects.—As described above, findings from this study document spatial overlap of the Juneau Access highway corridor and high value mountain goat wintering habitat. In such areas the probability of lethal and sub-lethal (i.e. Frid and Dill 2002) highway effects on mountain goats will increase following highway construction. Such effects should be carefully documented and explicitly integrated into mountain goat harvest strategies. For example, coordination between ADFG and law enforcement agencies will be required to accurately document mountain goat-vehicle collisions and reduce harvest quotas accordingly. In order to assess the extent to which sub-lethal effects alter population size and productivity future studies are recommended that compare the existing baseline data to comparable data collected during and after construction of the highway. Such studies would help wildlife managers determine how the highway affects mountain goat habitat use and population dynamics and, ultimately, ensure that local mountain goat populations are managed in a manner that explicitly incorporates sub-lethal effects.

Highway Mitigation and Design

Mountain Goat-Vehicle Collisions.—The Alaska Department of Transportation (DOT/PF) has a stated interest in reducing or mitigating the likelihood of mountain goat-vehicle collisions along the Juneau Access highway, in the event it is constructed. Findings from this study indicate that highway alignment intersects areas of moderate-high mountain goat winter use (i.e. 25.3 km) along eastern Lynn Canal and, to a lesser extent, east of Berners Bay; the Berners Bay and Katzehin beach forelands and the Slate Cove-Comet beach areas are not considered mountain goat habitat (Figure 14, Appendix 18-19). Consequently, to mitigate mountain goat-vehicle collisions DOT/PF should concentrate mitigation and design efforts in the eastern Lynn Canal and Berners Bay areas. Mountain goat-vehicle collision risk is only prevalent during the winter months (Nov-early May) but occurs during seasonal periods of reduced daylight and poor driving conditions resulting in increased difficulty of seeing and avoiding animals in low-light conditions. Appropriate design strategies for reducing mountain goat-vehicle collisions would involve, but are not limited to, "wildlife crossing" signage, reduced speed limits, structural design features (i.e. Singer et al. 1985, Clevenger and Huijser 2011) and adequate sight lines to enable drivers to see mountain goats that are in close proximity to the road (particularly relevant in conifer forest areas). Ultimately, fine-scale highway design that integrates field visits to identify traditionally used mountain goat trails, mountain goat GPS location data and geotechnical highway construction constraints is recommended in order to maximize efficacy of mountain goat-vehicle collision planning and mitigation. Such site specific analyses was beyond the scope of the current study but is recommended via future collaboration between ADFG and DOT/PF.

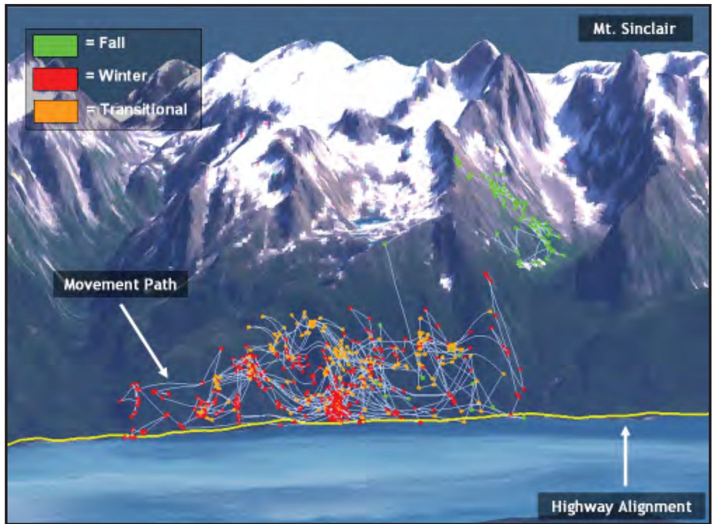

Figure 14: Three-dimensional depiction of seasonal movement patterns of a GPS radio-marked adult female mountain goat (LG-004) illustrating use of low elevation wintering habitats in close proximity to Lynn Canal and the Juneau Access road alignment during 2005-2006.

Mitigation strategies designed to reduce the incidence of mountain goat-vehicle collisions, as described above, are feasible but implementation success is uncertain based on limited previous study. Detailed post-development studies designed to determine effectiveness of site-specific mitigation prescriptions are recommended to ensure mitigation strategies are optimized for reducing mountain goat-vehicle collisions.

Avalanche Control.—Avalanche chutes are prevalent along the eastern side of Lynn Canal and Berners Bay and intersect the highway alignment in many areas. Human safety concerns require avalanche control activities upslope from the road corridor in areas adjacent to or current used by mountain goats during winter. Avalanche control activities (ie. helicopter surveillance, blasting) will cause significant disturbance to mountain goats in such areas. Further, because mountain goats occasionally forage in avalanche chutes during winter (including during times of high avalanche danger) the likelihood exists for mountain goats to be killed in human instigated avalanches that occur during routine control activities. Such direct mortalities could be mitigated if avalanche control crews examined avalanche chutes for the presence of mountain goats prior to blasting and adjusted avalanche control scheduling to occur during times when mountain goats were not present in avalanche paths.

FUTURE WORK

The mountain goat population monitoring and assessment work funded by FHWA and DOT/PF (2005-2012) and conducted in association with the Juneau Access project has been completed. However, companion studies associated with monitoring mountain goats in the vicinity of the Kensington Mine are planned to continue during the operational phase on mining operations (the current funding agreement between ADFG and Coeur Alaska continues through 2015 but is expected to be renewed by Coeur Alaska thereafter). The project area for ongoing mine-related monitoring work encompasses the area between Slate cove and the Katzehin River (i.e. the "Lions Head" and "Sinclair" study areas). In this area study animals (2012, n = 31) will continue to be monitored monthly to assess reproductive status and survival. Additionally, at 8-week intervals GPS data will be downloaded from each animal during aerial surveys. These data will be post-processed and integrated with the existing GPS location database. During late-summer 6-8 mountain goats will be captured to ensure scientifically defensible sample sizes are maintained. Three replicate aerial surveys will be conducted in early-fall 2012, weather permitting, in order to estimate mountain goat sightability, population abundance and composition. Results of these efforts will be summarized and submitted to Coeur Alaska and associated stakeholders as an annual research project report in fall 2012.

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Appendix 1: Variable definitions and coding used for modeling mountain goat resource selection in Lynn Canal, AK.

Lynn Canal Model

Variable	Transformation
elevation	elevation = [(elevation (m) - 781.488)/452.950]
$elevation^2$	$elevation^2$ = $(elevation)^2$
distance to cliffs	distance to cliffs = [(distance to cliffs (m) - 271.705)/337.733]
slope	slope = [(slope (deg) - 25.8196)/13.0668]
$slope^2$	$slope^2$ = $(slope)^2$
solar (Jan 1)	solar (Jan 1) = [(solar (Jan 1) - 552.708)/280.269]
solar $(Jan\ 1)^2$	solar (Jan 1) = $[solar\ (Jan\ 1)]^2$
solar (Aug 1)	solar (Aug 1) = [(solar (Aug 1) - 4011.030)/829.095]
solar $(Aug\ 1)^2$	solar (Aug 1) = $[solar\ (Aug\ 1)]^2$
VRM	VRM = [(VRM-0.00245)/0.00415]
VRM^2	VRM^2 = $(VRM)^2$

East Berners Model

Variable	Transformation
elevation	elevation = [(elevation (m) - 774.5089)/402.6433]
$elevation^2$	$elevation^2$ = $(elevation)^2$
distance to cliffs	distance to cliffs = [(distance to cliffs (m) - 233.7697)/220.9756]
slope	slope = [(slope (deg) - 27.03548)/11.54356]
$slope^2$	$slope^2$ = $(slope)^2$
solar (Jan 1)	solar (Jan 1) = [(solar (Jan 1) - 500.9735)/284.6371]
solar $(Jan\ 1)^2$	solar (Jan 1) = $[solar\ (Jan\ 1)]^2$
solar (Aug 1)	solar (Aug 1) = [(solar (Aug 1) - 3867.067)/867.823]
solar $(Aug\ 1)^2$	solar (Aug 1) = $[solar\ (Aug\ 1)]^2$
VRM	VRM = [(VRM-0.002367)/0.004453]
VRM^2	VRM^2 = $(VRM)^2$

Appendix 2: Mountain goat capture summary, 2005-2011, Lynn Canal, AK

Mtn Goat ID	Capture Date	Study Area	Collar Type	Sex	Est. Age	Kid	Weight (lbs.)	Rump Fat (cm)	Total Lgth (in)	Base Circ (in)	Status
LG001	9/26/2005	Lions Head	GPS-SST	M	9	--	308	1.4	8 13/16	4 15/16	Died, 4/17/2006
LG002	9/26/2005	Lions Head	GPS-SST	F	11	1	140	0.8	8 11/16	4	Died, 4/16/2006
LG003	9/26/2005	Lions Head	GPS-SST	F	7	1	180	0.9	9 5/16	4	Died, 4/10/2007
LG004	9/26/2005	Sinclair	GPS-SST	F	7	1	196	0.7	9 15/16	4 2/16	Release, 8/15/2007
LG005	9/26/2005	Sinclair	GPS-SST	M	9	--	--	0.7	9 4/16	5 6/16	Died, 5/9/2007
LG006	10/2/2005	Lions Head	GPS-SST	M	8	--	347	0.7	7 5/16	5 4/16	Died, 2/10/2006
LG007	10/2/2005	Lions Head	GPS-SST	M	2	--	163	0.0	8 15/16	5 7/16	Release, 8/15/2007
LG008	10/2/2005	Lions Head	GPS-SST	F	5	0	171	0.0	7 10/16	4 4/16	Release, 8/15/2007
LG008*	8/15/2010	Lions Head	GPS-SOB	F	7	1	172	--	7 13/16	4	Alive
LG009	10/2/2005	Lions Head	GPS-SST	F	10	0	--	1.2	8 6/16	4 7/16	Release, 8/15/2007
LG010	10/3/2005	Sinclair	GPS-SST	F	7	1	187	1.0	8 10/16	4 2/16	Release, 8/15/2007
LG011	10/3/2005	Sinclair	GPS-SST	M	9	--	335	1.6	9 8/16	5 8/16	Died, 2/11/2007
LG012	10/3/2005	Villard	GPS-SST	F	8	1	196	1.0	10 1/16	4 7/16	Release, 8/15/2007
LG013	10/3/2005	Villard	GPS-SST	F	9	1	--	--	--	--	Died, 10/5/2005
LG014	10/3/2005	Villard	GPS-SST	F	5	0	211	1.4	10 1/16	4 8/16	Release, 8/15/2007
LG014*	9/1/2009	Villard	GPS-SST	F	11	0	190	--	10 11/16	4 2/16*	Died, 6/2011
LG015	10/3/2005	Villard	GPS-SST	M	6	--	279	0.8	9 8/16	5 11/16	Release, 8/15/2007
LG015*	9/24/2008	Villard	VHF	M	8	--	303	--	9 11/16	5 10/16	Alive
LG016	10/14/2005	Sinclair	GPS-SST	M	5	--	273	0.9	8 9/16	5 5/16	Release, 8/15/2007
LG017	10/14/2005	Villard	GPS-SST	F	7	1	161	0.3	9 1/16	4 1/16	Release, 8/15/2007
LG017*	8/19/2008	Villard	VHF	F	8	0	149	--	8 14/16	3 12/16	Died, 1/2011
LG018	10/14/2005	Villard	GPS-SST	M	3	--	196	0.3	9 8/16	5 5/16	Release, 8/15/2007
LG019	10/15/2005	Lions Head	GPS-SST	M	5	--	273	--	9 6/16	5 9/16	Died, 6/26/2006
LG020	10/15/2005	Lions Head	GPS-SST	M	8	--	285	0.3	8 7/16	5 4/16	Release, 8/15/2007
LG021	10/15/2005	Lions Head	GPS-SST	F	4	0	194	1.0	9 9/16	4 7/16	Release, 8/15/2007
LG022	10/15/2005	Lions Head	GPS-SST	F	8	1	--	0.3	8 9/16	4 3/16	Release, 8/15/2007
LG023	10/15/2005	Lions Head	GPS-SST	M	9	--	221	0.2	9 3/16	5 1/16	Release, 8/15/2007
LG024	7/28/2006	Lions Head	GPS-SST	M	3	--	134	0.0	8 12/16	4 14/16	Died, 7/13/2008
LG025	7/28/2006	Lions Head	GPS-SST	F	6	1	130	0.5	8 4/16	3 14/16	Died, 5/11/2007
LG026	7/28/2006	Lions Head	GPS-SST	M	6	--	251	1.9	8 8/16	4 12/16	Died, 11/17/2006
LG027	7/28/2006	Lions Head	GPS-SST	M	10	--	274	0.9	10 4/16	5 4/16	Died, 12/31/2007
LG028	7/28/2006	Lions Head	GPS-SST	M	8	--	--	--	9 6/16	5 8/16	Died, 7/18/2007
LG029	7/28/2006	Sinclair	GPS-SST	F	7	0	160	0.7	9 2/16	3 12/16	Release, 9/11/2008
LG030	7/28/2006	Lions Head	GPS-SST	F	8	?	--	0.8	8 14/16	3 14/16	Died, 4/25/2007
LG031	7/28/2006	East Berners	GPS-SST	M	12	--	223	1.2	9 14/16	5	Died, 3/18/2007
LG032	7/28/2006	East Berners	GPS-SST	F	4	1	138	0.8	8 2/16	3 12/16	Died, 6/6/2007
LG033	7/29/2006	East Berners	GPS-SST	M	9	--	256	1.2	9 8/16	5 10/16	Died, 5/12/2007
LG034	7/29/2006	East Berners	GPS-SST	M	6	--	258	0.4	8 8/16	5	Release, 9/11/2008
LG035	7/29/2006	East Berners	GPS-SST	F	5	1	--	0.0	8 12/16	4 2/16	Release, 9/11/2008
LG036	7/29/2006	Lions Head	GPS-SST	M	6	--	308	2.0	10	5 12/16	Release, 9/11/2008
LG037	7/29/2006	Lions Head	GPS-SST	M	4	--	216	0.2	8 6/16	5 2/16	Died, 2/18/2008
LG038	7/29/2006	Lions Head	GPS-SST	F	4	0	141	1.0	7 10/16	4 4/16	Release, 9/11/2008
LG039	8/29/2006	Sinclair	GPS-SST	F	10	0	165	1.0	8 11/16	3 12/16	Died, 5/10/2007

Appendix 2 (continued): Mountain goat capture summary, 2005-2011, Lynn Canal, AK

Mtn Goat ID	Capture Date	Study Area	Collar Type	Sex	Est. Age	Kid	Weight (lbs.)	Rump Fat (cm)	Total Lgth (in)	Base Circ (in)	Status
LG040	8/29/2006	Sinclair	GPS-SST	M	8	--	--	--	8 5/16	5 4/16	Release, 9/11/2008
LG040*	9/24/2008	Sinclair	VHF	M	10	--	309	--	8 6/16	5 3/16	Alive
LG041	8/29/2006	Sinclair	GPS-SST	F	5	1	--	--	--	--	Release, 9/11/2008
LG042	8/29/2006	Villard	GPS-SST	F	3	0	178	1.2	9 7/16	4 4/16	Release, 9/11/2008
LG043	8/29/2006	Villard	GPS-SST	F	4	1	164	0.8	9 8/16	4 2/16	Release, 9/11/2008
LG044	8/29/2006	Villard	GPS-SST	M	12	--	--	1.2	9 9/16	5 5/16	Died, 10/19/2006
LG045	9/25/2006	Sinclair	GPS-SST	F	6	0	185	1.1	9 2/16	4 1/16	Release, 9/11/2008
LG046	9/25/2006	Villard	GPS-SST	M	8	--	331	0.8	9 13/16	5 8/16	Died, 9/1/2008
LG047	9/25/2006	Villard	GPS-SST	M	11	--	294	0.3	8 2/16	5 1/16	Died, 2/23/2007
LG048	9/25/2006	Villard	GPS-SST	M	12	--	291	0.3	9 3/16	5 1/16	Died, 4/26/2007
LG049	9/25/2006	Villard	GPS-SST	M	6	--	340	--	9 7/16	5 3/16	Release, 9/11/2008
LG050	10/7/2006	Lions Head	GPS-SST	M	8	--	250	--	8 7/16	5 1/16	Died, 4/17/2007
LG051	10/7/2006	Sinclair	GPS-SST	F	2	0	145	--	6 1/16	3 13/16	Release, 9/11/2008
LG052	10/7/2006	Sinclair	GPS-SST	F	3	0	160	--	8 3/16	4 2/16	Release, 9/11/2008
LG053	10/7/2006	Lions Head	GPS-SST	M	3	--	171	--	7 5/16	4 15/16	Release, 9/11/2008
LG054	10/12/2006	Villard	GPS-SST	M	7	--	320	--	9 12/16	5 9/16	Release, 9/11/2008
LG055	10/12/2006	Villard	GPS-SST	F	12	0	203	--	9	3 12/16	Died, 10/31/2006
LG056	10/12/2006	Villard	GPS-SST	M	9	--	339	--	9 12/16	5 3/16	Died, 4/16/2007
LG057	10/12/2006	Villard	GPS-SST	F	8	1	180	--	7	3 12/16	Died, 8/5/2007
LG058	10/12/2006	Villard	GPS-SST	M	4	--	263	--	9 7/16	5 3/16	Release, 9/11/2008
LG059	10/12/2006	Villard	GPS-SST	F	5	1	158	--	8 12/16	3 15/16	Release, 9/11/2008
LG060	10/13/2006	Sinclair	GPS-SST	M	5	--	287	--	9 8/16	5 7/16	Release, 9/1/2008
LG061	10/13/2006	Sinclair	GPS-SST	M	10	--	350	--	10 3/16	5 8/16	Release, 8/18/2008
LG061*	8/18/2008	Sinclair	VHF	M	12	--	301	--	10 4/16	5 7/16	Died, 5/2009
LG062	10/13/2006	Sinclair	GPS-SST	M	10	--	310	--	9 9/16	5 7/16	Release, 9/1/2008
LG063	10/13/2006	Sinclair	GPS-SST	M	10	--	297	--	8 12/16	6 2/16	Died, 3/16/2007
LG064	10/13/2006	Sinclair	GPS-SST	M	4	--	281	--	9	5 9/16	Died, 10/4/2007
LG065	7/29/2007	East Berners	GPS-SST	M	8	--	252	--	9 7/16	5 9/16	Died, 9/4/2008
LG066	7/29/2007	East Berners	GPS-SST	F	7	1	147	--	8 7/16	3 14/16	Release, 6/6/2010
LG067	7/29/2007	East Berners	GPS-SST	M	11	--	--	--	9 11/16	5 7/16	Died, 9/20/2007
LG068	7/29/2007	East Berners	GPS-SST	F	11	0	171	--	9 12/16	4 2/16	Died, 4/24/2009
LG069	7/29/2007	Lions Head	GPS-SST	M	1	--	95	--	5 8/16	4 4/16	Died, 10/31/2008
LG070	7/29/2007	East Berners	GPS-SST	F	5	1	139	--	7 11/16	3 13/16	Release, 6/6/2010
LG071	8/1/2007	Villard	GPS-SST	F	5	1	164	--	9 9/16	4 5/16	Died, 4/1/2009
LG072	8/1/2007	Villard	GPS-SST	F	5	1	165	--	9 14/16	4 5/16	Died, 10/24/2007
LG073	8/1/2007	Villard	GPS-SST	M	11	--	309	--	9	5 12/16	Died, 3/28/2008
LG074	8/1/2007	Villard	GPS-SST	M	6	--	298	--	9 8/16	5 12/16	Release, 6/6/2010
LG075	8/2/2007	Sinclair	GPS-SST	M	3	--	141	--	7 14/16	5 4/16	Died, 7/7/2008
LG076	8/2/2007	Sinclair	GPS-SST	F	4	1	155	--	8 8/16	4 6/16	Died, 8/8/2009
LG077	8/2/2007	Sinclair	GPS-SST	M	6	--	249	--	8 3/16	5 4/16	Died, 10/17/2008
LG078	8/2/2007	Sinclair	GPS-SST	F	9	1	175	--	8 2/16	3 14/16	Release, 9/11/2008
LG079	8/2/2007	Sinclair	GPS-SST	M	11	--	269	--	9 10/16	5 12/16	Died, 8/24/2007
LG080	8/2/2007	Sinclair	GPS-SST	M	6	--	281	--	7 4/16	5 2/16	Release, 9/11/2008

Mtn Goat ID	Capture Date	Study Area	Collar Type	Sex	Est. Age	Kid	Weight (lbs.)	Rump Fat (cm)	Total Lgth (in)	Base Circ (in)	Status
LG081	8/2/2007	Sinclair	GPS-SST	M	4	--	217	--	9 1/16	5 2/16	Release, 9/11/2008
LG082	8/2/2007	Villard	VHF	F	6	1	152	--	8 9/16	4 5/16	Died, 9/3/2007
LG083	8/3/2007	Lions Head	VHF	M	5	--	258	--	8 3/16	5 1/16	Died, 6/2011
LG084	8/3/2007	Lions Head	VHF	M	4	--	180	--	7 11/16	5 1/16	Died, 4/2011
LG085	8/3/2007	Villard	--	F	9	0	191	--	9 5/16	4 3/16	Died, 8/3/2007
LG086	8/11/2007	Lions Head	VHF	M	4	--	223	--	8 2/16	4 15/16	Died, 10/7/2008
LG087	8/11/2007	Lions Head	GPS-SST	M	5	--	233	--	8 11/16	5 6/16	Died, 2/21/2010
LG088	8/11/2007	Sinclair	VHF	F	8	0	160	--	8 8/16	4 1/16	Died, 11/2009
LG089	8/11/2007	Sinclair	VHF	M	4	--	240	--	9 5/16	5 4/16	Died, 11/2009
LG090	8/11/2007	Sinclair	GPS-SST	F	3	0	157	--	8 2/16	4 8/16	Release, 9/11/2008
LG091	8/11/2007	Villard	VHF	F	5	0	172	--	9 2/16	4 4/16	Died, 10/22/2011
LG092	8/16/2008	East Berners	GPS-SST	M	7	--	279	--	8 13/16	5 7/16	Died, 4/23/2009
LG093	8/16/2008	East Berners	GPS-SST	M	3	--	173	--	8 2/16	5	Died, 6/2010
LG094	8/16/2008	East Berners	GPS-SST	F	13	1	167	--	8 1/16	3 9/16	Died, 1/16/2009
LG095	8/16/2008	East Berners	GPS-SOB	M	5	--	266	--	9 10/16	5 9/16	Died, 10/1/2008
LG096	8/16/2008	East Berners	GPS-SST	M	5	--	258	--	9	5 10/16	Died, 8/2011
LG097	8/16/2008	Lions Head	GPS-SST	F	5	1	151	--	8 15/16	4	Release, 6/25/2011
LG098	8/16/2008	Lions Head	GPS-SST	M	6	--	279	--	9 1/16	5 3/16	Release, 6/25/2011
LG099	8/18/2008	Lions Head	GPS-SST	M	6	--	266	--	10 3/16	5 1/16	Release, 6/25/2011
LG100	8/18/2008	Sinclair	GPS-SST	F	10	1	163	--	10 1/16	3 14/16	Died, 10/6/2008
LG101	8/18/2008	Sinclair	GPS-SST	M	5	--	277	--	9 4/16	5 4/16	Died, 10/8/2009
LG102	8/18/2008	Sinclair	VHF	M	7	--	328	--	8 9/16*	5 12/16	Alive
LG103	8/18/2008	Sinclair	GPS-SST	F	7	0	185	--	9 1/16	4 3/16	Alive
LG103*	9/10/2011	Sinclair	GPS-SOB	F	10	0	--	--	9 5/16	--	Alive
LG104	8/18/2008	Sinclair	GPS-SST	F	6	0	192	--	10 5/16	3 15/16	Release, 6/25/2011
LG105	8/19/2008	East Berners	GPS-SST	F	5	0	179	--	8 5/16	3 15/16	Release, 6/25/2011
LG106	8/19/2008	Lions Head	VHF	M	5	--	242	--	9 9/16	5 2/16	Died, 4/2010
LG107	8/19/2008	Villard	GPS-SST	M	7	--	307	--	8 12/16	5 2/16	Release, 6/25/2011
LG108	8/19/2008	Villard	GPS-SST	F	4	2	165	--	8 6/16	4 2/16	Release, 6/25/2011
LG109	8/19/2008	Villard	VHF	M	3	--	166	--	9 1/16	5 4/16	Alive
LG110	8/19/2008	Villard	GPS-SST	M	6	--	298	--	9 1/16	5 4/16	Release, 6/25/2011
LG111	9/21/2008	East Berners	GPS-SST	F	4	1	194	--	9	4 5/16	Release, 6/25/2011
LG112	9/21/2008	Lions Head	GPS-SST	F	11	1	199	--	8 15/16	3 12/16	Died, 2/4/2009
LG113	9/21/2008	Villard	GPS-SST	F	4	0	182	--	8 6/16	4 3/16	Release, 6/25/2011
LG114	9/21/2008	Villard	GPS-SST	M	7	--	345	--	9	5 8/16	Release, 6/25/2011
LG115	9/21/2008	Villard	GPS-SST	M	8	--	306	--	8 8/16	5 5/16	Died, 11/17/2008
LG116	9/21/2008	Villard	GPS-SST	F	4	0	186	--	8 5/16	3 10/16	Release, 6/25/2011
LG117	9/24/2008	Lions Head	GPS-SST	F	3	0	170	--	7 15/16	4 9/16	Release, 6/25/2011
LG118	9/24/2008	Lions Head	GPS-SST	F	3	0	166	--	7 10/16	3 14/16	Alive
LG119	9/24/2008	Sinclair	VHF	M	4	--	237	--	8 11/16	5 5/16	Alive
LG120	9/24/2008	Sinclair	GPS-SST	F	5	1	175	--	8 8/16	4 2/16	Died, 3/22/2009
LG121	8/5/2009	East Berners	VHF	M	7	--	255	0.7	8 5/16	5 6/16	Died, 8/2011
LG122	8/5/2009	East Berners	VHF	F	1	0	86	--	3 12/16	3	Alive

Appendix 2 (continued): Mountain goat capture summary, 2005-2011, Lynn Canal, AK

Mtn Goat ID	Capture Date	Study Area	Collar Type	Sex	Est. Age	Kid	Weight (lbs.)	Rump Fat (cm)	Total Lgth (in)	Base Circ (in)	Status
LG123	8/5/2009	East Berners	VHF	F	6	0	181	1.0	9 2/16	4 10/16	Alive
LG124	8/5/2009	Lions Head	VHF	M	5	--	291	1.1	8 2/16	5	Alive
LG125	8/5/2009	Lions Head	VHF	F	4	0	150	0.0	8	3 10/16	Alive
LG126	8/5/2009	Lions Head	VHF	F	6	1	175	--	8 14/16	4 2/16	Alive
LG127	8/5/2009	Lions Head	VHF	F	11	1	182	--	8 9/16	3 13/16	Died, 3/2010
LG128	8/5/2009	Lions Head	VHF	F	6	0	170	--	8 10/16	4	Died, 7/2010
LG129	8/31/2009	East Berners	GPS-SST	M	5	--	256	--	8 9/16	5 6/16	Alive
LG130	8/31/2009	East Berners	GPS-SST	F	4	1	184	--	6 15/16*	4 1/16	Alive
LG131	8/31/2009	East Berners	GPS-SST	M	3	--	192	--	7 12/16	4 14/16	Alive
LG132	8/31/2009	East Berners	GPS-SST	M	5	--	251	--	9 5/16	5 8/16	Alive
LG133	8/31/2009	East Berners	GPS-SST	M	5	--	259	--	8 11/16	5 6/16	Died, 2/12/2011
LG134	8/31/2009	East Berners	GPS-SST	M	6	--	260	--	9 8/16	5 6/16	Alive
LG135	9/1/2009	East Berners	GPS-SST	M	8	--	320	--	9 3/16	5 3/16	Alive
LG136	9/1/2009	Sinclair	GPS-SST	F	2	0	131	--	7	3 15/16	Died, 10/18/2009
LG137	9/1/2009	Sinclair	GPS-SST	M	9	--	342	--	10 1/16	5 13/16	Alive
LG138	9/1/2009	Villard	GPS-SST	F	7	1	191	--	9 15/16	4 2/16	Alive
LG139	8/15/2010	East Berners	GPS-SST	M	6	--	292	--	9 14/16	5 6/16	Alive
LG140	8/15/2010	East Berners	GPS-SST	F	5	1	168	--	10 1/16	3 13/16	Alive
LG141	8/15/2010	Lions Head	GPS-SOB	M	7	--	307	--	9 6/16	5 10/16	Alive
LG143	8/15/2010	Lions Head	GPS-SOB	F	6	1	175	--	8	3 14/16	Alive
LG144	8/15/2010	Sinclair	GPS-SOB	F	6	1	163	--	--	--	Died, 6/14/2011
LG145	8/15/2010	Sinclair	GPS-SOB	F	6	1	192	--	9 3/16	4 2/16	Alive
LG146	8/15/2010	Sinclair	GPS-SOB	M	2	--	134	--	7 1/16	4 14/16	Alive
LG147	9/10/2011	Sinclair	GPS-SST	F	3	0	145	--	6 15/16	3 15/16	Alive
LG148	9/10/2011	Sinclair	GPS-SST	F	6	0	182	--	8 4/16	4 3/16	Alive
LG149	9/10/2011	Sinclair	GPS-SST	F	6	0	164	--	7 12/16	4 1/16	Alive
LG150	9/10/2011	Sinclair	GPS-SST	M	5	--	234	--	8 7/16	4 15/16	Alive
LG151	9/10/2011	Sinclair	GPS-SOB	F	5	1	180	--	7 7/16	4 2/16	Alive
LG152	9/10/2011	Sinclair	GPS-SST	M	11	--	296	--	9 9/16*	5 6/16	Alive
LG153	9/10/2011	Sinclair	GPS-SOB	M	5	--	243	--	7 12/16	5	Alive

* denotes animal was recaptured (n = 7 cases)

Appendix 3: Incidence of respiratory bacteria documented in mountain goats in the Lions Head/Sinclair study areas (n = 5), 2010. Results are also provided for three other populations in southeast Alaska in 2010, for comparison.

Area	Lynn Canal	Klukwan	Baranof	Cleveland	All Areas
Pasteurella trehalosi	0	2	5	2	9
Pasteurella sp.	0	1	0	0	1
Pasteurella sp.*	0	0	0	2	2
Total Pasturella	0	3	5	3	11
Arcanobacterium pyogenes	1	1	0	1	2
Mannheimia haemolytica	1	0	0	0	0
Moraxella sp.	1	1	0	0	1
Staphylococcus aureus	0	0	1	1	2
Mycoplasma (culture)	0	0	0	--	0
Mycoplasma ovipneumonia (PCR)	0	0	0	0	0
n (tested)	5	5	5	5	20

Notes:

Pasturella sp. = not identifiable to species

Pasteurella sp.* = organism most like P. trehalosi but looks different than other P. trehalosi (grows on MacConkey agar)

Total Pasturella = # of animals with some form of Pasturella (CG012 had 2 forms)

Appendix 4: Incidence of disease prevalence of mountain goats in the Lions Head, Sinclair, VIllard and East Berners study areas, 2010. Results are also provided for three other populations in southeast Alaska in 2010, for comparison.

	Baranof			Cleveland			Haines			Berners			Kakuhan			Villard			Total		
Disease	n	Positive	Prop	n	Positive	Prop	n	Positive	Prop	n	Positive	Prop	n	Positive	Prop	n	Positive	Prop	n	Positive	Prop
Contagious Ecthyma	12	1	0.08	10	1	0.10	13	1	0.08	20	1	0.05	23	0	0.00	22	0	0.00	100	4	0.04
Chlamydia	11	0	0.00	12	0	0.00	22	0	0.00	27	0	0.00	29	0	0.00	30	1	0.03	131	1	0.01
Q Fever	12	0	0.00	11	0	0.00	22	0	0.00	29	0	0.00	30	0	0.00	30	1	0.03	134	1	0.01
Bluetongue	10	0	0.00	10	0	0.00	10	0	0.00	10	0	0.00	11	0	0.00	9	0	0.00	60	0	0.00
Bovine respiratory synctial virus (BRSV)	10	0	0.00	9	0	0.00	10	0	0.00	10	0	0.00	11	0	0.00	8	0	0.00	58	0	0.00
Infectious bovine rhinotrachetis (IBR)	10	0	0.00	9	0	0.00	10	0	0.00	10	0	0.00	11	0	0.00	8	0	0.00	58	0	0.00
Parainfluenza-3 (PI-3)	10	0	0.00	9	0	0.00	10	0	0.00	10	0	0.00	11	0	0.00	8	0	0.00	58	0	0.00
Epizootic hemorrhagic disease (EHD)	10	0	0.00	9	0	0.00	10	0	0.00	10	0	0.00	11	0	0.00	8	0	0.00	58	0	0.00
Caprinae arthritis encephalitis (CAE)	10	0	0.00	9	0	0.00	10	0	0.00	10	0	0.00	11	0	0.00	8	0	0.00	58	0	0.00
Malignant cataharral fever-ovine (MCF)	10	0	0.00	9	0	0.00	10	0	0.00	10	0	0.00	11	0	0.00	8	0	0.00	58	0	0.00
Leptospirosis cannicola	10	0	0.00	9	0	0.00	10	0	0.00	10	0	0.00	11	0	0.00	8	0	0.00	58	0	0.00
Leptospirosis grippo	10	0	0.00	9	0	0.00	10	1	0.10	10	0	0.00	11	0	0.00	8	1	0.13	58	2	0.03
Leptospirosis hardjo	10	0	0.00	9	0	0.00	10	0	0.00	10	0	0.00	11	0	0.00	8	0	0.00	58	0	0.00
Leptospirosis ictero	10	0	0.00	9	0	0.00	10	3	0.30	10	2	0.20	11	1	0.09	8	2	0.25	58	8	0.14
Leptospirosis pomona	10	0	0.00	9	0	0.00	10	0	0.00	10	0	0.00	11	0	0.00	8	0	0.00	58	0	0.00

Appendix 5: Trace mineral concentration documented for mountain goats in the Lions Head and Sinclair study areas, 2010. Results are also provided for three other populations in southeast Alaska in 2010, for comparison.

	Se			Fe			Cu			Zn			Mo			Mn		
Area	Mean	n	SE	Mean	n	SE	Mean	n	SE	Mean	n	SE	Mean	n	SE	Mean	n	SE
Baranof	0.37	12	0.01	1.95	12	0.11	1.10	12	0.06	0.76	12	0.05	<0.05	12	0.00	<0.006	12	0.00
Cleveland	0.26	5	0.01	1.71	5	0.09	0.81	5	0.03	0.70	5	0.04	<0.05	5	0.00	<0.006	5	0.00
Grandchild	0.27	2	0.08	2.86	2	0.03	1.07	2	0.05	0.77	2	0.06	<0.05	2	0.00	<0.006	2	0.00
Kakuhan	0.19	6	0.04	1.98	6	0.12	1.04	6	0.05	0.61	6	0.03	<0.05	6	0.00	<0.006	6	0.00
Haines	0.30	22	0.03	2.27	21	0.07	1.07	21	0.07	0.78	21	0.05	<0.05	21	0.00	<0.006	21	0.00
Total	0.30	47	0.02	2.11	46	0.06	1.04	46	0.04	0.74	46	0.03	<0.05	46	0.00	<0.006	46	0.00

Appendix 6: Mountain goat GPS collar (Telonics TGW-3590) fix success summary, 2005-2011, Lynn Canal, AK

	Successful						Unsuccessful		
	2D		3D		2D/3D				
ID	Fixes	Proportion	Fixes	Proportion	Fixes	Proportion	Fixes	Proportion	Fix Attempts
LG001	341	0.42	354	0.44	695	0.86	117	0.14	812
LG002	412	0.51	160	0.20	572	0.71	236	0.29	808
LG003	981	0.44	933	0.42	1914	0.85	330	0.15	2244
LG004	1203	0.44	1160	0.42	2363	0.86	388	0.14	2751
LG005	1159	0.49	746	0.32	1905	0.81	454	0.19	2359
LG006	178	0.34	248	0.47	426	0.81	98	0.19	524
LG007	1197	0.44	1064	0.39	2261	0.83	467	0.17	2728
LG008	1288	0.47	935	0.34	2223	0.81	505	0.19	2728
LG009	1263	0.46	911	0.33	2174	0.80	553	0.20	2727
LG010	1278	0.47	962	0.35	2240	0.82	485	0.18	2725
LG011	900	0.45	752	0.38	1652	0.83	332	0.17	1984
LG012	1181	0.43	1200	0.44	2381	0.87	343	0.13	2724
LG014	1694	0.45	1389	0.37	3083	0.81	705	0.19	3788
LG015	1189	0.44	1207	0.44	2396	0.88	327	0.12	2723
LG016	1327	0.50	993	0.37	2320	0.87	360	0.13	2680
LG017	1194	0.45	1145	0.43	2339	0.87	341	0.13	2680
LG018	1244	0.46	1099	0.41	2343	0.87	337	0.13	2680
LG019	511	0.50	341	0.34	852	0.84	165	0.16	1017
LG020	1065	0.40	1168	0.44	2233	0.83	443	0.17	2676
LG021	1188	0.44	1019	0.38	2207	0.82	469	0.18	2676
LG022	1031	0.39	1302	0.49	2333	0.87	343	0.13	2676
LG023	1150	0.43	1121	0.42	2271	0.85	405	0.15	2676
LG024	1440	0.50	748	0.26	2188	0.76	677	0.24	2865
LG025	493	0.44	409	0.37	902	0.81	218	0.19	1120
LG026	137	0.31	278	0.62	415	0.93	33	0.07	448
LG027	956	0.46	866	0.42	1822	0.87	262	0.13	2084
LG028	655	0.46	585	0.41	1240	0.87	180	0.13	1420
LG029	1287	0.41	1443	0.46	2730	0.88	375	0.12	3105
LG030	451	0.42	409	0.38	860	0.79	223	0.21	1083
LG031	384	0.41	455	0.49	839	0.90	92	0.10	931
LG032	590	0.47	500	0.40	1090	0.87	161	0.13	1251
LG033	554	0.48	413	0.36	967	0.84	181	0.16	1148
LG034	1416	0.46	1145	0.37	2561	0.83	540	0.17	3101
LG035	1190	0.38	1579	0.51	2769	0.89	332	0.11	3101
LG036	1347	0.43	1259	0.41	2606	0.84	494	0.16	3100
LG037	972	0.43	1023	0.45	1995	0.88	280	0.12	2275
LG038	1394	0.45	1192	0.38	2586	0.83	514	0.17	3100
LG039	478	0.49	352	0.36	830	0.85	150	0.15	980
LG040	730	0.28	487	0.18	1217	0.46	1417	0.54	2634
LG041	1340	0.45	1282	0.43	2622	0.88	355	0.12	2977
LG042	1265	0.43	1234	0.41	2499	0.84	477	0.16	2976
LG043	1125	0.38	1087	0.37	2212	0.74	764	0.26	2976
LG044	39	0.19	159	0.78	198	0.98	5	0.02	203
LG045	1349	0.47	746	0.26	2095	0.73	774	0.27	2869
LG046	1278	0.45	1237	0.44	2515	0.89	313	0.11	2828
LG047	281	0.47	260	0.43	541	0.90	63	0.10	604
LG048	383	0.45	297	0.35	680	0.80	172	0.20	852
LG049	1309	0.46	1252	0.44	2561	0.89	307	0.11	2868
LG050	381	0.50	208	0.27	589	0.77	179	0.23	768
LG051	1409	0.50	860	0.30	2269	0.80	552	0.20	2821
LG052	1214	0.43	1127	0.40	2341	0.83	480	0.17	2821
LG053	1222	0.43	1170	0.41	2392	0.85	428	0.15	2820
LG054	1234	0.44	1228	0.44	2462	0.88	339	0.12	2801
LG055	32	0.42	43	0.57	75	0.99	1	0.01	76
LG056	288	0.39	362	0.49	650	0.87	94	0.13	744
LG057	536	0.45	439	0.37	975	0.82	213	0.18	1188
LG058	1251	0.45	1286	0.46	2537	0.91	264	0.09	2801
LG059	1270	0.45	1052	0.38	2322	0.83	478	0.17	2800
LG060	1395	0.51	920	0.33	2315	0.84	441	0.16	2756
LG061	1148	0.43	1093	0.40	2241	0.83	460	0.17	2701
LG062	1277	0.46	902	0.33	2179	0.79	577	0.21	2756
LG063	252	0.41	266	0.43	518	0.84	98	0.16	616
LG064	640	0.45	486	0.34	1126	0.79	298	0.21	1424
LG065	675	0.42	738	0.46	1413	0.88	199	0.12	1612
LG066	1916	0.46	1549	0.37	3465	0.83	704	0.17	4169

Appendix 6 (continued): Mountain goat GPS collar (Telonics TGW-3590) fix success summary, 2005-2011, Lynn Canal, AK

	Successful						Unsuccessful		
	2D		3D		2D/3D				
ID	Fixes	Proportion	Fixes	Proportion	Fixes	Proportion	Fixes	Proportion	Fix Attempts
LG067	79	0.39	110	0.54	189	0.93	15	0.07	204
LG068	1007	0.40	1246	0.49	2253	0.89	287	0.11	2540
LG069	808	0.44	620	0.34	1428	0.78	412	0.22	1840
LG070	1433	0.34	2392	0.57	3825	0.92	344	0.08	4169
LG071	580	0.48	422	0.35	1002	0.82	216	0.18	1218
LG072	55	0.33	102	0.61	157	0.93	11	0.07	168
LG073	407	0.42	460	0.48	867	0.90	92	0.10	959
LG074	1641	0.39	1873	0.45	3514	0.85	642	0.15	4156
LG075	309	0.45	209	0.31	518	0.76	163	0.24	681
LG076	803	0.27	600	0.20	1403	0.48	1545	0.52	2948
LG077	338	0.38	351	0.40	689	0.78	195	0.22	884
LG078	723	0.44	725	0.45	1448	0.89	177	0.11	1625
LG079	37	0.42	46	0.52	83	0.94	5	0.06	88
LG080	734	0.45	579	0.36	1313	0.81	312	0.19	1625
LG081	901	0.55	322	0.20	1223	0.75	401	0.25	1624
LG087	923	0.50	448	0.24	1371	0.74	478	0.26	1849
LG090	919	0.58	439	0.28	1358	0.86	230	0.14	1588
LG092	516	0.52	334	0.33	850	0.85	151	0.15	1001
LG093	1128	0.42	1254	0.47	2382	0.89	307	0.11	2689
LG094	88	0.14	104	0.17	192	0.31	420	0.69	612
LG095	54	0.29	124	0.67	178	0.97	6	0.03	184
LG096	980	0.43	1088	0.48	2068	0.91	211	0.09	2279
LG097	1289	0.47	840	0.31	2129	0.78	613	0.22	2742
LG098	1152	0.42	1114	0.41	2266	0.83	475	0.17	2741
LG099	1419	0.52	726	0.27	2145	0.78	589	0.22	2734
LG100	70	0.36	105	0.54	175	0.89	21	0.11	196
LG101	814	0.49	636	0.38	1450	0.87	215	0.13	1665
LG103	1335	0.49	816	0.30	2151	0.79	582	0.21	2733
LG104	1418	0.52	806	0.29	2224	0.81	509	0.19	2733
LG105	959	0.35	1506	0.55	2465	0.90	265	0.10	2730
LG107	669	0.25	1969	0.72	2638	0.97	92	0.03	2730
LG108	944	0.35	1295	0.47	2239	0.82	491	0.18	2730
LG110	1177	0.43	1204	0.44	2381	0.87	348	0.13	2729
LG111	871	0.34	1384	0.53	2255	0.87	344	0.13	2599
LG112	240	0.44	208	0.38	448	0.82	97	0.18	545
LG113	877	0.34	1559	0.60	2436	0.94	154	0.06	2590
LG114	546	0.21	1393	0.54	1939	0.75	659	0.25	2598
LG115	82	0.36	112	0.49	194	0.85	34	0.15	228
LG116	1205	0.46	888	0.34	2093	0.81	503	0.19	2596
LG117	912	0.44	620	0.30	1532	0.75	518	0.25	2050
LG118	1136	0.44	952	0.37	2088	0.81	498	0.19	2586
LG120	331	0.46	244	0.34	575	0.80	141	0.20	716
LG129	471	0.44	267	0.25	738	0.69	330	0.31	1068
LG130	549	0.45	445	0.37	994	0.82	220	0.18	1214
LG131	461	0.35	694	0.52	1155	0.87	169	0.13	1324
LG132	564	0.46	409	0.33	973	0.80	249	0.20	1222
LG133	569	0.47	355	0.30	924	0.77	279	0.23	1203
LG134	610	0.50	453	0.37	1063	0.87	158	0.13	1221
LG135	441	0.36	634	0.52	1075	0.88	148	0.12	1223
LG137	636	0.48	444	0.33	1080	0.81	247	0.19	1327
LG138	526	0.49	289	0.27	815	0.77	249	0.23	1064
LG139	553	0.44	489	0.39	1042	0.83	210	0.17	1252
LG140	480	0.28	1113	0.66	1593	0.94	95	0.06	1688
LG144	26	0.02	941	0.78	967	0.80	244	0.20	1211
LG147	37	0.30	56	0.45	93	0.75	31	0.25	124
LG148	48	0.39	68	0.55	116	0.94	8	0.06	124
LG149	52	0.42	50	0.40	102	0.82	22	0.18	124
LG150	50	0.40	60	0.48	110	0.89	14	0.11	124
LG152	44	0.36	71	0.58	115	0.93	8	0.07	123
Total	99983	0.43	93698	0.40	193681	0.83	39816	0.17	233497

Appendix 7: Relationships between mountain goat GPS radio-collar activity sensor values and field observations of percent of time spent active and bedded, 2007-2009, Lynn Canal, AK.

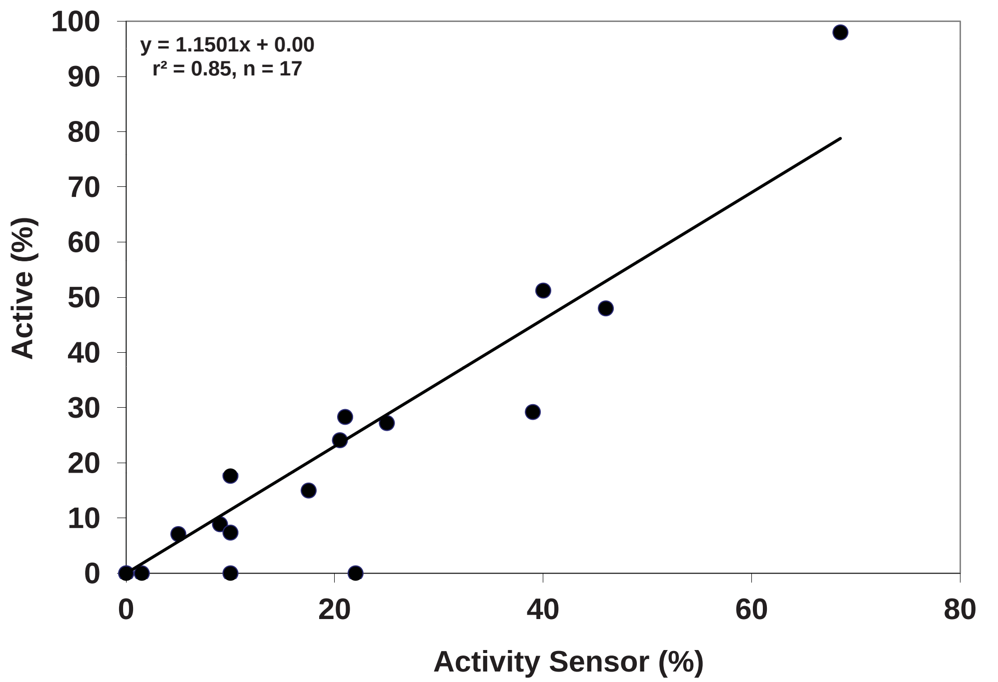


Figure 1: Relationship between mountain goat GPS radio-collar activity sensor values and field observations of percent of time spent active, 2007-2009, Lynn Canal, AK.

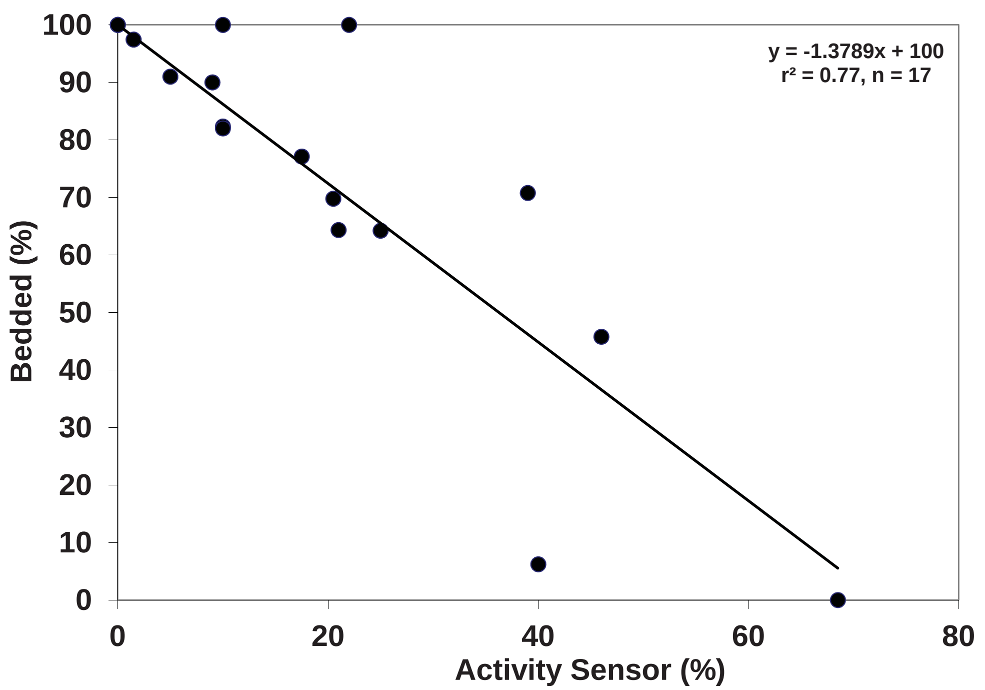


Figure 2: Relationship between mountain goat GPS radio-collar activity sensor values and field observations of percent of time spent bedded, 2007-2009, Lynn Canal, AK.

Appendix 8a: Summer resource selection function variable response curves derived from mountain goat GPS and remote sensing data in the Lions Head, Sinclair, Villard study areas, AK.

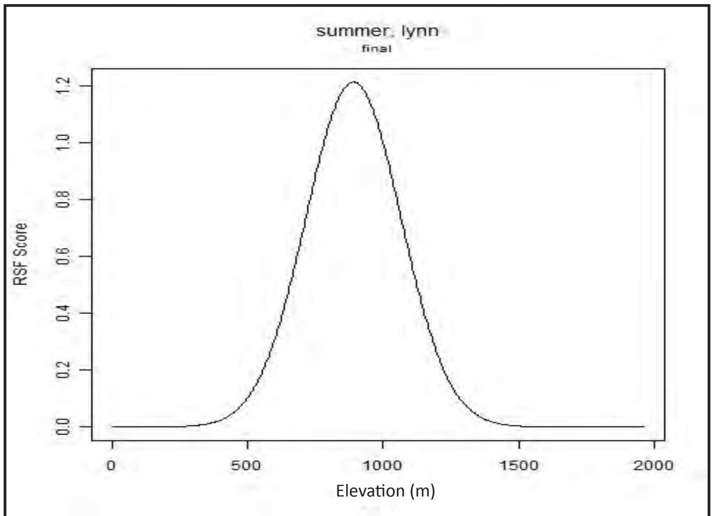


Figure 1: Relationship between mountain goat resource selection and elevation during summer.

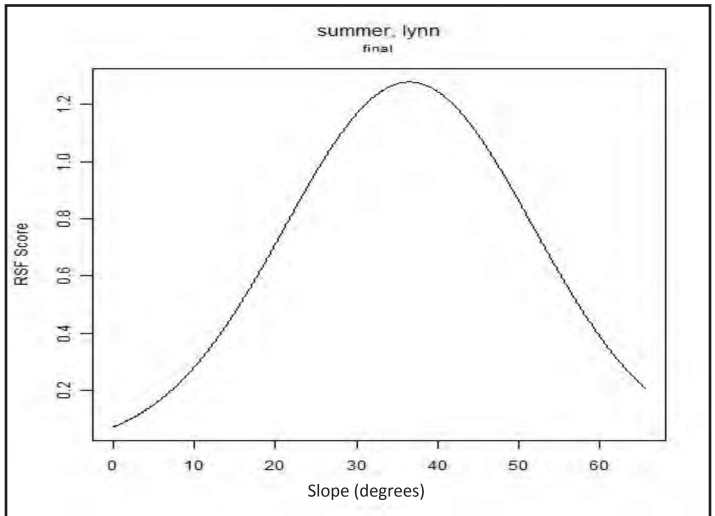


Figure 2: Relationship between mountain goat resource selection and slope during summer.

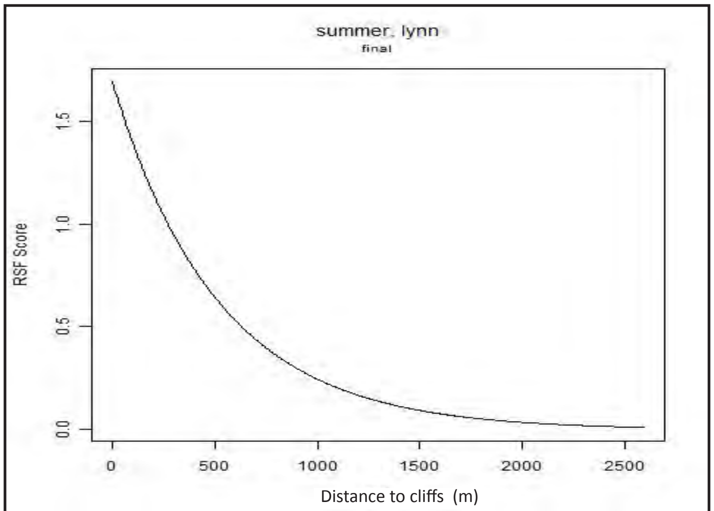


Figure 3: Relationship between mountain goat resource selection and distance to cliffs during summer.

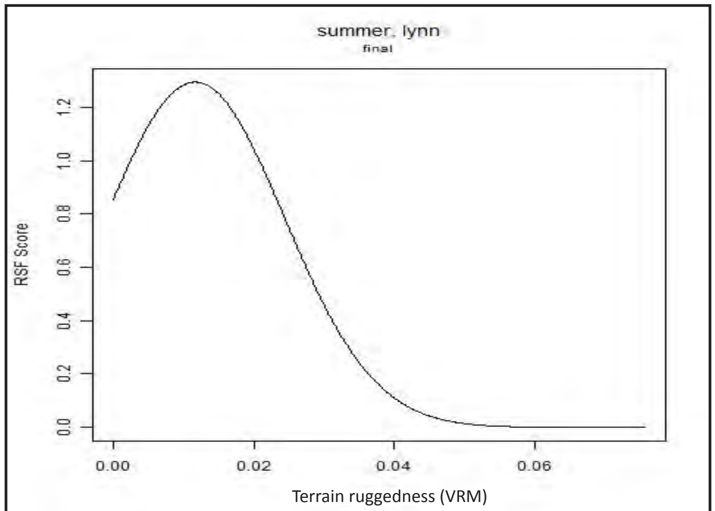


Figure 4: Relationship between mountain goat resource selection and terrain ruggedness during summer.

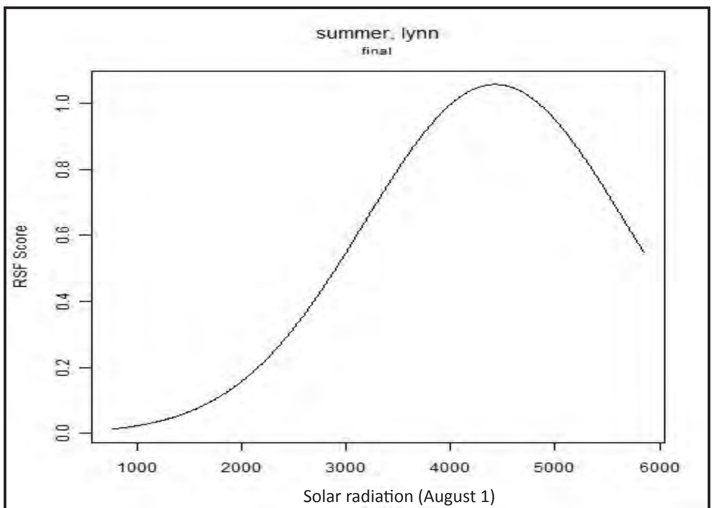


Figure 5: Relationship between mountain goat resource selection and solar radiation during summer.

Appendix 8b: Winter resource selection function variable response curves derived from mountain goat GPS and remote sensing data in the Lions Head, Sinclair, Villard study areas, AK.

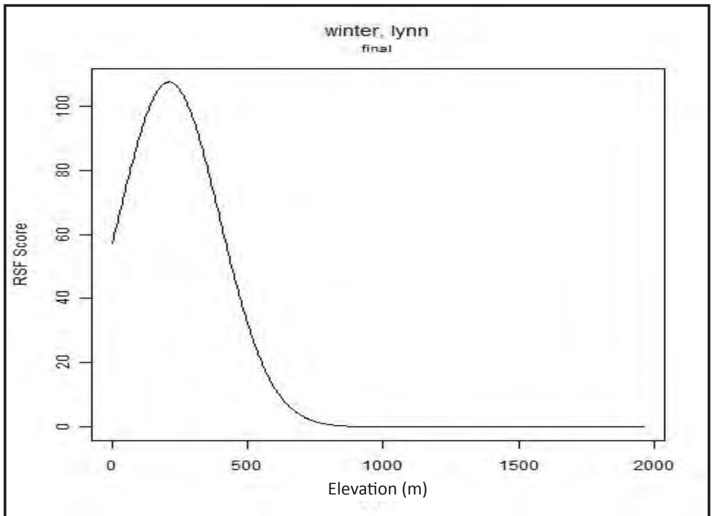


Figure 1: Relationship between mountain goat resource selection and elevation during winter.

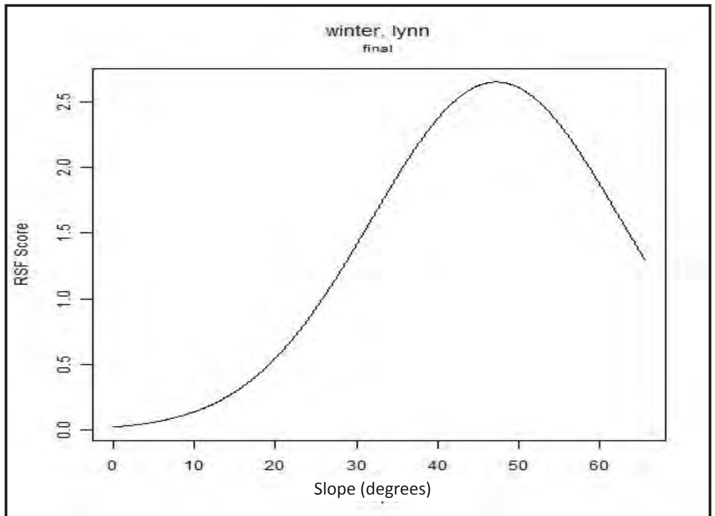


Figure 2: Relationship between mountain goat resource selection and slope during winter.

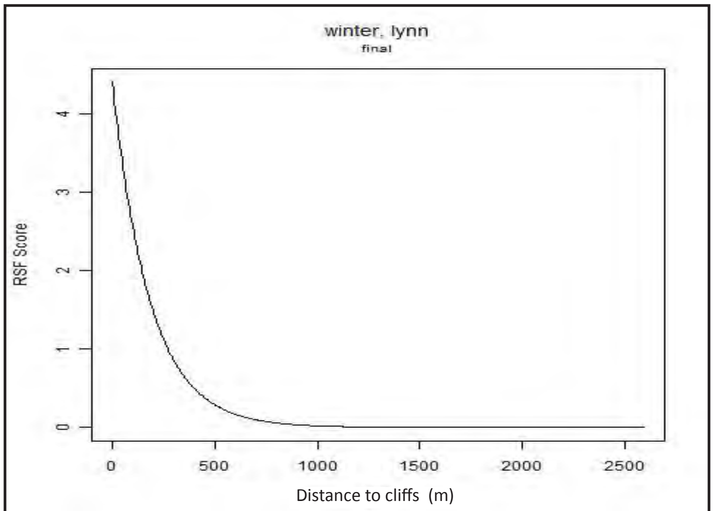


Figure 3: Relationship between mountain goat resource selection and distance to cliffs during winter.

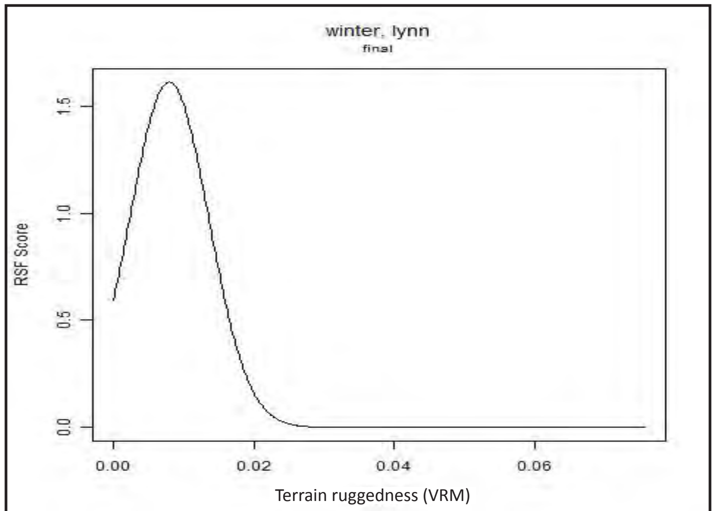


Figure 4: Relationship between mountain goat resource selection and terrain ruggedness during winter.

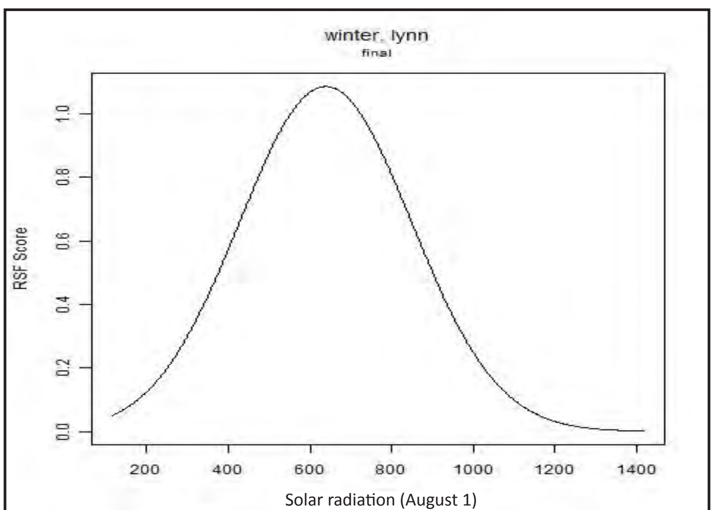


Figure 5: Relationship between mountain goat resource selection and solar radiation during winter.

Appendix 8c: Summer resource selection function variable response curves derived from mountain goat GPS and remote sensing data in the East Berners study area, AK.

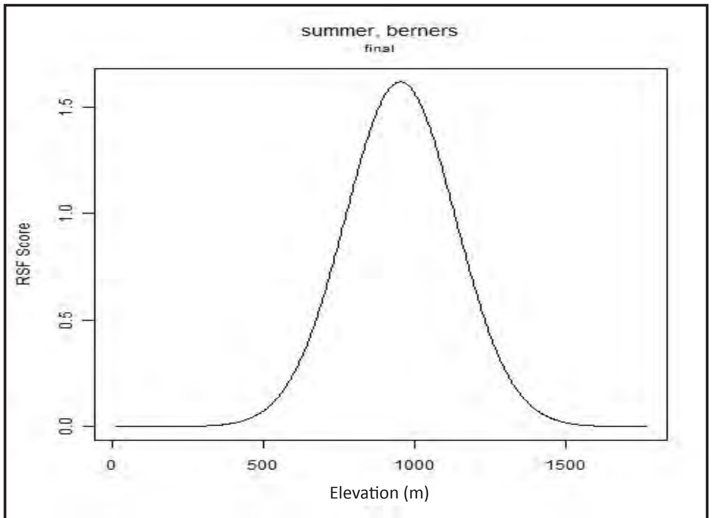


Figure 1: Relationship between mountain goat resource selection and elevation during summer.

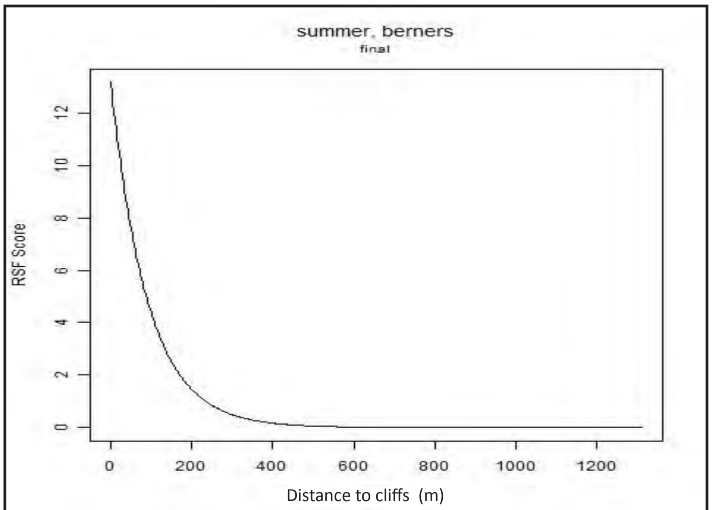


Figure 2: Relationship between mountain goat resource selection and distance to cliffs during summer.

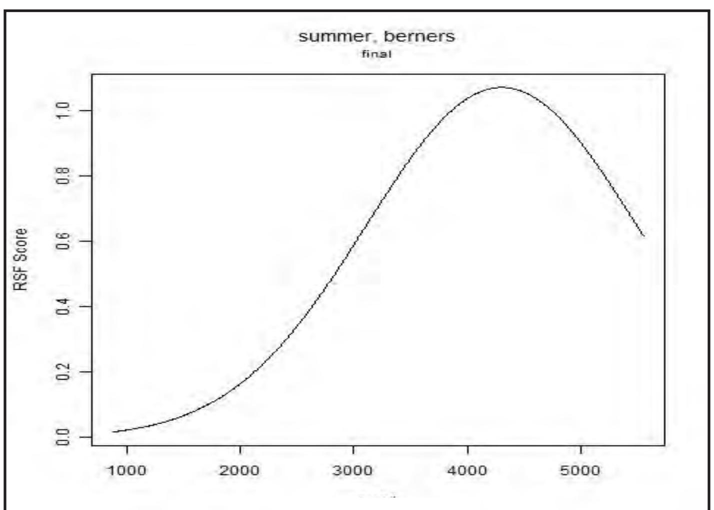


Figure 3: Relationship between mountain goat resource selection and solar radiation during summer.

Appendix 8d: Winter resource selection function variable response curves derived from mountain goat GPS and remote sensing data in the East Berners study area, AK.

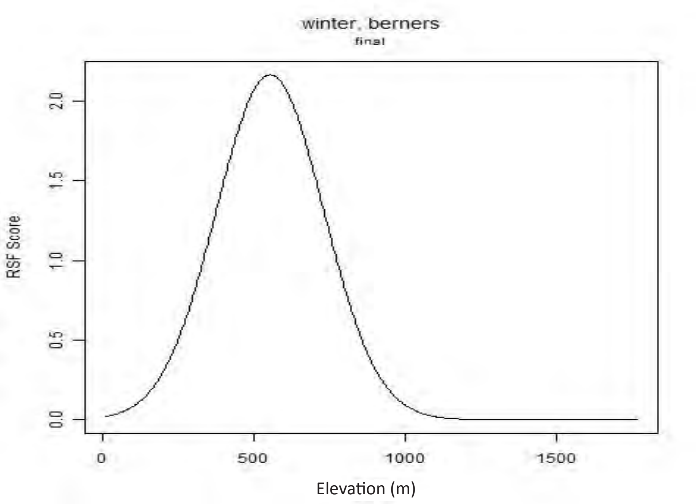


Figure 1: Relationship between mountain goat resource selection and elevation during winter.

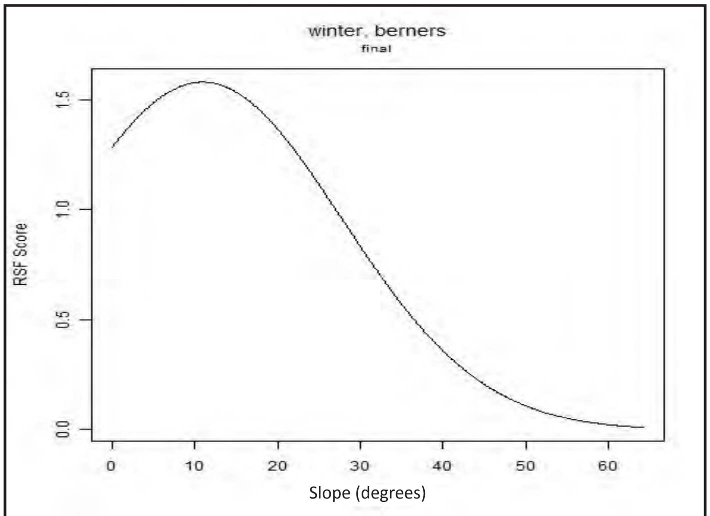


Figure 2: Relationship between mountain goat resource selection and slope during winter.

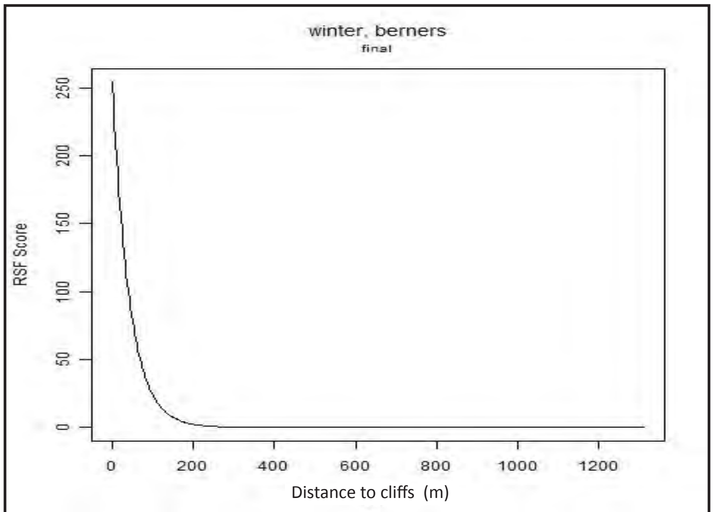


Figure 3: Relationship between mountain goat resource selection and distance to cliffs during winter.

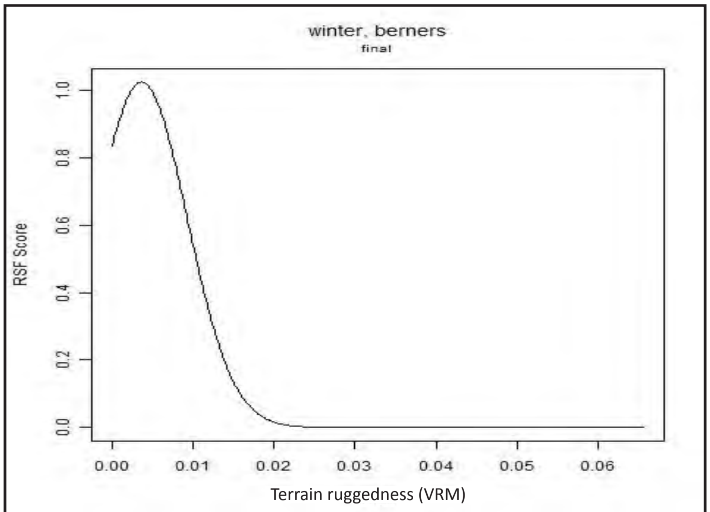


Figure 4: Relationship between mountain goat resource selection and terrain ruggedness during winter.

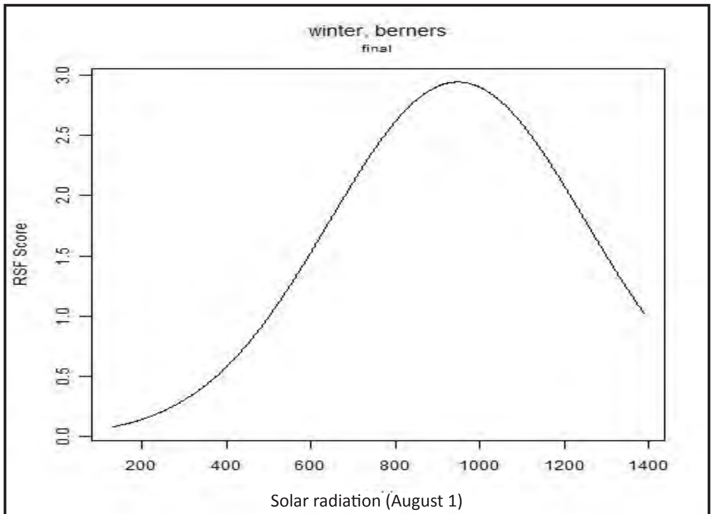
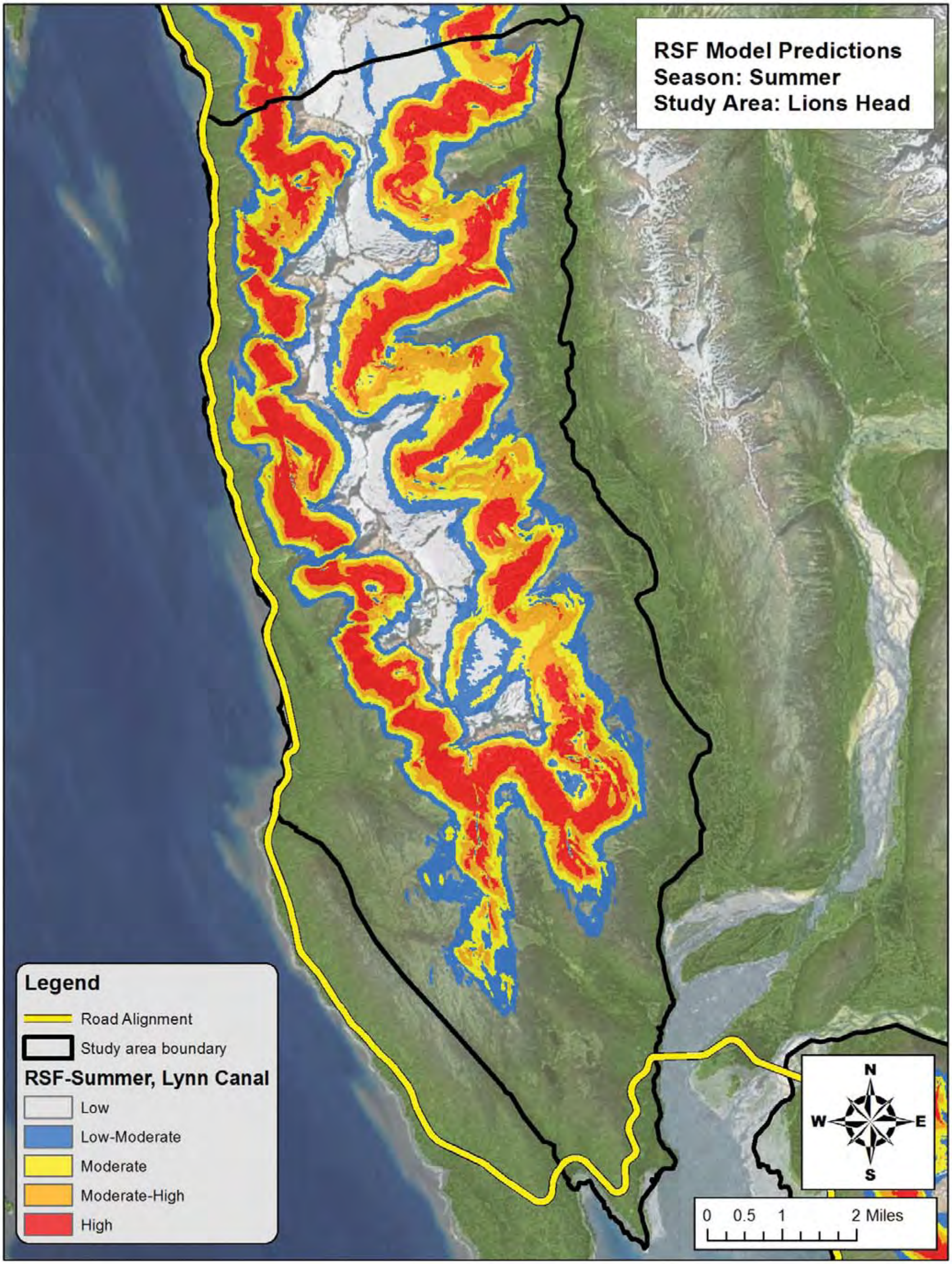
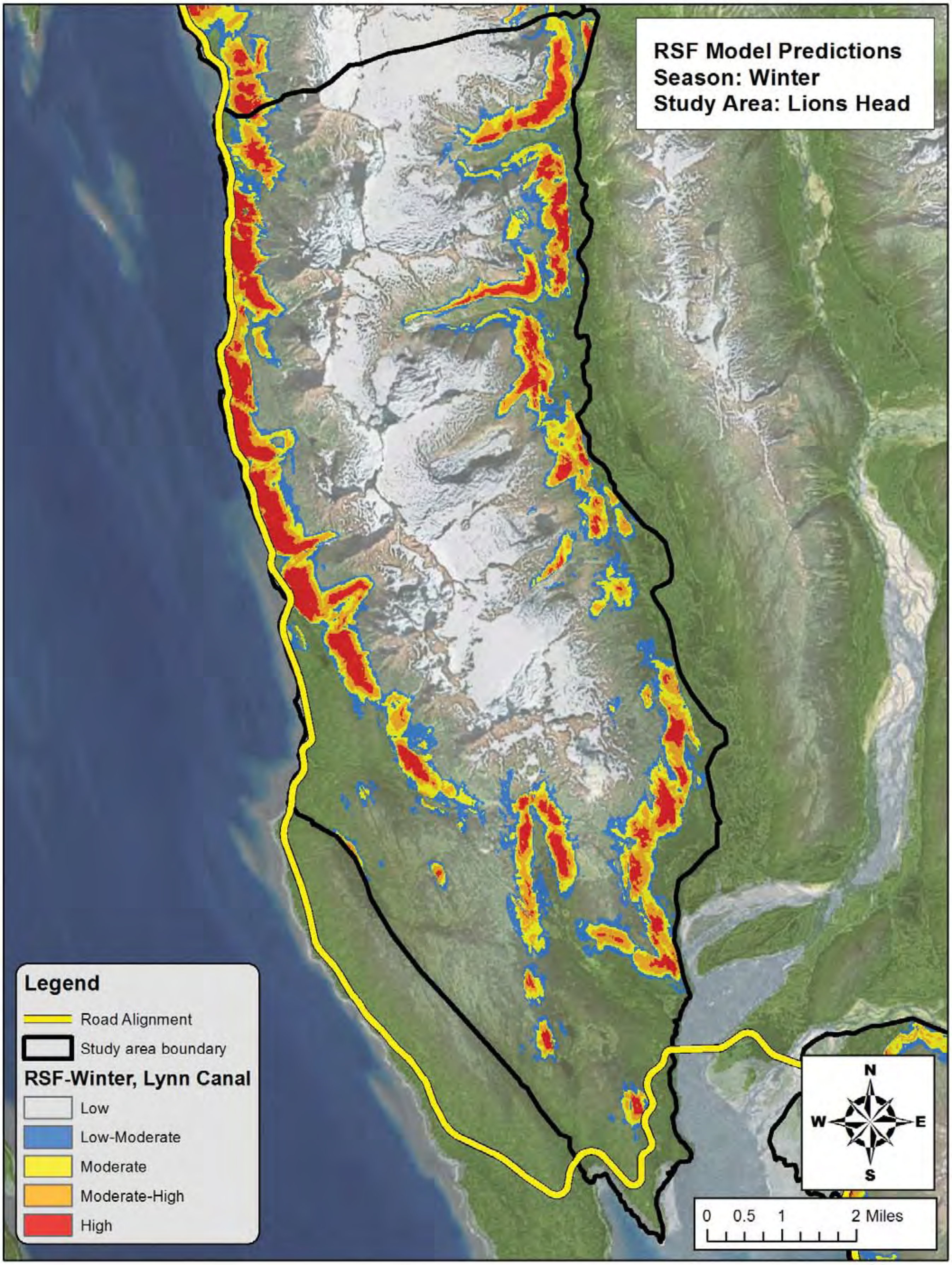


Figure 5: Relationship between mountain goat resource selection and solar radiation during winter.

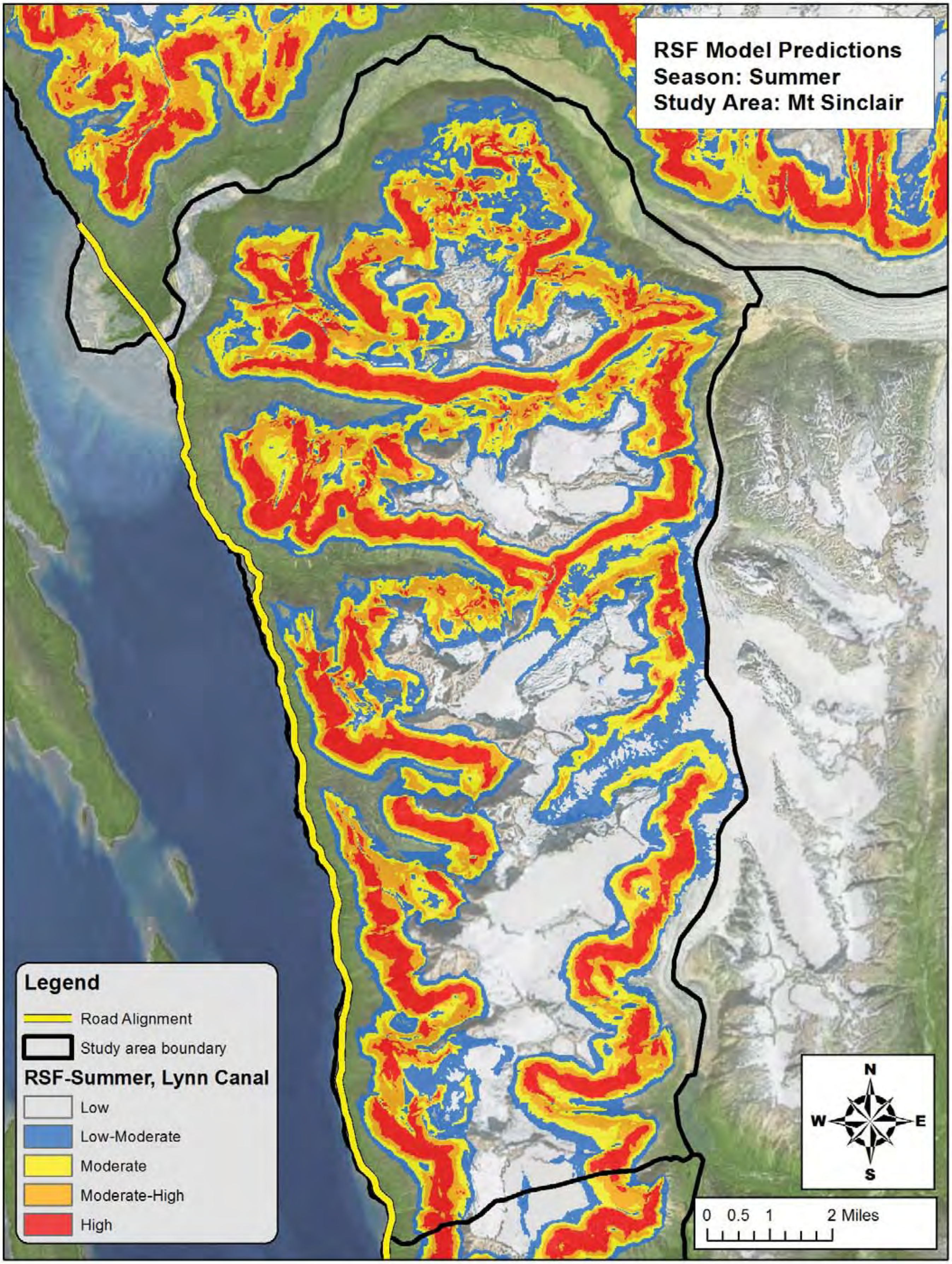
Appendix 9a: Map predicting relative probability of use for mountain goats during summer in the Lions Head study area. Results are based on the "Lions Head/Sinclair/Villard-Summer" model, 2005-2011. Areas in the "Low" category are transparent; only areas within the study area boundary were modeled .



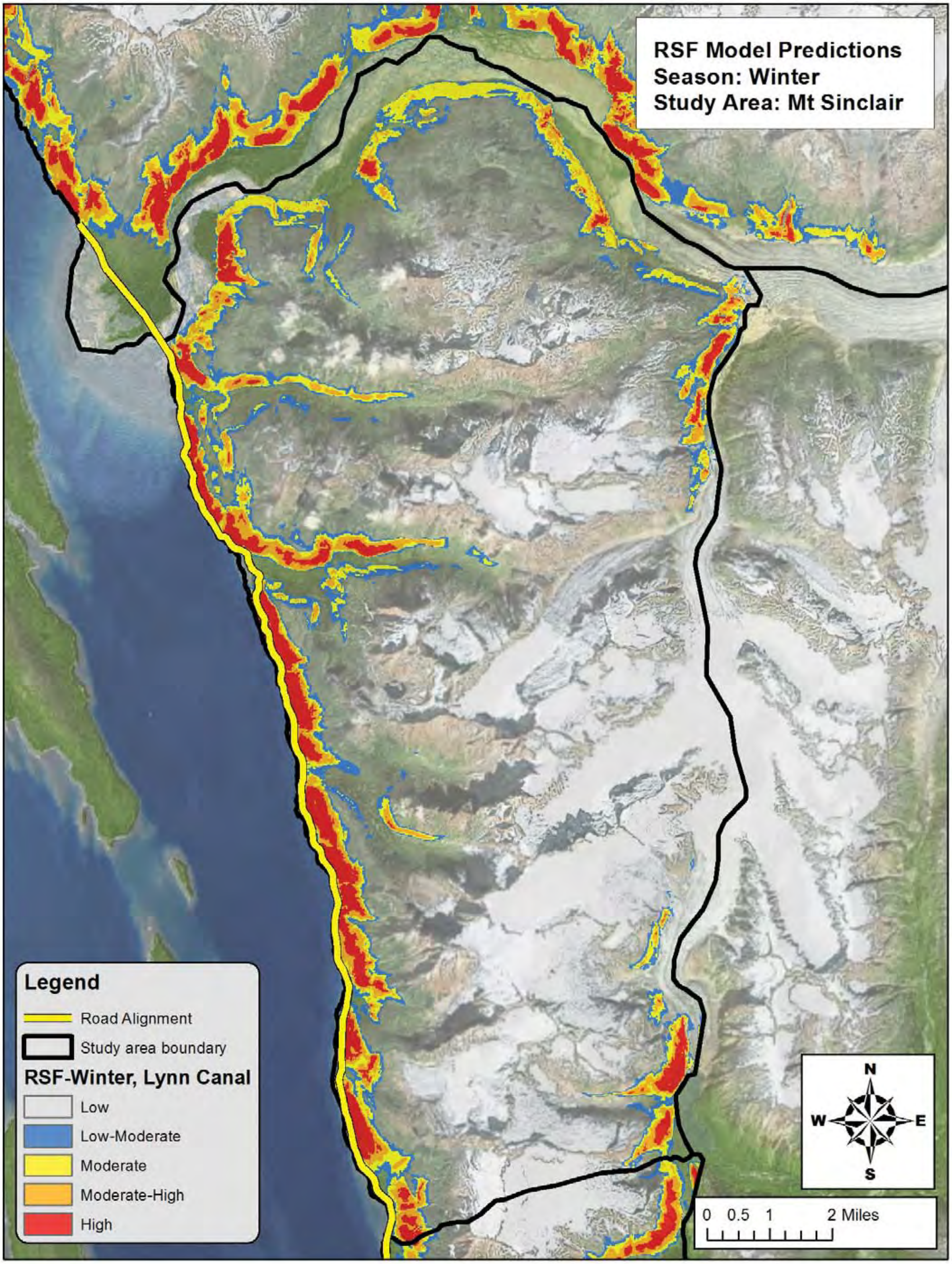
Appendix 9b: Map predicting relative probability of use for mountain goats during winter in the Lions Head study area. Results are based on the “Lions Head/Sinclair/Villard-Winter” model, 2005-2011. Areas in the “Low” category are transparent; only areas within the study area boundary were modeled .



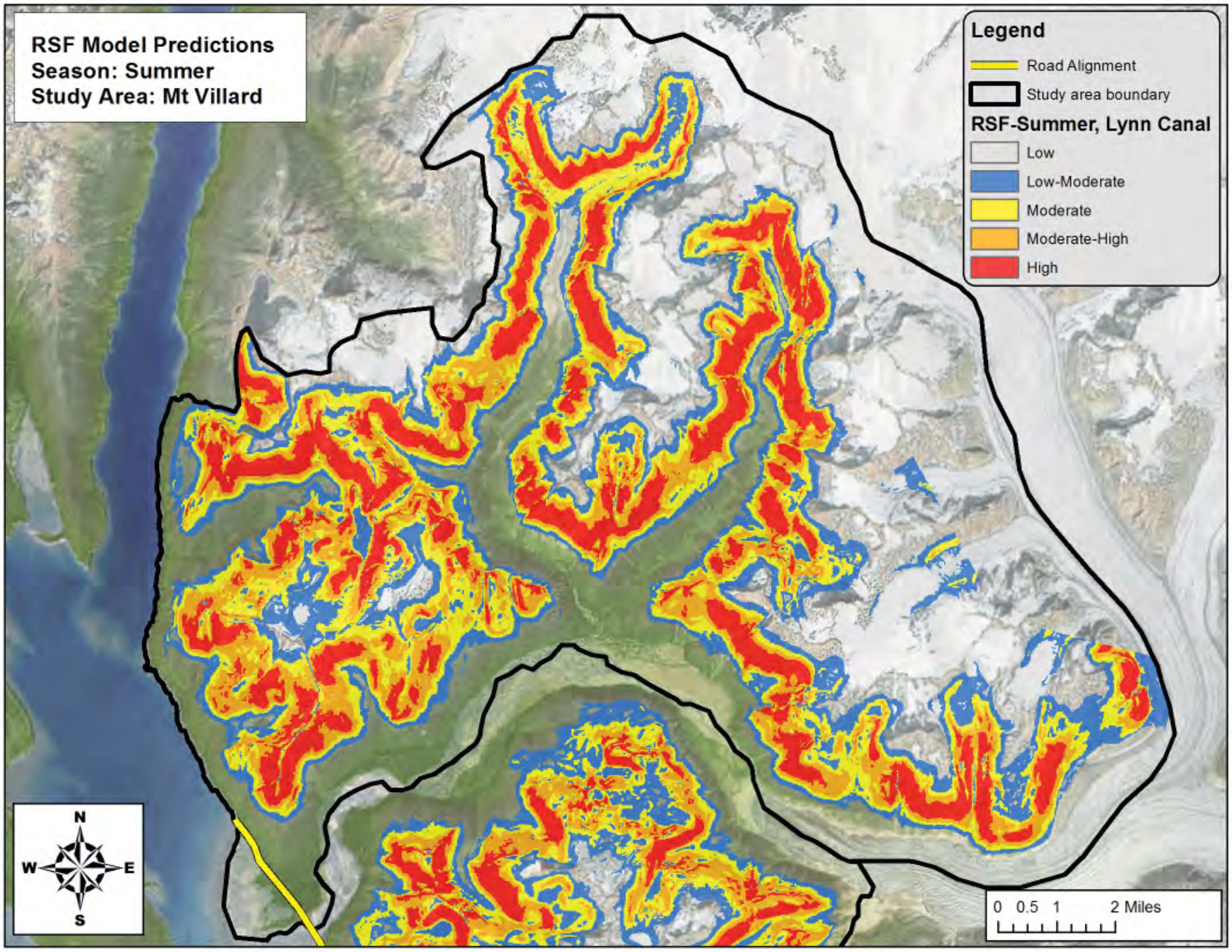
Appendix 9c: Map predicting relative probability of use for mountain goats during summer in the Mt. Sinclair study area. Results are based on the "Lions Head/Sinclair/Villard-Summer" model, 2005-2011. Areas in the "Low" category are transparent; only areas within the study area boundary were modeled .



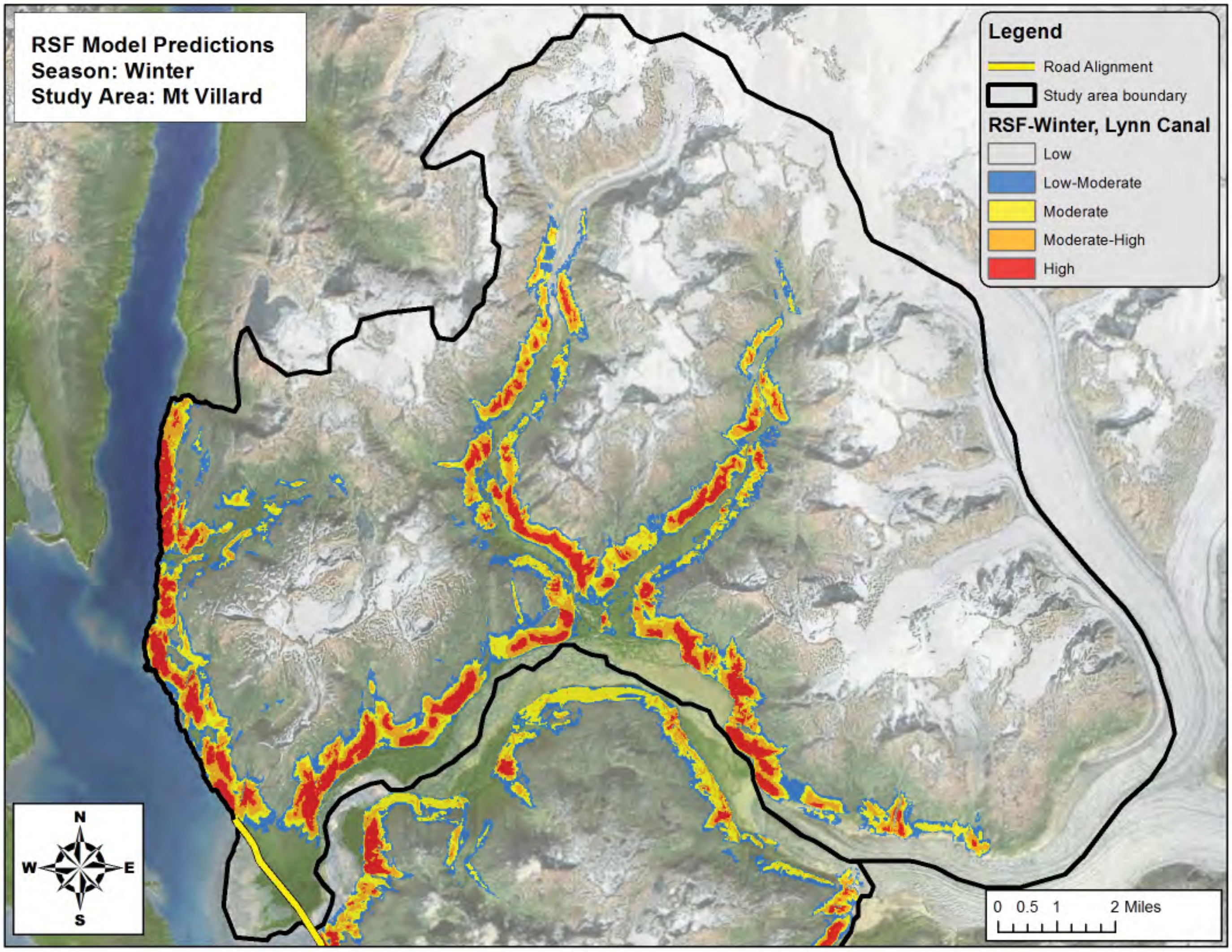
Appendix 9d: Map predicting relative probability of use for mountain goats during winter in the Mt. Sinclair study area. Results are based on the “Lions Head/Sinclair/Villard-Winter” model, 2005-2011. Areas in the “Low” category are transparent; only areas within the study area boundary were modeled .



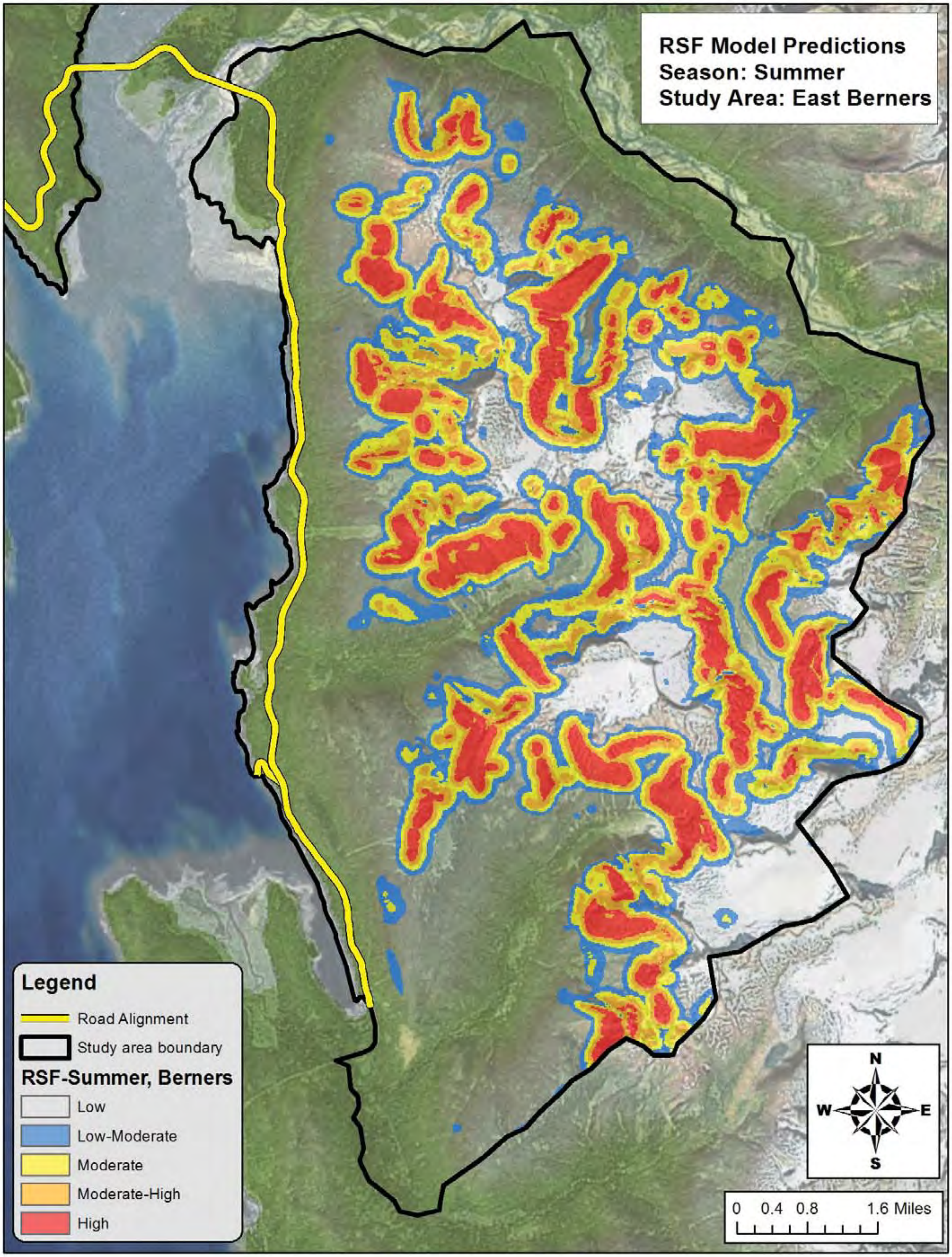
Appendix 9e: Map predicting relative probability of use for mountain goats during summer in the Mt. Villard study area. Results are based on the "Lions Head/Sinclair/Villard-Summer" model, 2005-2011. Areas in the "Low" category are transparent; only areas within the study area boundary were modeled .



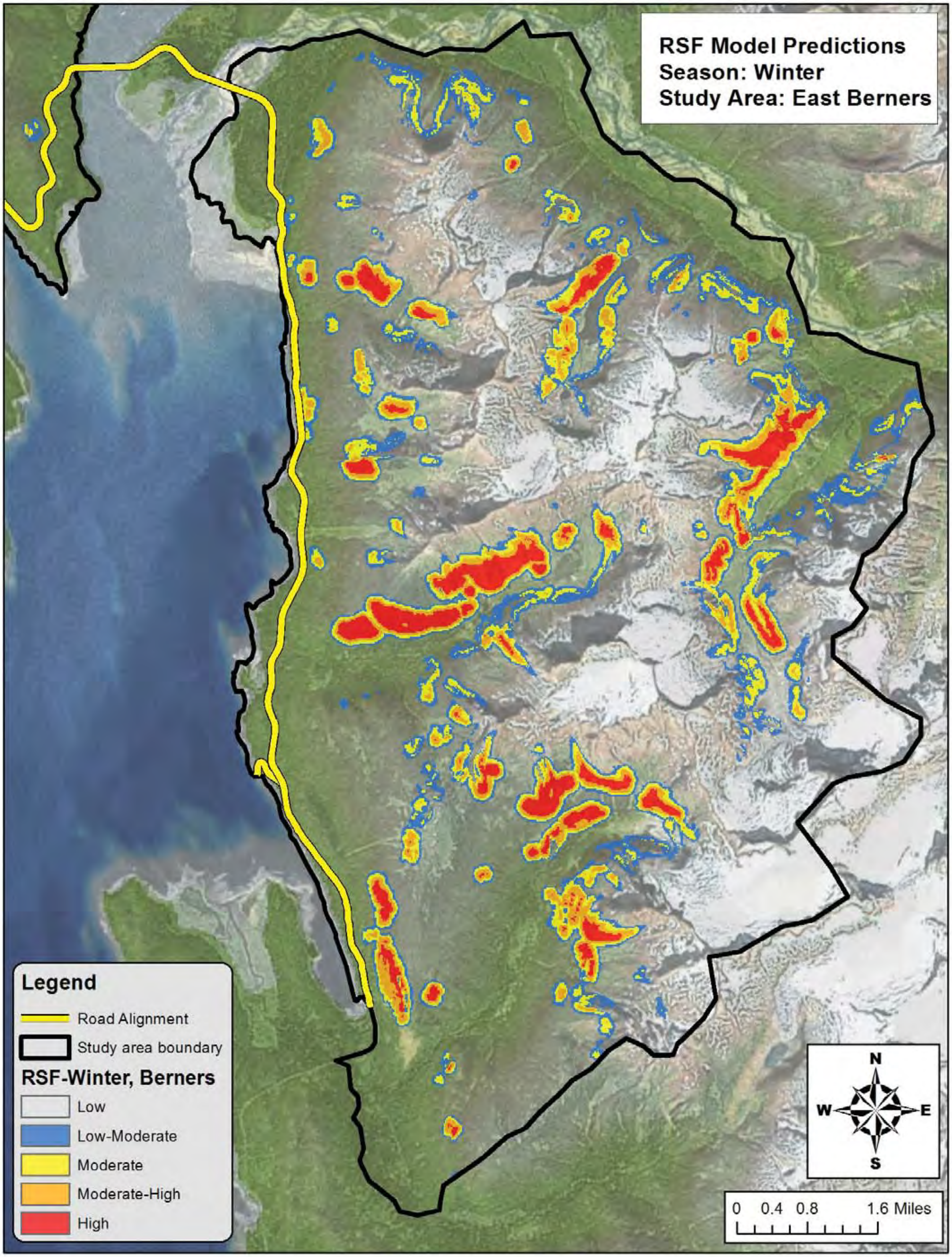
Appendix 9f: Map predicting relative probability of use for mountain goats during winter in the Mt. Villard study area. Results are based on the "Lions Head/Sinclair/Villard-Winter" model, 2005-2011. Areas in the "Low" category are transparent; only areas within the study area boundary were modeled .



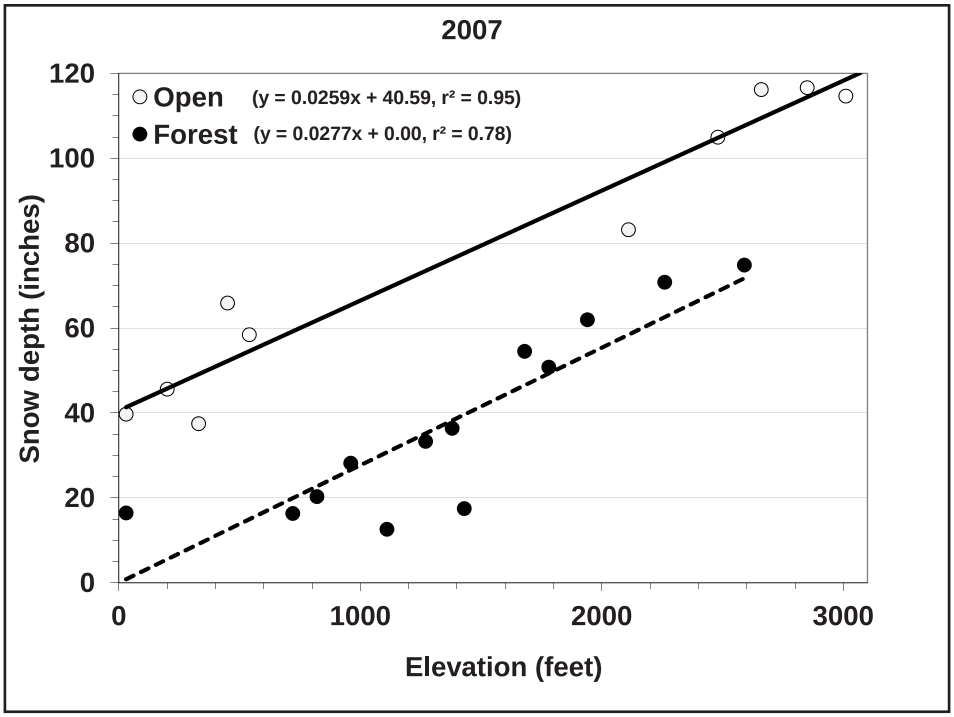
Appendix 9g: Map predicting relative probability of use for mountain goats during summer in the Lions Head study area. Results are based on the "East Berners-Summer" model, 2006-2011. Areas in the "Low" category are transparent; only areas within the study area boundary were modeled .

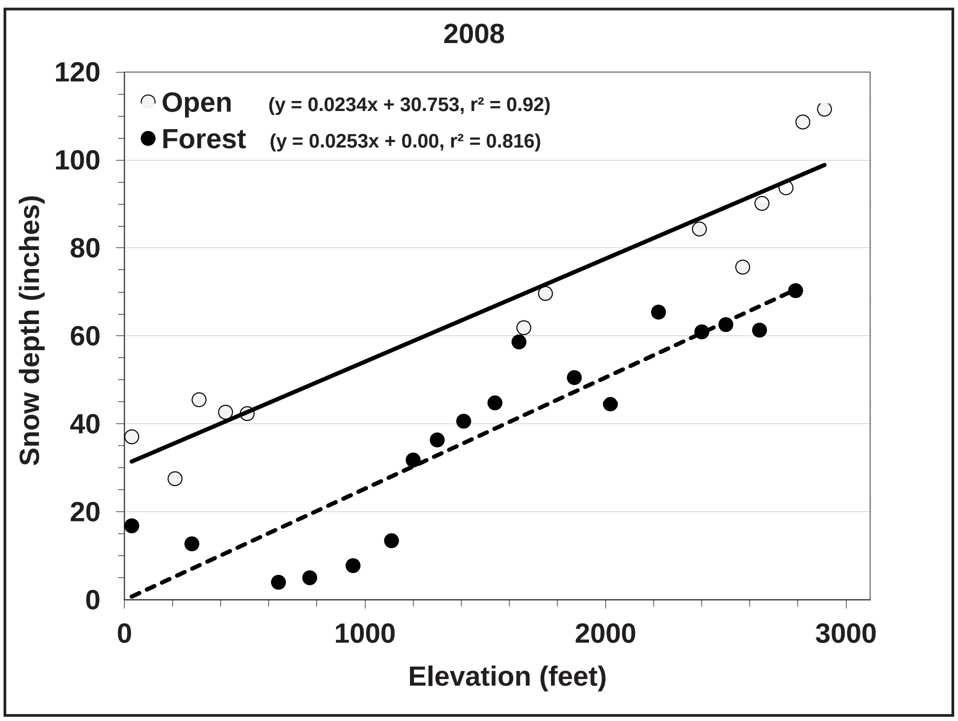


Appendix 9h: Map predicting relative probability of use for mountain goats during winter in the Lions Head study area. Results are based on the “East Berners-Winter” model, 2006-2011. Areas in the “Low” category are transparent; only areas within the study area boundary were modeled .



Appendix 10: Relationship between snow depth and elevation in non-forested sites in late-March 2007 and 2008. Data were collected on Echo Ridge, AK.





Appendix 11: Monthly snowfall (in.) recorded at the NWS weather station in Haines, AK between 2005-2011.

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total	% of normal
2005	1.4	28.6	8.6	39.6	21.9	14.8	0.0	0.3	115.2	73%
2006	0.1	42.9	77.1	81.6	27.7	77.8	1.8	0.0	309.0	197%
2007	0.5	4.8	55.4	76.5	38.6	30.3	2.0	0.0	208.1	133%
2008	19.4	25.1	56.8	60.6	45.9	42.0	8.9	0.0	258.7	165%
2009	0.0	47.2	20.1	67.9	8.3	57.7	0.3	0.0	201.5	128%
2010	0.0	23.8	23.7	17.2	20.4	3.4	1.8	0.0	90.3	58%
Average, Study period	3.6	28.7	40.3	57.2	27.1	37.7	2.5	0.1	197.1	126%
Average, Long-term[1]	2.5	29.2	40.0	46.9	23.9	22.7	2.1	0.0	156.9	100%

[1] Haines COOP NWS Station, 1999-2011

Appendix 12: Daily snowfall (in.) and snow depth records collected at the NWS weather station in Haines, AK between 2005-2010. Snowfall data depict distinct “peaks” associated with snowfall events. Snow depth data describe the seasonal snow profile and integrate temperature such that distinct “dips” in the snow depth profile depict warm, melting phases.

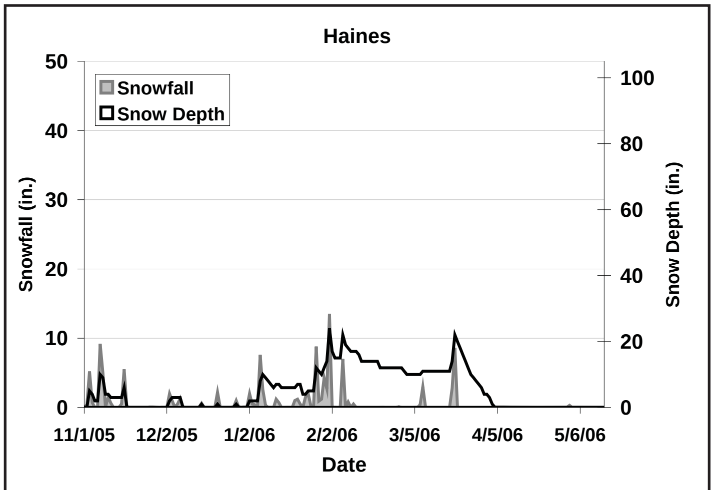


Figure 1: Daily measures of snowfall and snow depth recorded at the NWS station in Haines, AK during the winter of 2005-2006.

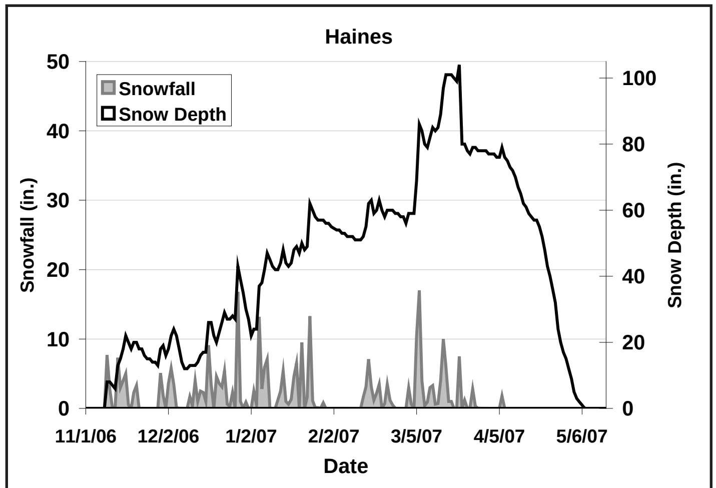


Figure 2: Daily measures of snowfall and snow depth recorded at the NWS station in Haines, AK during the winter of 2006-2007.

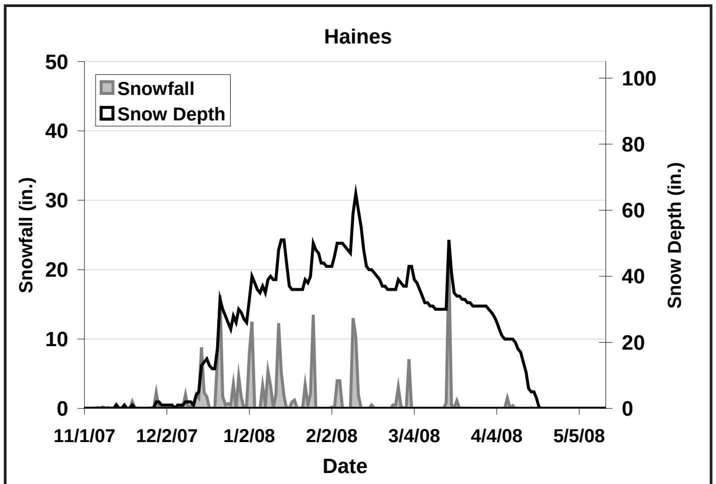


Figure 3: Daily measures of snowfall and snow depth recorded at the NWS station in Haines, AK during the winter of 2007-2008.

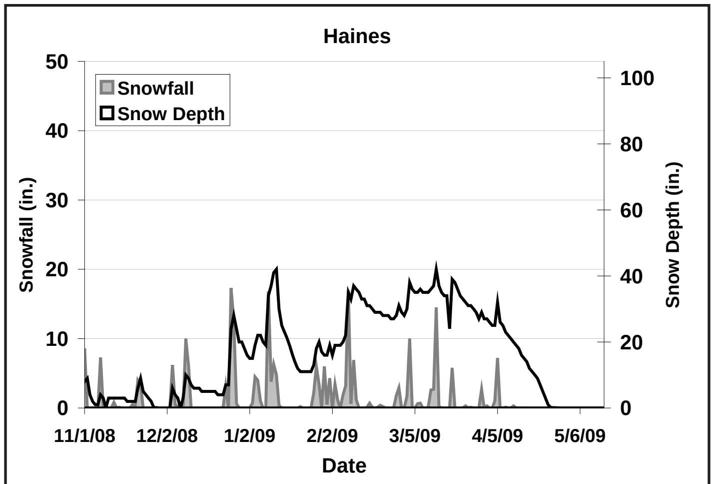


Figure 4: Daily measures of snowfall and snow depth recorded at the NWS station in Haines, AK during the winter of 2008-2009.

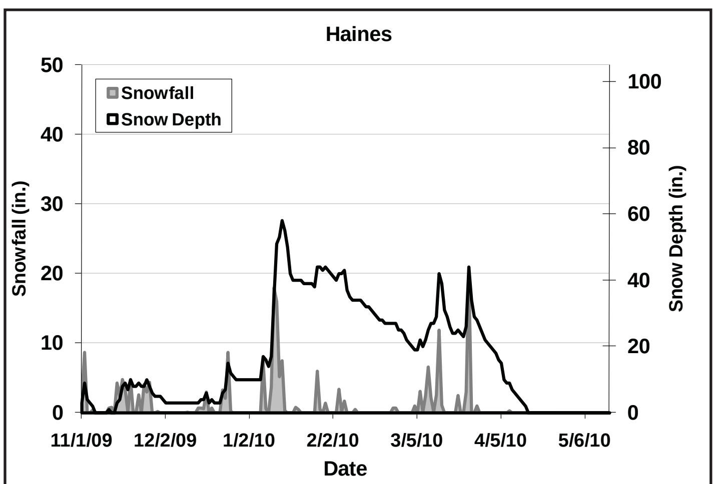


Figure 5: Daily measures of snowfall and snow depth recorded at the NWS station in Haines, AK during the winter of 2009-2010.

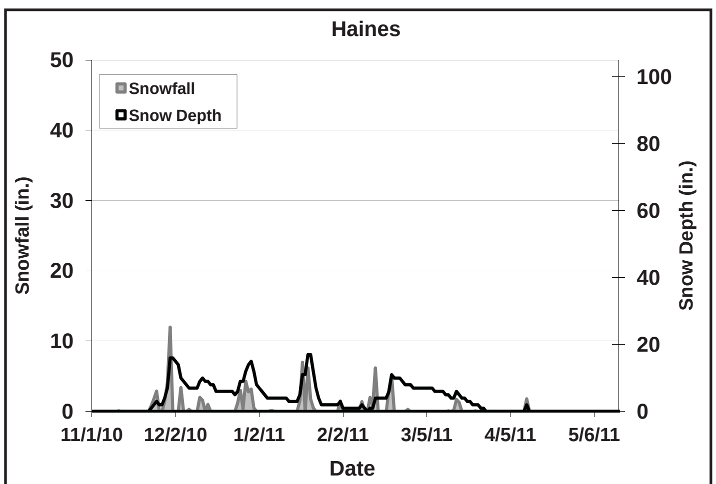


Figure 6: Daily measures of snowfall and snow depth recorded at the NWS station in Haines, AK during the winter of 2010-2011.

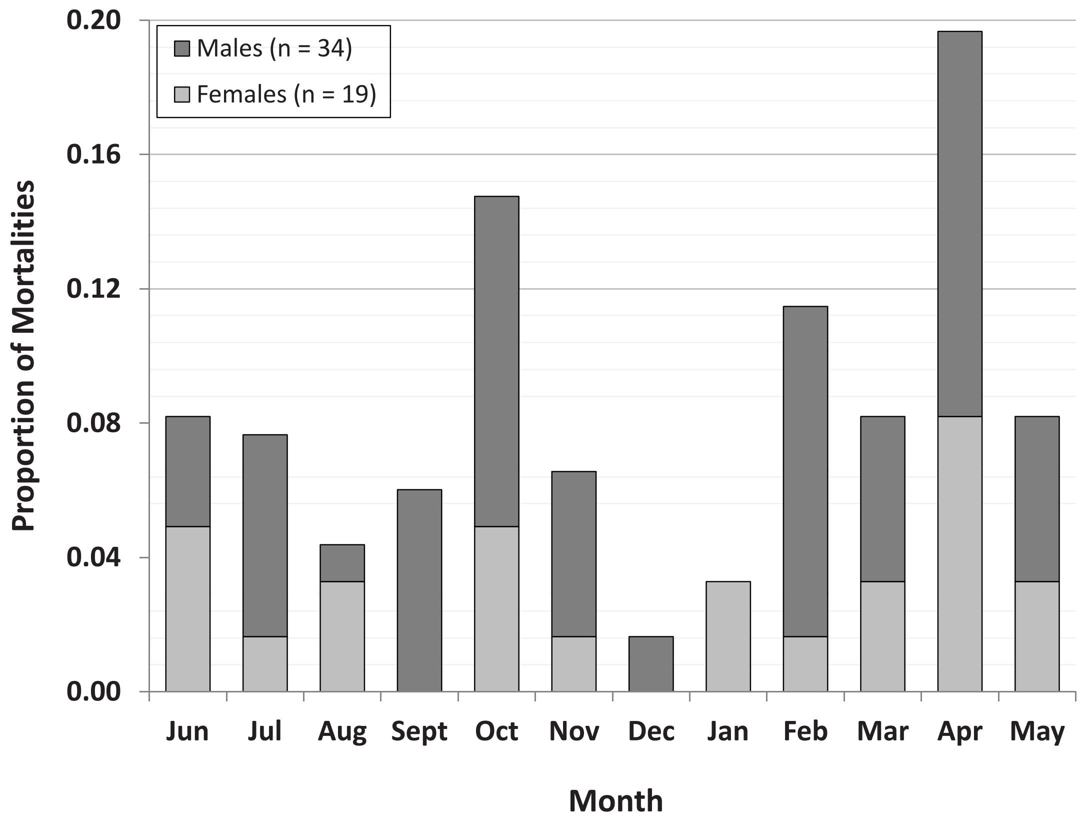
Appendix 13: Proportion of radio-marked female mountain goats observed with kids at heel in relation to age, Lynn Canal, AK, 2005-2011.

Age	n	Kid	No kid	Proportion with kid	SE
1	1	0	1	0.00	0.00
2	4	0	4	0.00	0.00
3	8	0	8	0.00	0.00
4	18	8	10	0.44	0.12
5	29	21	8	0.72	0.08
6	34	22	12	0.65	0.08
7	28	19	9	0.68	0.09
8	21	18	3	0.86	0.08
9	18	14	4	0.78	0.10
10-11	17	10	7	0.59	0.12
12+	5	2	3	0.40	0.22
All ages	183	114	69	0.62	0.04

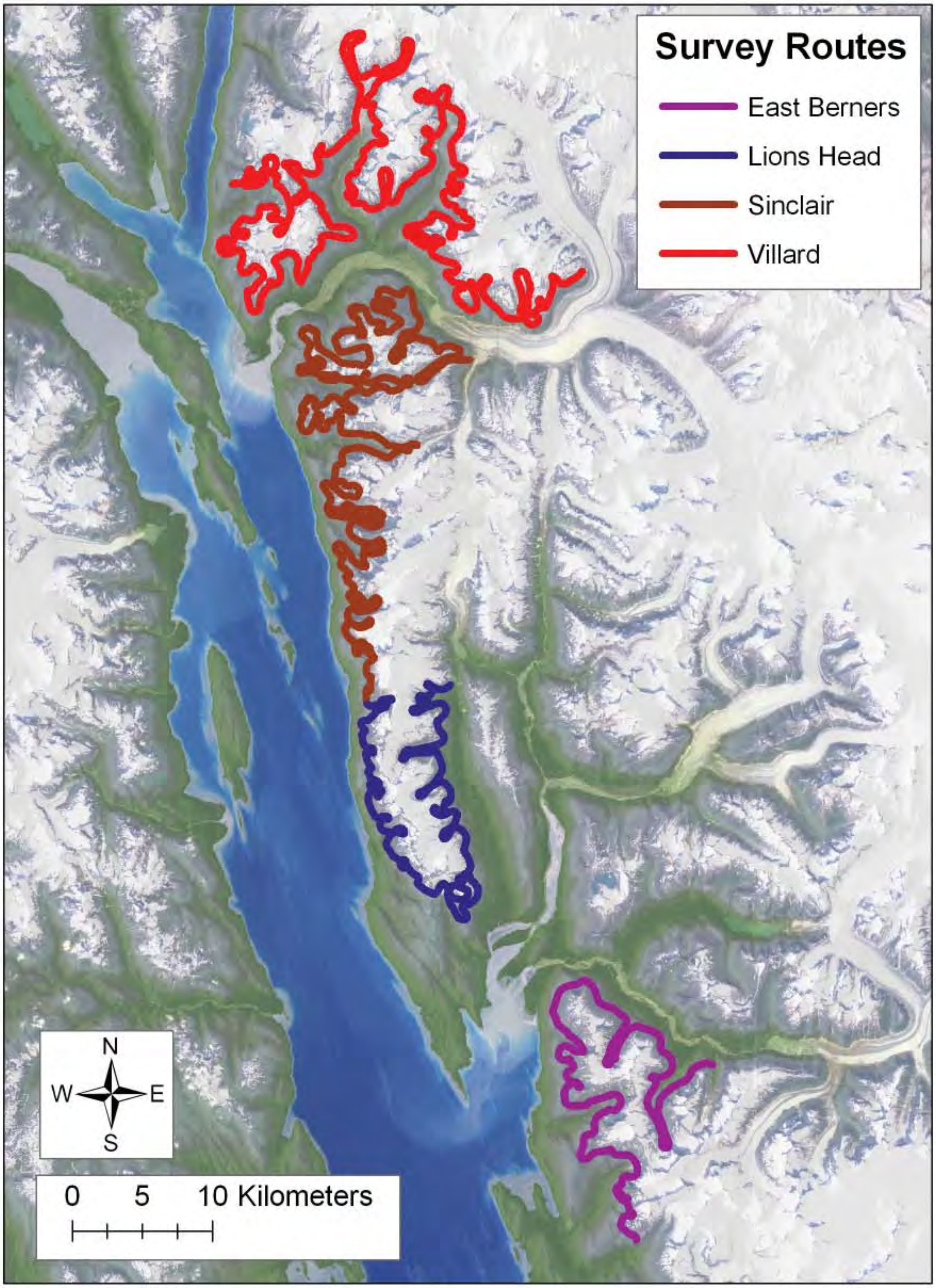
Appendix 14: Annual survival estimates for kids associated with radio-marked adult females, 2006-2011, Lynn Canal, AK.

Year	At Risk	Died	Kid survival	SE
2006	14	6	0.57	0.13
2007	6	3	0.50	0.20
2008	6	4	0.33	0.19
2009	13	10	0.23	0.12
2010	15	7	0.53	0.13
All Years	54	30	0.44	0.07

Appendix 15. Proportion of radio-marked mountain goat mortalities in relation to sex and month in the Lynn Canal study area, 2005-2011.



Appendix 16a: Mountain goat aerial survey routes in the Lynn Canal study area. Each area was surveyed by fixed- and/or rotor-wing aircraft during August-October, 2005-2011.



Appendix 16b: Summary of mountain goat population composition and minimum abundance data collected during aerial surveys on the East Berners Mountains survey route, 2006-2011. These data do not account for differences in mountain goat sighting probabilities that occur between surveys. As a result, the number of mountain goats recorded represent the minimum number of animals on the survey route during a given survey.

Study area	Year	Date	Time of day	Survey time	Adults	Kids	Total	% Kids	Temp (F)	Weather	Median wind speed (knots)	Aircraft	# Observers	Complete survey?
East Berners	2006	8/28/06	1244-1326	42	86	42	128	32.8	40-50	Mostly Clear	5	Heliocourier	3	N
East Berners	2006	9/3/06	1550-1637	47	83	21	104	20.2	51	Partly Cloudy	5	Heliocourier	2	Y
East Berners	2006	10/3/06	1325-1406	41	70	22	92	23.9	35-40	High Overcast	10	Heliocourier	3	Y
East Berners	2007	9/2/07	1759-1929	90	105	28	133	21.1	44	Clear	3	Heliocourier	2	Y
East Berners	2007	9/22/07	0841-1005	84	97	28	125	22.4	35-40	High Overcast	5	Cub	2	Y
East Berners	2007	10/4/07	1305-1409	64	97	22	119	18.5	26-34	High Overcast	5	Cub	2	Y
East Berners	2008	9/25/08	0833-0932	59	125	38	163	23.3	40	Mostly Clear	5	Hughes 500	3	Y
East Berners	2009	8/10/09	1755-1930	95	85	28	113	24.8	46	Cloudy	8	Cub	2	N
East Berners	2009	8/20/09	1904-1922	18	23	6	29	20.7	52	Cloudy	5	Cub	2	N
East Berners	2009	10/2/09	1706-0824, 0930-1026	134	74	26	100	26.0	37-42	High Overcast	8	Cub	2	Y
East Berners	2010	9/11/10	1505-1705	120	72	14	86	16.3	51	Clear	0	Cub	2	Y
East Berners	2010	9/22/10	1316-1537	141	67	15	82	18.3	42	Mostly Clear	5	Cub	2	Y
East Berners	2011	9/27/11	1437-1558	81	116	31	147	21.1	35	High Overcast	5	Cub	2	Y

Appendix 16c: Summary of mountain goat population composition and minimum abundance data collected during aerial surveys on the Lions Head survey route, 2005-2011. These data do not account for differences in mountain goat sighting probabilities that occur between surveys. As a result, the number of mountain goats recorded represent the minimum number of animals on the survey route during a given survey.

Study area	Year	Date	Time of day	Survey time	Adults	Kids	Total	% Kids	Temp (F)	Weather	Median wind speed (knots)	Aircraft	# Observers	Complete survey?
Lions Head	2005	8/11/05	1925-2000	35	35	5	40	12.5	70	Clear	5	Cub	2	Y
Lions Head	2005	10/3/05	1244-1337	57	55	8	65	12.3	45	Clear	5	Heliocouirer	3	Y
Lions Head	2006	8/28/06	1339-1426	47	49	9	58	15.5	40-50	Mostly Clear	5	Heliocourier	3	Y
Lions Head	2006	9/3/06	1652-1739	47	54	11	65	16.9	51	Partly Cloudy	5	Heliocourier	2	Y
Lions Head	2006	10/2/06	1133-1213, 1424-1440	57	92	13	105	12.4	26-31	Mostly Cloudy	10	Heliocourier	3	Y
Lions Head	2006	10/16/06	1123-1235	62	91	23	114	20.2	35-42	Mostly Clear	18	Hughes 500	3	Y
Lions Head	2007	8/10/07	1556-1656	60	18	2	20	10.0	51-57	Clear	5	Heliocourier	3	Y
Lions Head	2007	8/27/07	1012-1107, 1134-1203	84	43	3	46	6.5	44-50	High Overcast	3	Heliocourier	3	Y
Lions Head	2007	9/13/07	0758-0905	68	46	5	51	9.8	~45-55	High Overcast/ Low Fog	3	Cub	2	Y
Lions Head	2007	9/28/07	1010-1121, 1438-1449	82	78	15	93	16.1	35-40	Mostly Clear	5	Hughes 500	3	Y
Lions Head	2007	10/4/07	1421-1519	58	78	8	86	9.3	26-34	High Overcast	8	Cub	2	Y
Lions Head	2008	9/25/08	1101-1139, 1306-1333	65	62	18	80	22.5	40	Mostly Clear	5	Hughes 500	3	Y
Lions Head	2008	10/7/08	1120-1246	86	63	13	76	17.1	31	Clear/High Overcast	8	Cub	2	Y
Lions Head	2009	8/12/09	1806-2038	152	76	18	94	19.1	43-46	Ptly/Mostly Cloudy	5	Cub	2	N
Lions Head	2009	10/3/09	1143-1559	76	51	16	67	23.9	40	High Overcast	13	Cub	2	Y
Lions Head	2010	9/6/10	1217-1405	108	49	14	63	22.2	44-48	Mostly Clear	15	Cub	2	Y
Lions Head	2010	9/21/10	1009-1111, 1500-1547	109	58	23	81	28.4	36-42	Clear	3	Cub	2	Y
Lions Head	2011	9/18/11	1125-1250	85	89	30	119	25.2	39-42	High Overcast	5	Cub	2	Y

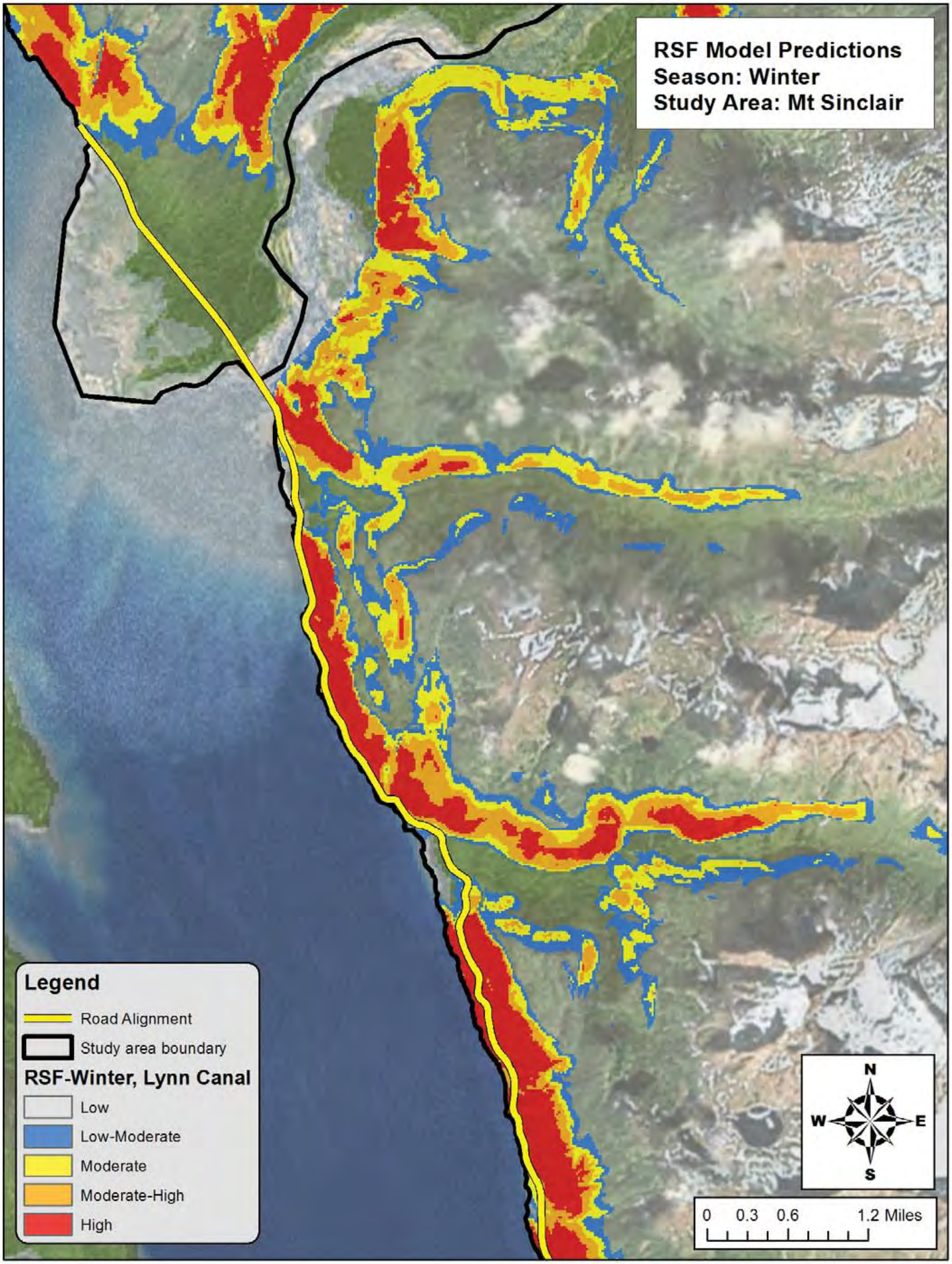
Appendix 16d: Summary of mountain goat population composition and minimum abundance data collected during aerial surveys on the Mt. Sinclair survey route, 2005-2011. These data do not account for differences in mountain goat sighting probabilities that occur between surveys. As a result, the number of mountain goats recorded represent the minimum number of animals on the survey route during a given survey.

Study area	Year	Date	Time of day	Survey time	Adults	Kids	Total	% Kids	Temp (F)	Weather	Median wind speed (knots)	Aircraft	# Observers	Complete survey?
Sinclair Mtn.	2005	8/11/05	2000-2117	77	77	17	94	18.1	70	Clear	5	Cub	2	Y
Sinclair Mtn.	2005	10/3/05	1338-1400, 1445-1556	93	159	30	189	15.9	45	Clear	5	Heliocouirer	3	Y
Sinclair Mtn.	2006	8/28/06	1426-1530	64	86	21	107	19.6	40-50	Mostly Clear	5	Heliocourier	3	N
Sinclair Mtn.	2006	9/2/06	1605-1739	94	128	31	159	19.5	50-56	High Overcast	5	Heliocourier	4	Y
Sinclair Mtn.	2006	9/23/06	1526-1717	111	153	22	182	12.1	40-42	High Overcast	5	Heliocourier	3	Y
Sinclair Mtn.	2006	10/16/06	1235-1311, 1402-1415, 1506-1638	141	227	41	268	15.3	35-42	Mostly Clear	18	Hughes 500	3	Y
Sinclair Mtn.	2007	8/27/07	1203-1258, 1402-1457	110	57	4	61	6.6	44-50	High Overcast	3	Heliocourier	3	Y
Sinclair Mtn.	2007	9/13/07	0905-1055, 1155-1220	135	75	13	88	14.8	~45-55	High Overcast/ Low Fog	3	Cub	2	Y
Sinclair Mtn.	2007	9/28/07	1449-1551, 1703-1803	122	173	38	211	18.0	35-40	High Overcast	5	Hughes 500	3	Y
Sinclair Mtn.	2008	9/25/08	1333-1509, 1627-1651	120	127	27	154	17.5	40	Mostly Clear	5	Hughes 500	3	Y
Sinclair Mtn.	2008	10/7/08	1246-1512	146	123	26	149	17.4	31	Clear/High Overcast	8	Cub	2	Y
Sinclair Mtn.	2010	9/6/10	1405-1549, 1626-1715	153	62	18	80	22.5	44-48	Mostly Clear	15	Cub	2	Y
Sinclair Mtn.	2010	9/21/10	1111-1244, 1322-1456	187	59	19	78	24.4	36-42	Clear	3	Cub	2	Y
Sinclair Mtn.	2011	9/18/11	1250-1457, 1534-1620	173	127	33	160	20.6	39-42	High Overcast	5	Cub	2	Y

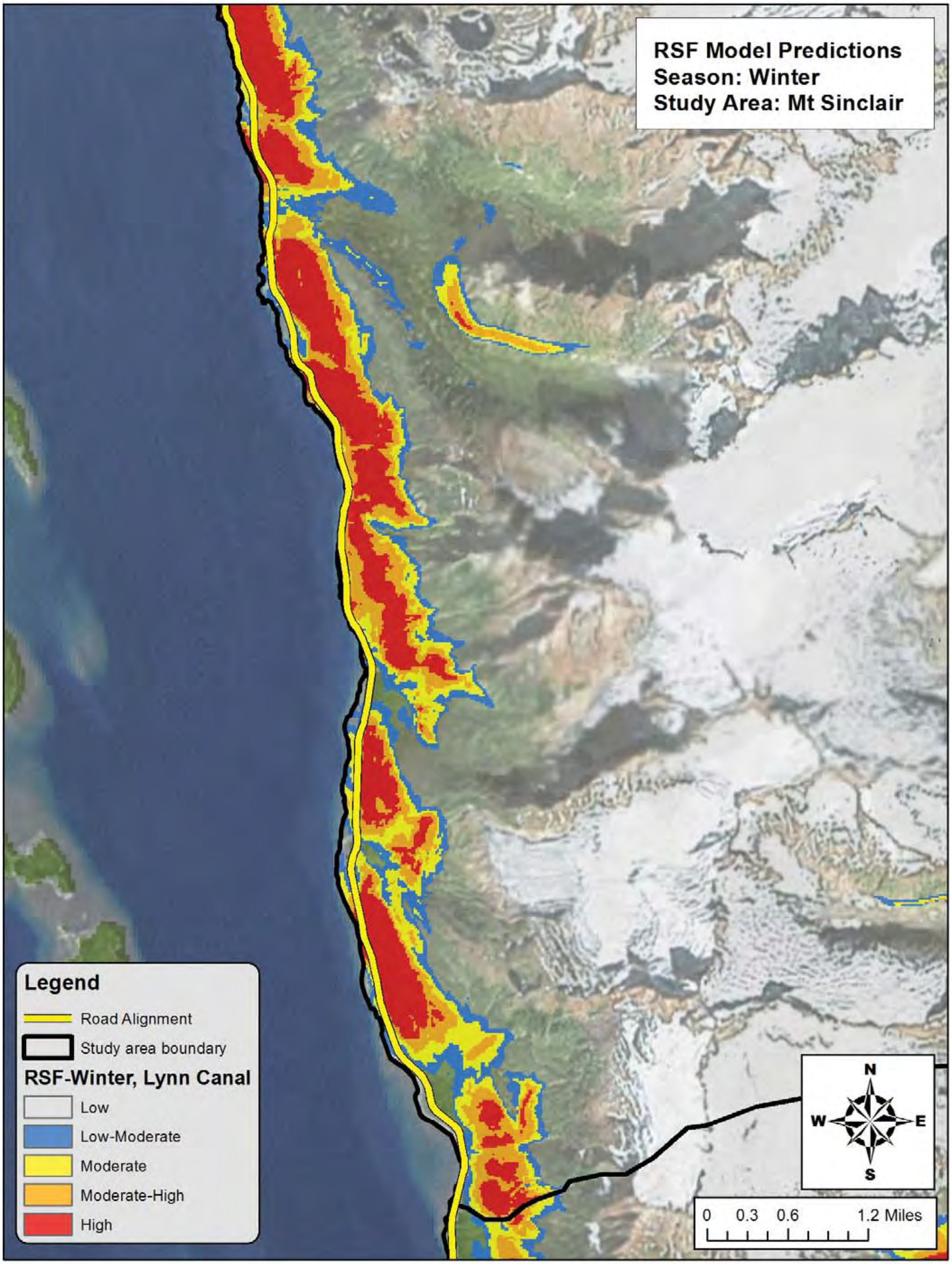
Appendix 16e: Summary of mountain goat population composition and minimum abundance data collected during aerial surveys on the Mt. Villard survey route, 2005-2011. These data do not account for differences in mountain goat sighting probabilities that occur between surveys. As a result, the number of mountain goats recorded represent the minimum number of animals on the survey route during a given survey.

Study area	Year	Date	Time of day	Survey time	Adults	Kids	Total	% Kids	Temp (F)	Weather	Median wind speed (knots)	Aircraft	# Observers	Complete survey?
Mt. Villard	2005	8/12/05	0748-0913	85	23	4	27	14.8	68	Clear	5	Cub	2	Y
Mt. Villard	2006	9/2/06	1741-1912	91	102	23	125	18.4	50-56	High Overcast	5	Heliocourier	4	Y
Mt. Villard	2006	9/23/06	1723-1831	68	90	12	102	11.8	40-42	High Overcast	5	Heliocourier	3	N
Mt. Villard	2006	10/1/06	1222-1240	18	41	12	53	22.6	31	Mostly Cloudy	10	Heliocourier	3	N
Mt. Villard	2006	10/2/06	1230-1355	85	165	28	193	14.5	26-31	Mostly Cloudy	10	Heliocourier	3	Y
Mt. Villard	2006	10/17/06	1012-1117	65	145	29	174	16.7	35-31	High Overcast	5	Hughes 500	3	N
Mt. Villard	2007	9/3/07	1740-1914, 1935-1958	117	88	23	111	20.7	47-54	Clear	5	Heliocourier	3	Y
Mt. Villard	2007	9/14/07	1050-1218	88	74	23	97	23.7	44	Overcast/Fog	14	Heliocourier	3	Y
Mt. Villard	2007	9/22/07	1248-1546	178	132	22	154	14.3	35-40	Overcast/Lt Snow/Fog	8	Cub	2	Y
Mt. Villard	2008	9/6/08	1748-1905	77	52	10	62	16.1	45-55	Partly Cloudy/High Overcast	5	Cub	2	N
Mt. Villard	2008	9/25/08	1511-1537, 1653-1820	113	164	30	194	15.5	40	Mostly Clear	5	Hughes 500	3	Y
Mt. Villard	2009	10/3/09	1403-1622	139	56	16	72	22.2	32	High Overcast	15	Cub	2	Y
Mt. Villard	2010	9/12/10	1335-1602	147	62	19	81	23.5	41-48	Clear	20	Cub	2	Y
Mt. Villard	2011	9/18/11	1627-1853	146	156	35	191	18.3	39-42	High Overcast	5	Cub	2	Y

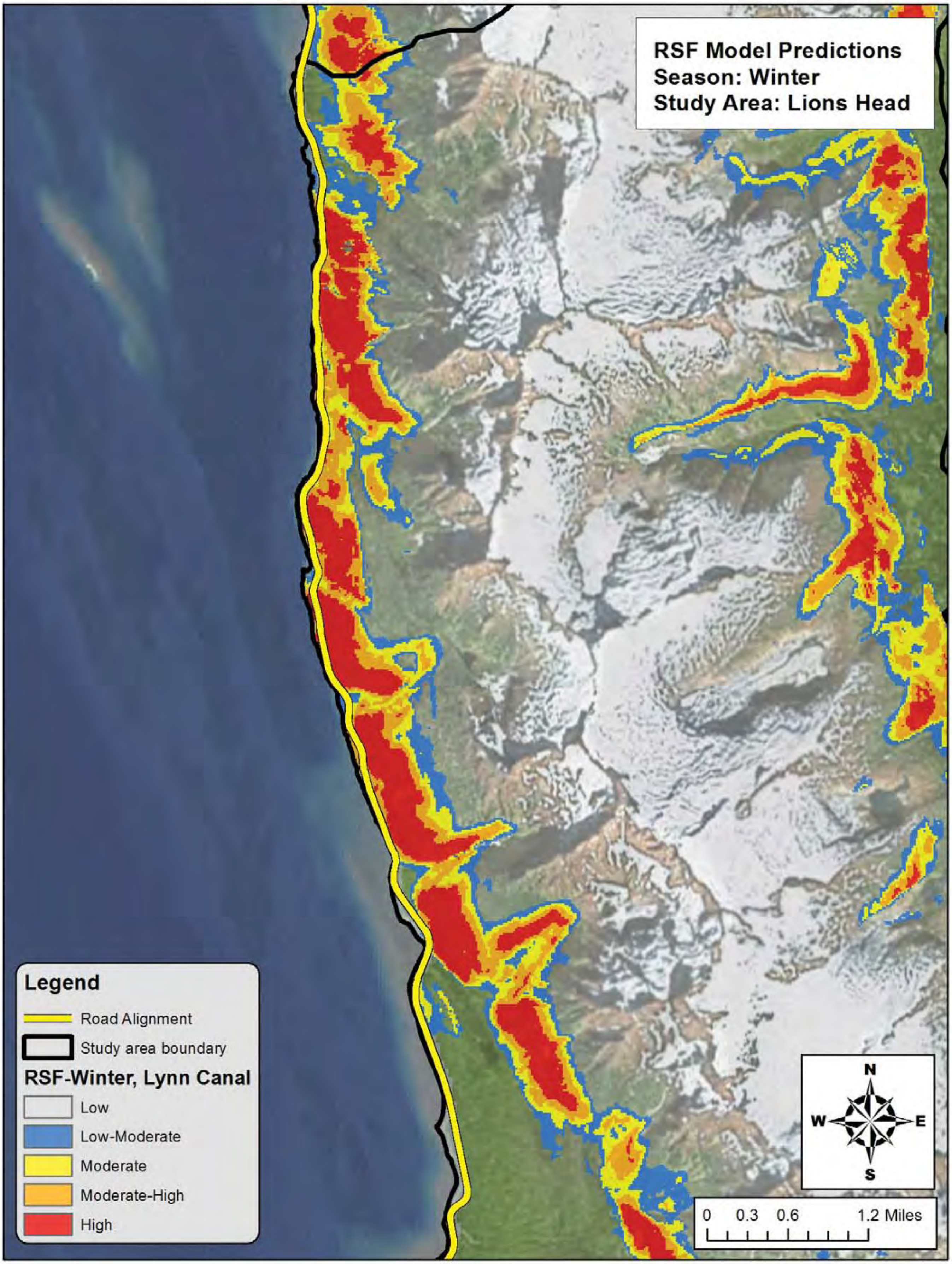
Appendix 17a: Map predicting relative probability of use for mountain goats during winter along the Juneau Access road alignment.



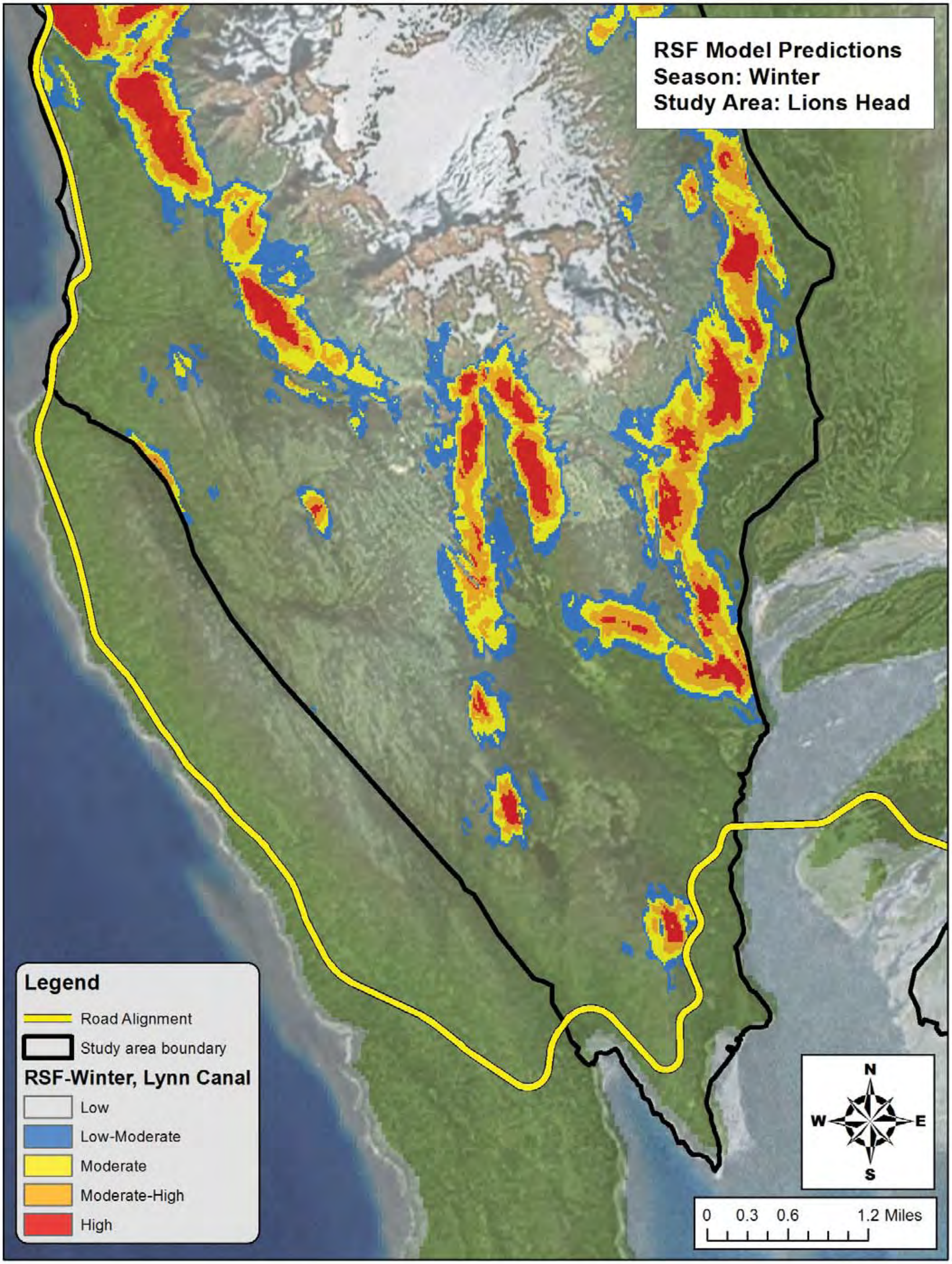
Appendix 17b: Map predicting relative probability of use for mountain goats during winter along the Juneau Access road alignment.



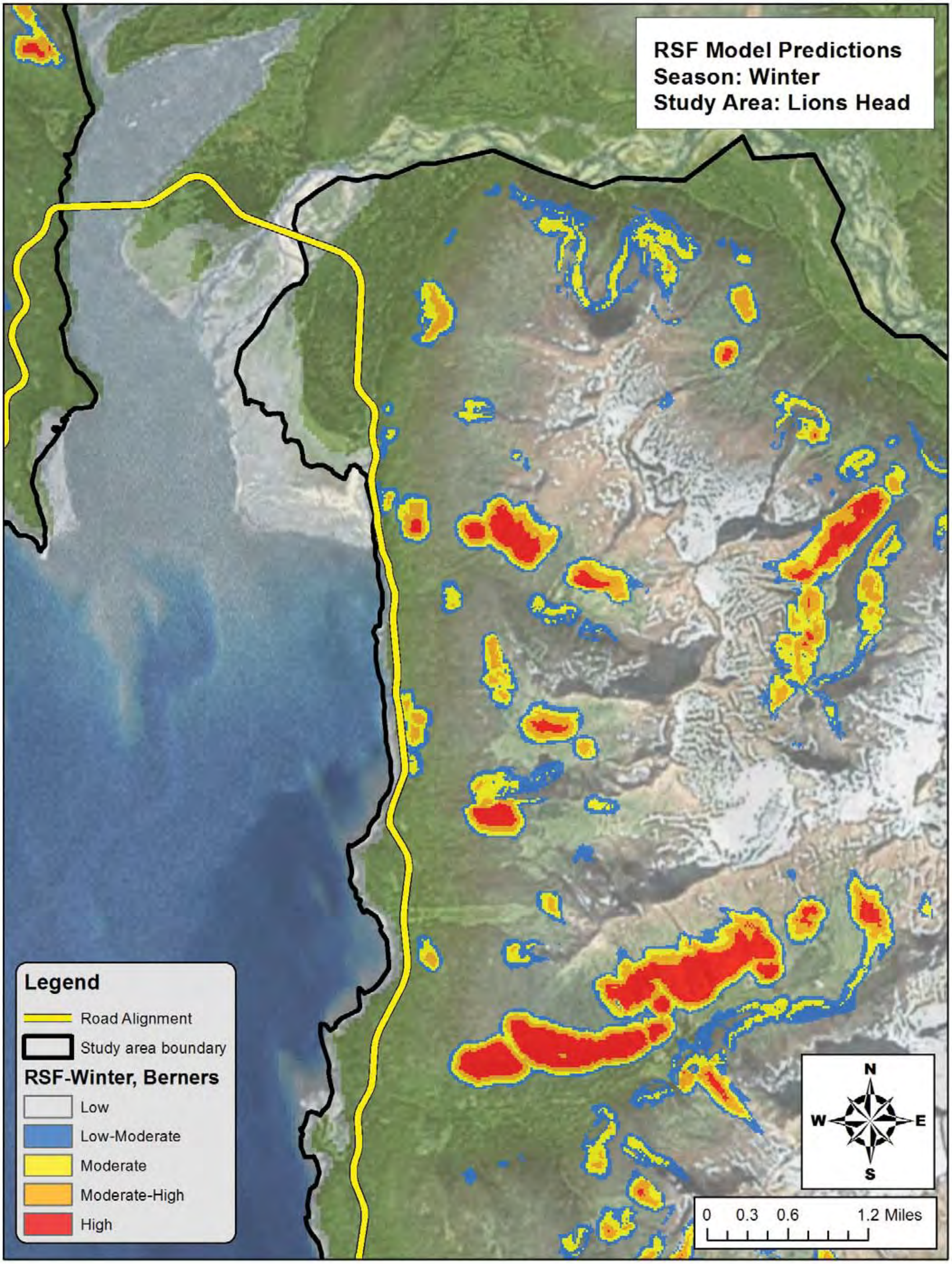
Appendix 17c: Map predicting relative probability of use for mountain goats during winter along the Juneau Access road alignment.



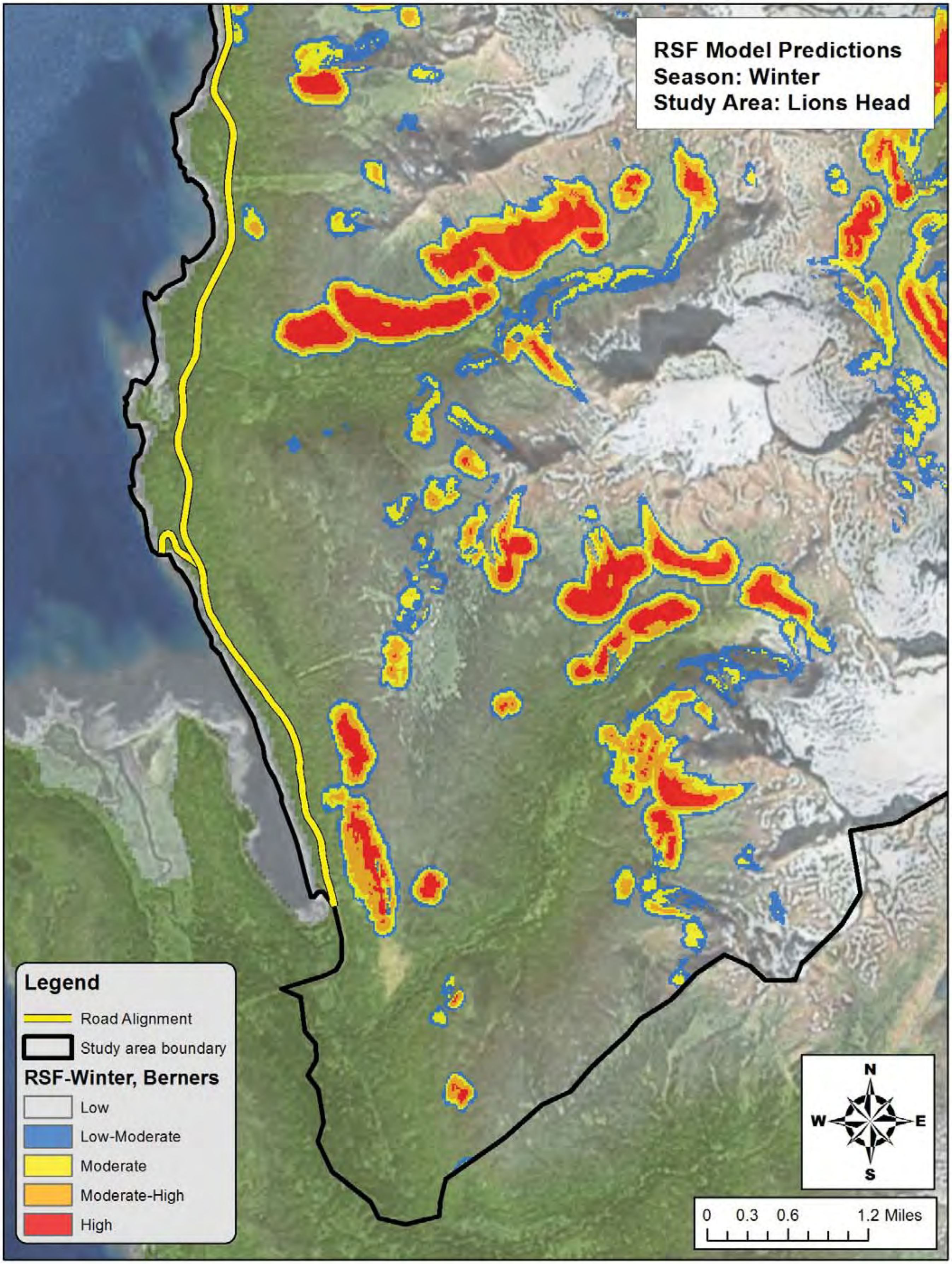
Appendix 17d: Map predicting relative probability of use for mountain goats during winter along the Juneau Access road alignment.



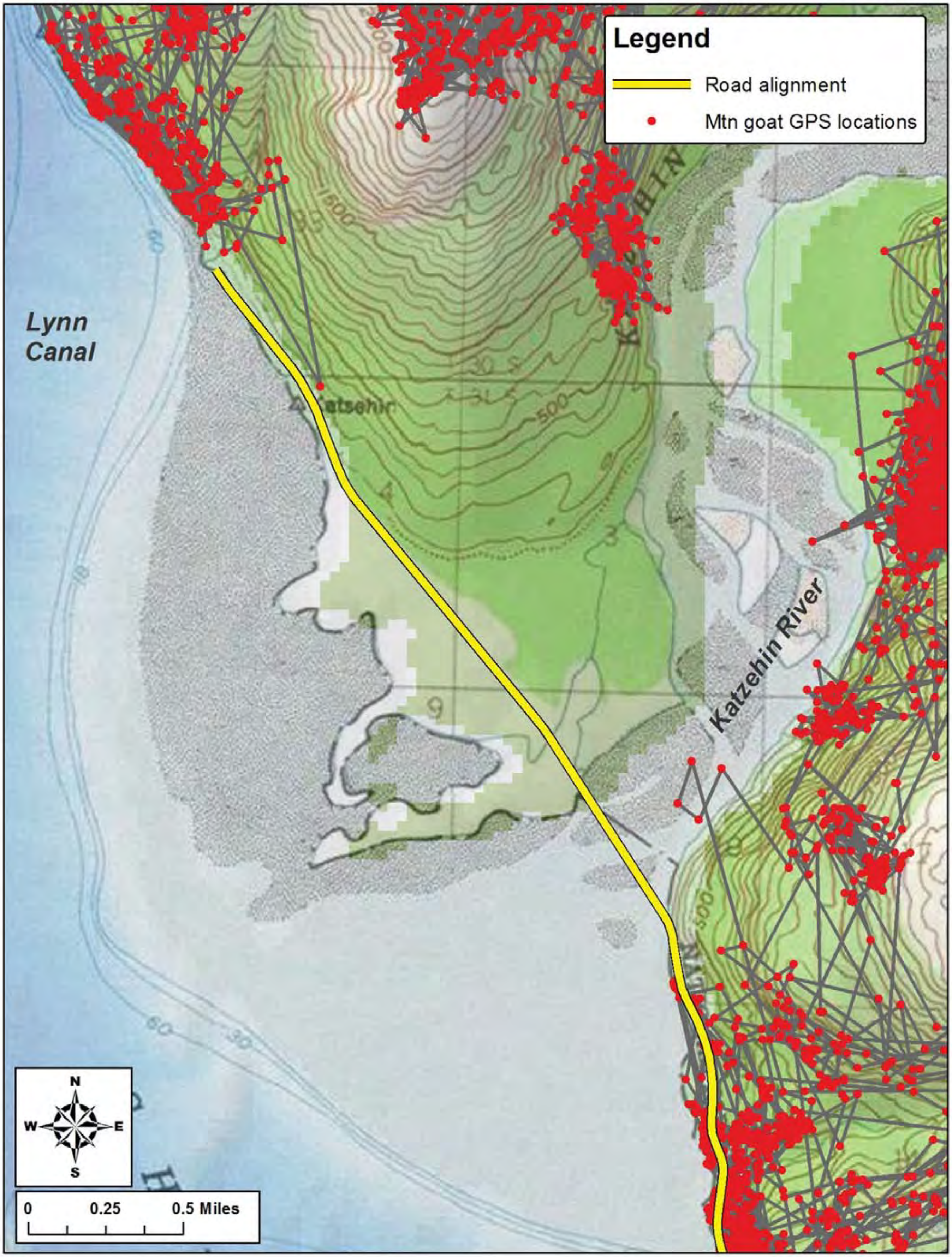
Appendix 17e: Map predicting relative probability of use for mountain goats during winter along the Juneau Access road alignment.



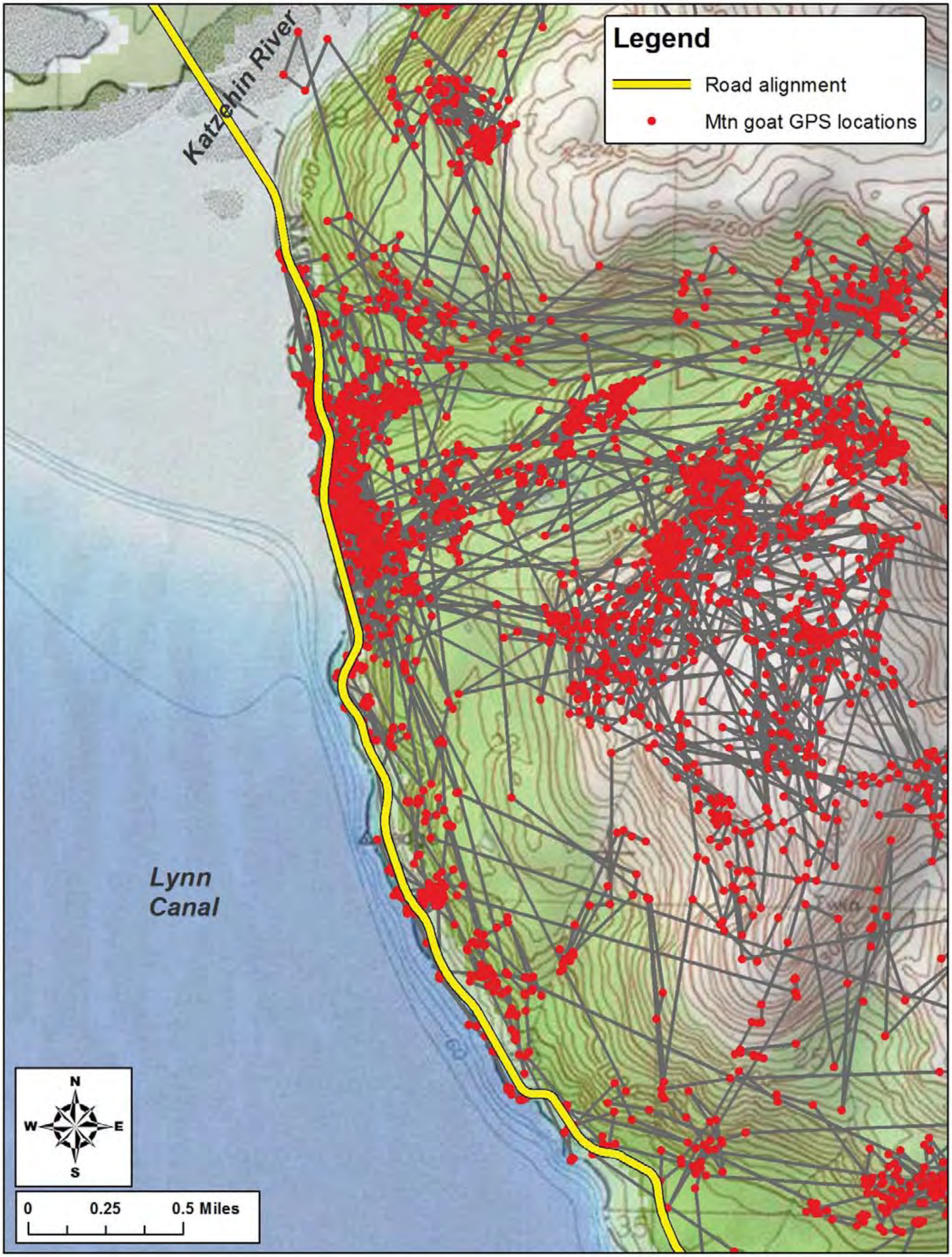
Appendix 17f: Map predicting relative probability of use for mountain goats during winter along the Juneau Access road alignment.



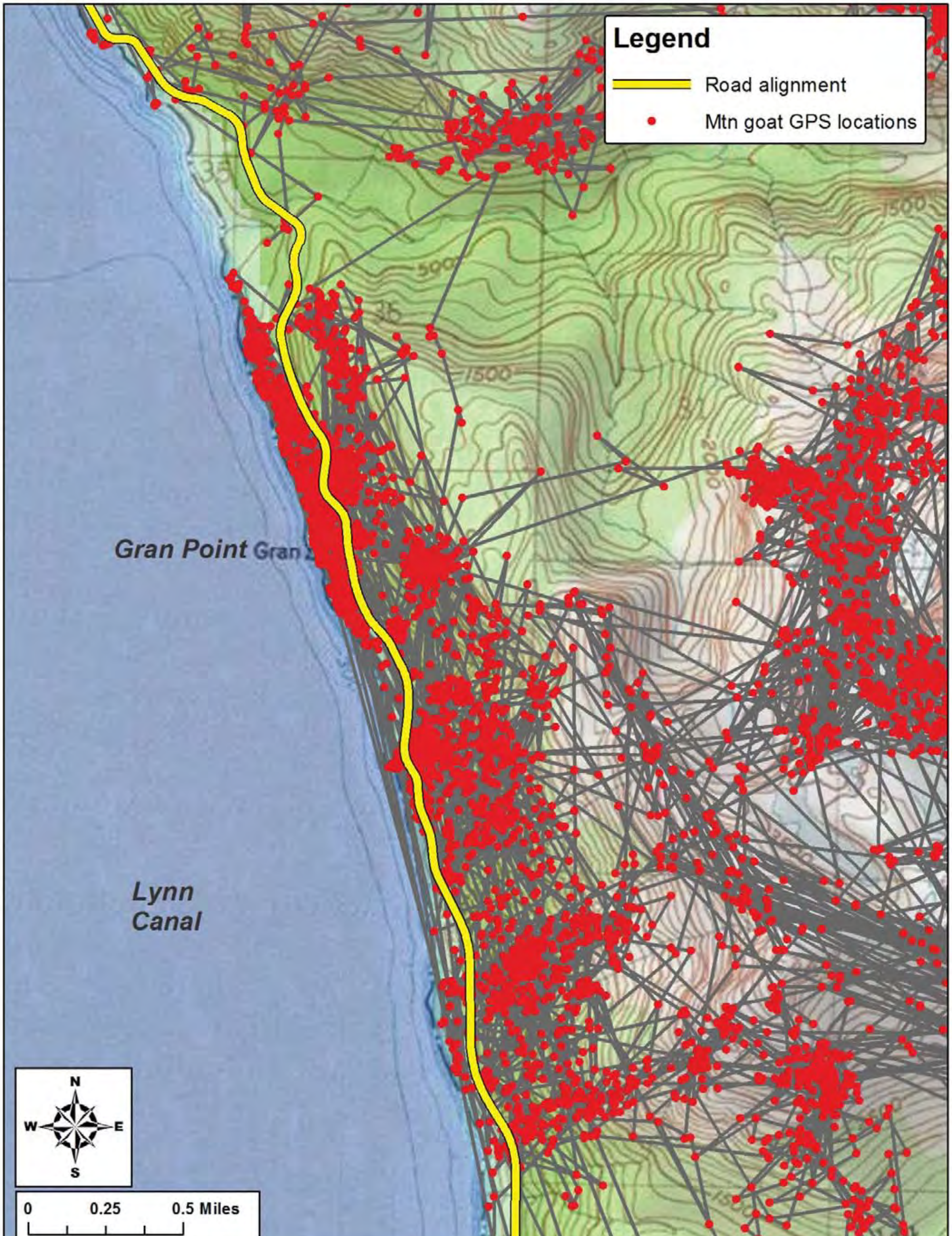
Appendix 18a: Map depicting mountain goat GPS locations in the vicinity of the Katzehin River relative to the location of the Juneau Access highway alignment, 2005-2011, Lynn Canal, AK. GPS locations describe use patterns of a sub-set of the population and do not necessairly comprehensively characterize all areas used by mountain goats in local areas.



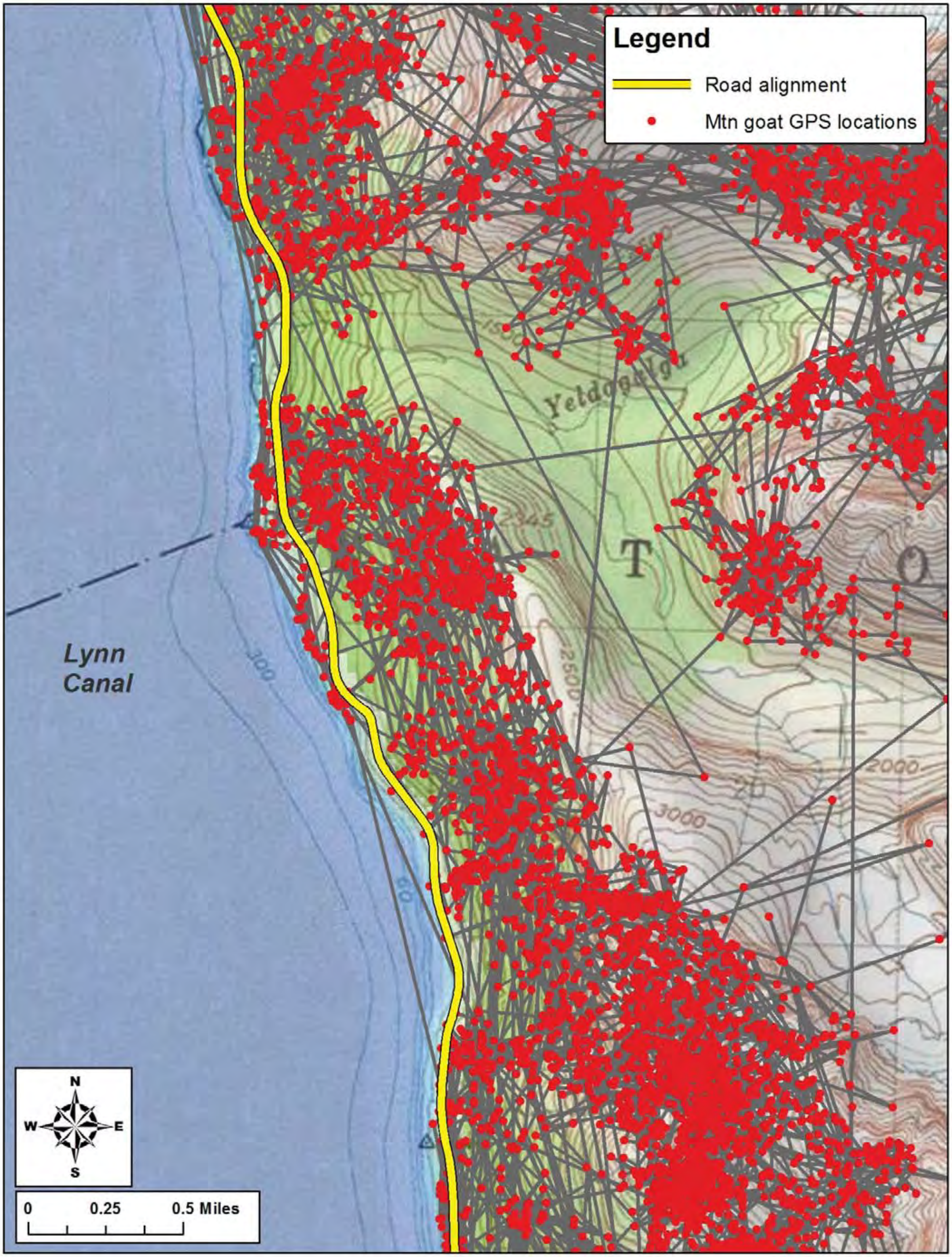
Appendix 18b: Map depicting mountain goat GPS locations south of the Katzehin River relative to the location of the Juneau Access highway alignment, 2005-2011, Lynn Canal, AK. GPS locations describe use patterns of a sub-set of the population and do not necessarily comprehensively characterize all areas used by mountain goats in local areas.



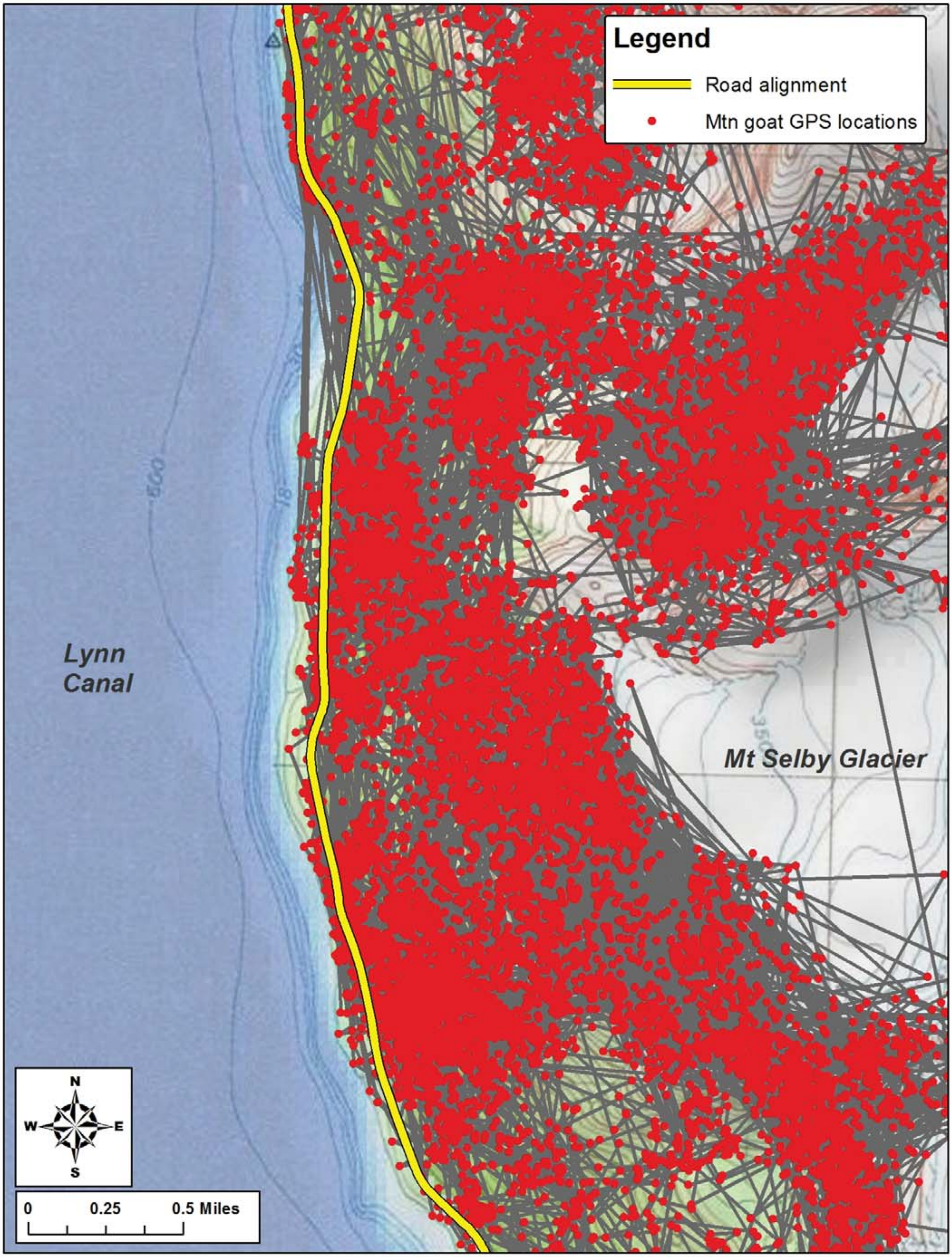
Appendix 18c: Map depicting mountain goat GPS locations in the vicinity of Gran Point relative to the location of the Juneau Access highway alignment, 2005-2011, Lynn Canal, AK. GPS locations describe use patterns of a sub-set of the population and do not necessarily comprehensively characterize all areas used by mountain goats in local areas.



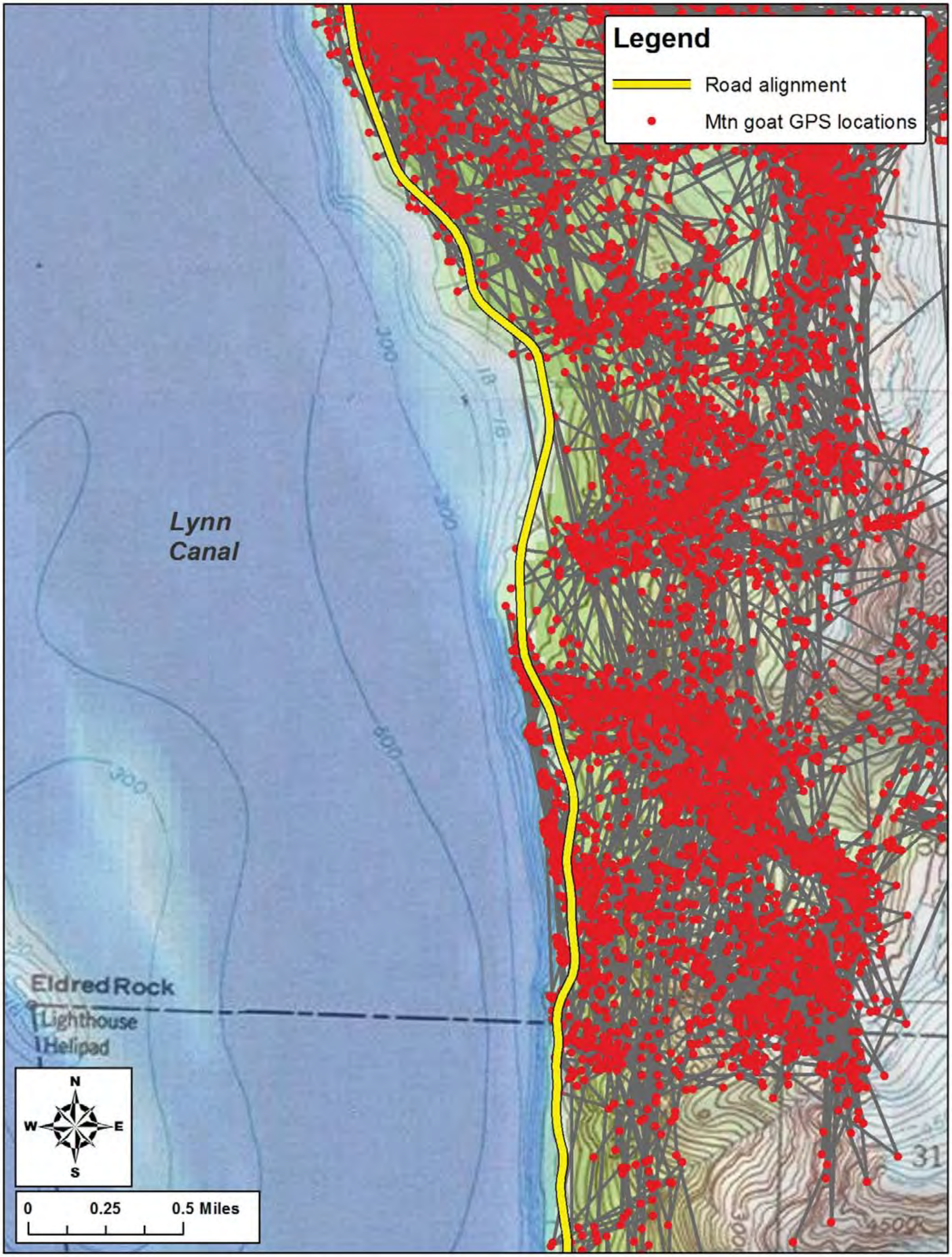
Appendix 18d: Map depicting mountain goat GPS locations in the vicinity of Yeldagalga Creek relative to the location of the Juneau Access highway alignment, 2005-2011, Lynn Canal, AK. GPS locations describe use patterns of a sub-set of the population and do not necessairly comprehensively characterize all areas used by mountain goats in local areas.



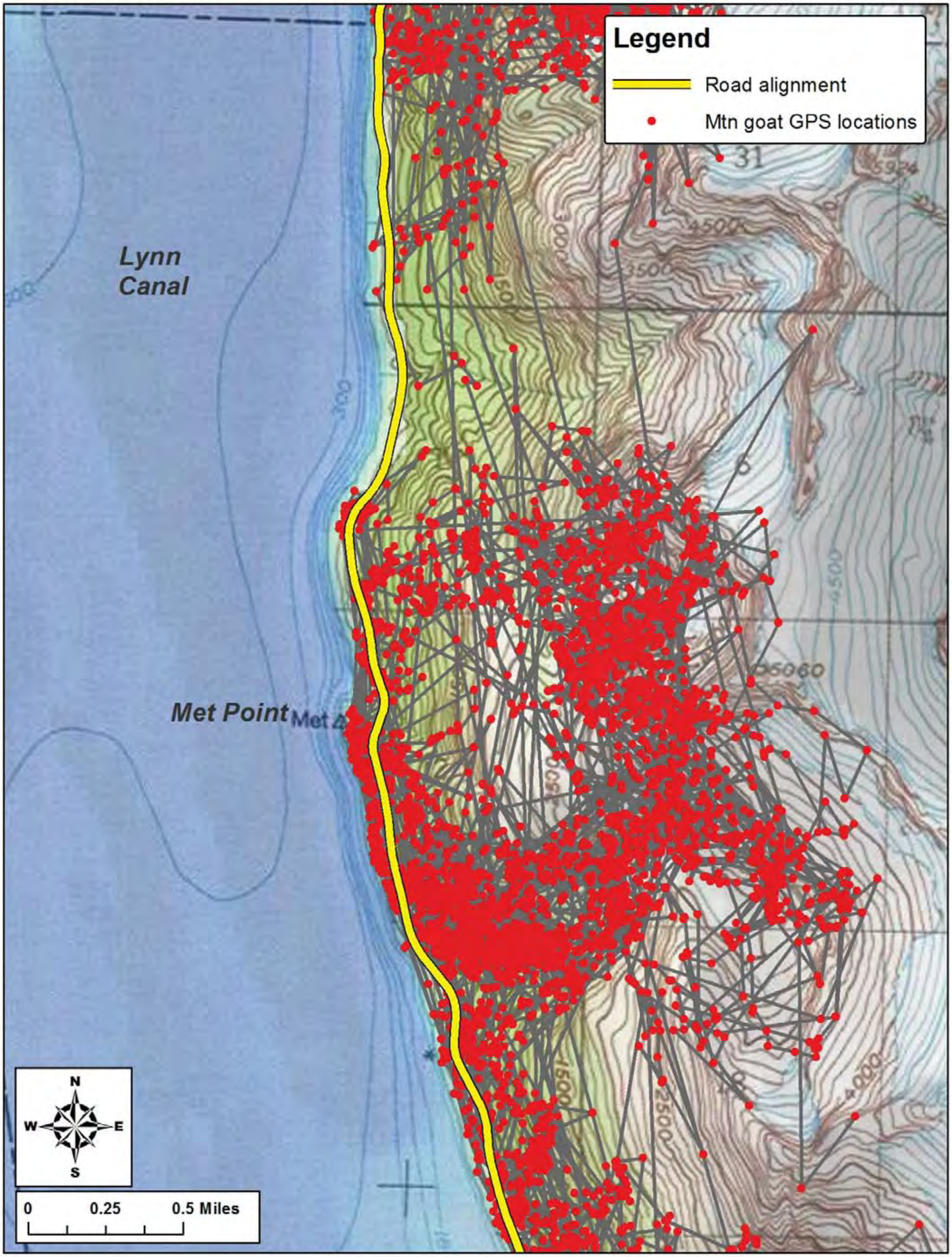
Appendix 18e: Map depicting mountain goat GPS locations in the vicinity of Mt Selby relative to the location of the Juneau Access highway alignment, 2005-2011, Lynn Canal, AK. GPS locations describe use patterns of a sub-set of the population and do not necessarily comprehensively characterize all areas used by mountain goats in local areas.



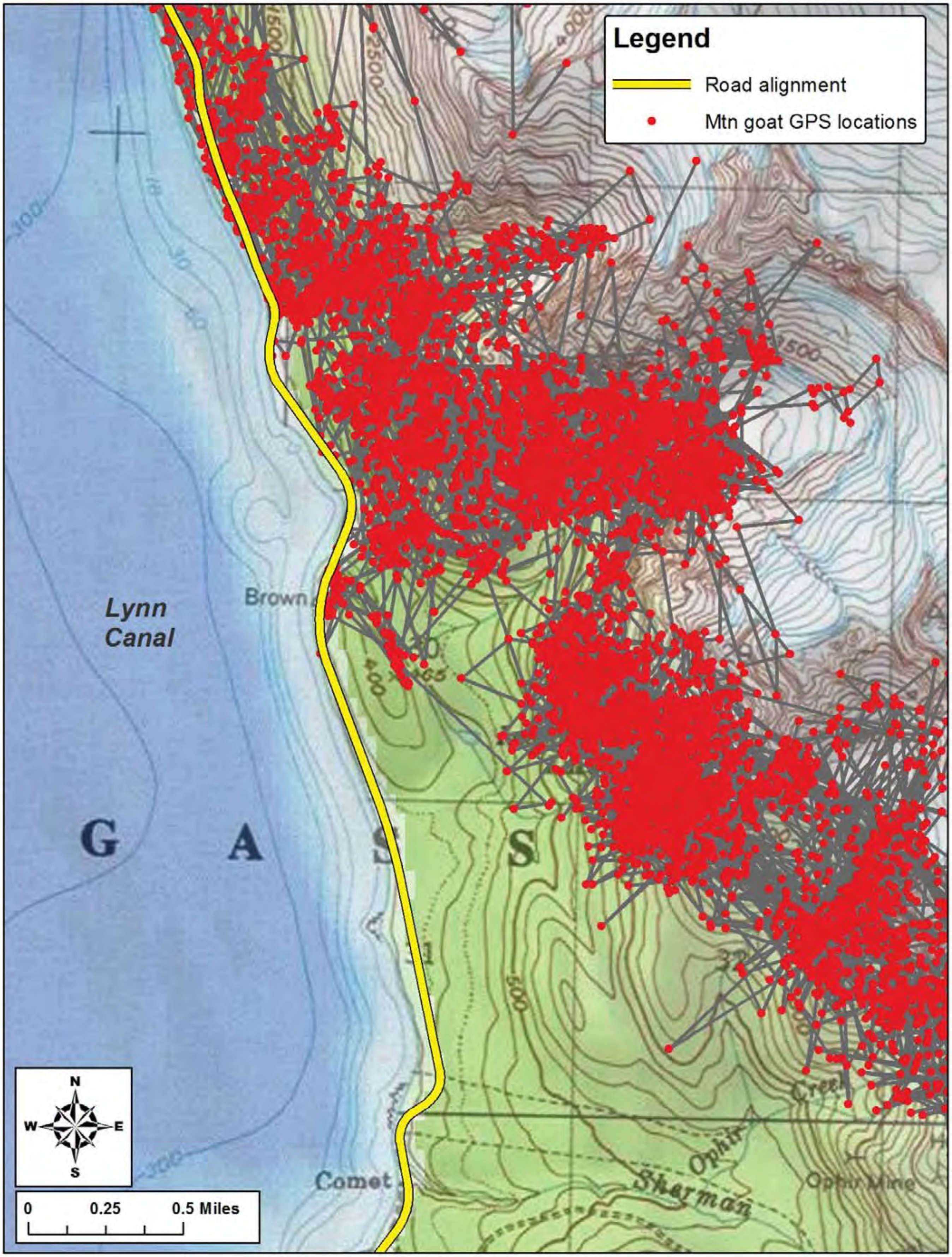
Appendix 18f: Map depicting mountain goat GPS locations east of Eldred Rock relative to the location of the Juneau Access highway alignment, 2005-2011, Lynn Canal, AK. GPS locations describe use patterns of a sub-set of the population and do not necessairly comprehensively characterize all areas used by mountain goats in local areas.



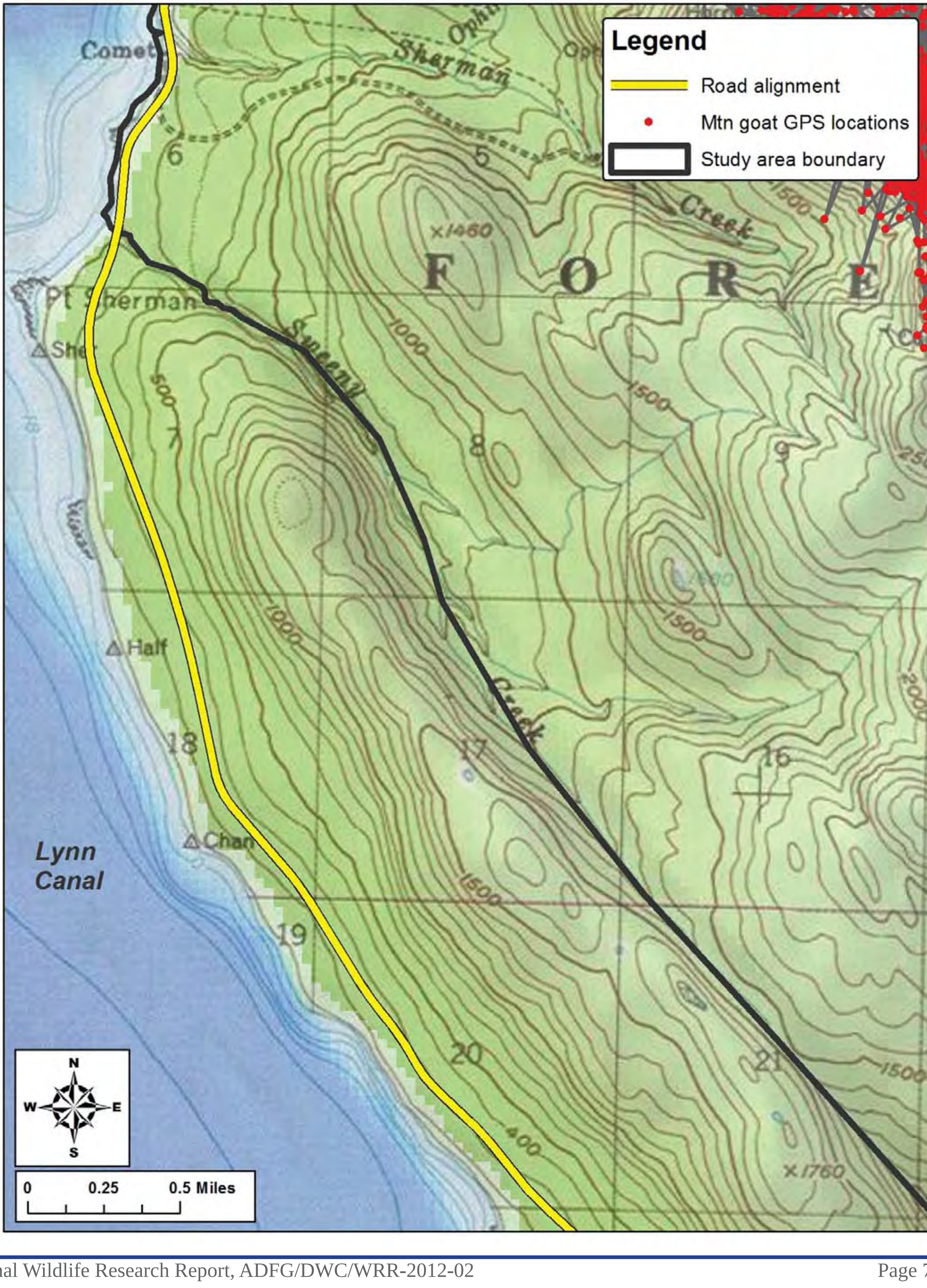
Appendix 18g: Map depicting mountain goat GPS locations in the vicinity of Met Point relative to the location of the Juneau Access highway alignment, 2005-2011, Lynn Canal, AK. GPS locations describe use patterns of a sub-set of the population and do not necessarily comprehensively characterize all areas used by mountain goats in local areas.



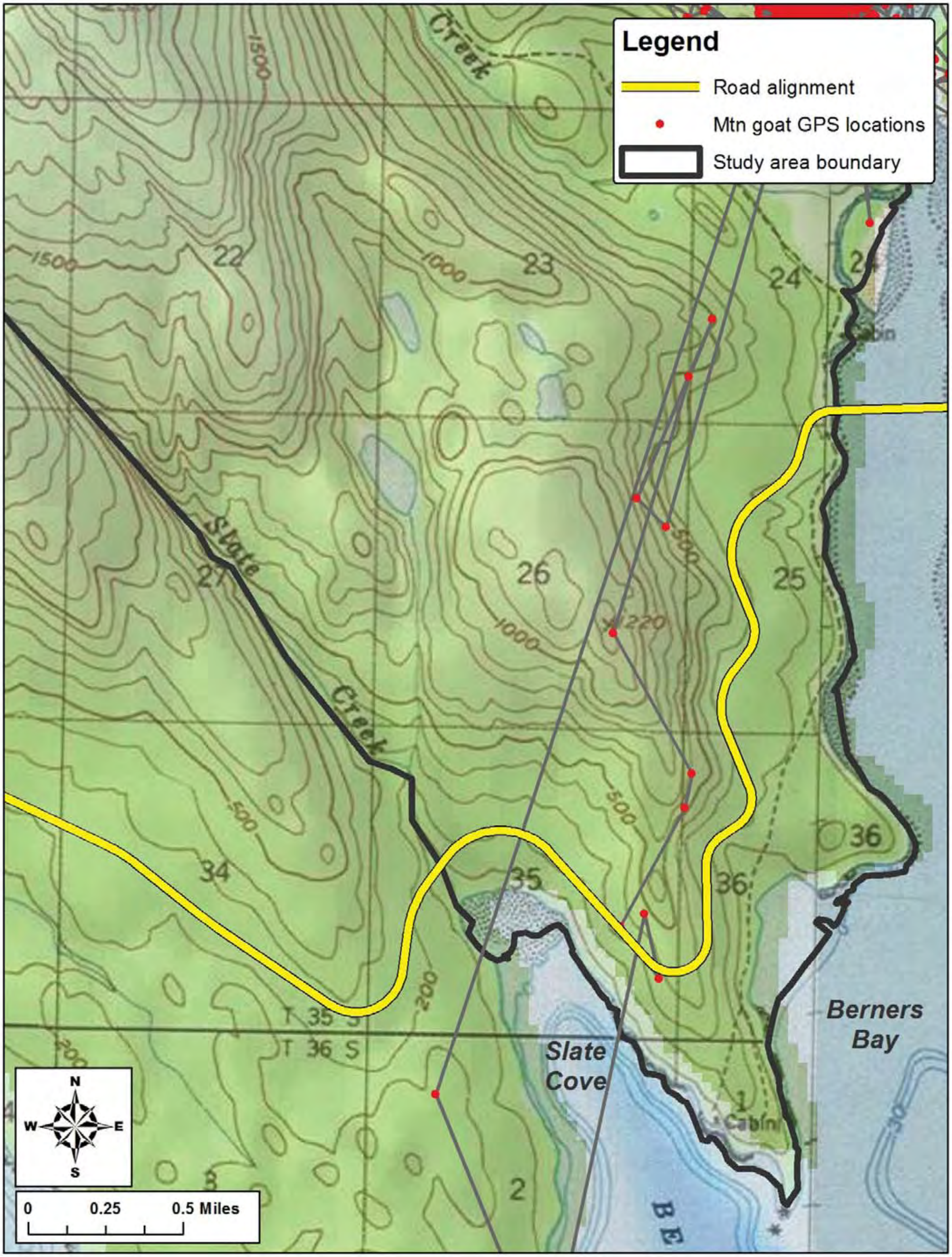
Appendix 18h: Map depicting mountain goat GPS locations in the vicinity of Independence Lake relative to the location of the Juneau Access highway alignment, 2005-2011, Lynn Canal, AK. GPS locations describe use patterns of a sub-set of the population and do not necessarily comprehensively characterize all areas used by mountain goats in local areas.



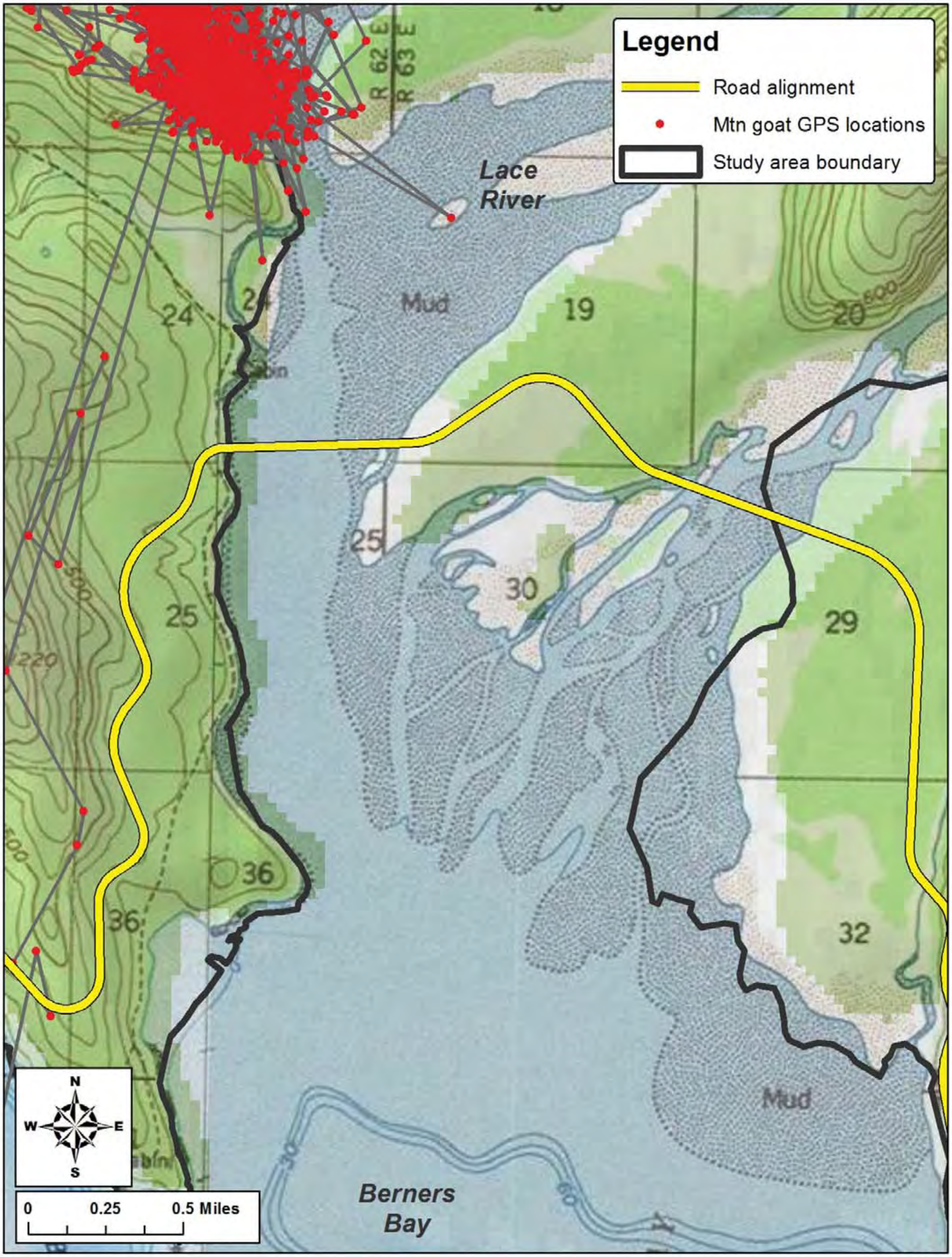
Appendix 18i: Map depicting mountain goat GPS locations in the vicinity of Sweeney Creek relative to the location of the Juneau Access highway alignment, 2005-2011, Lynn Canal, AK. GPS locations describe use patterns of a sub-set of the population and do not necessarily comprehensively characterize all areas used by mountain goats in local areas.



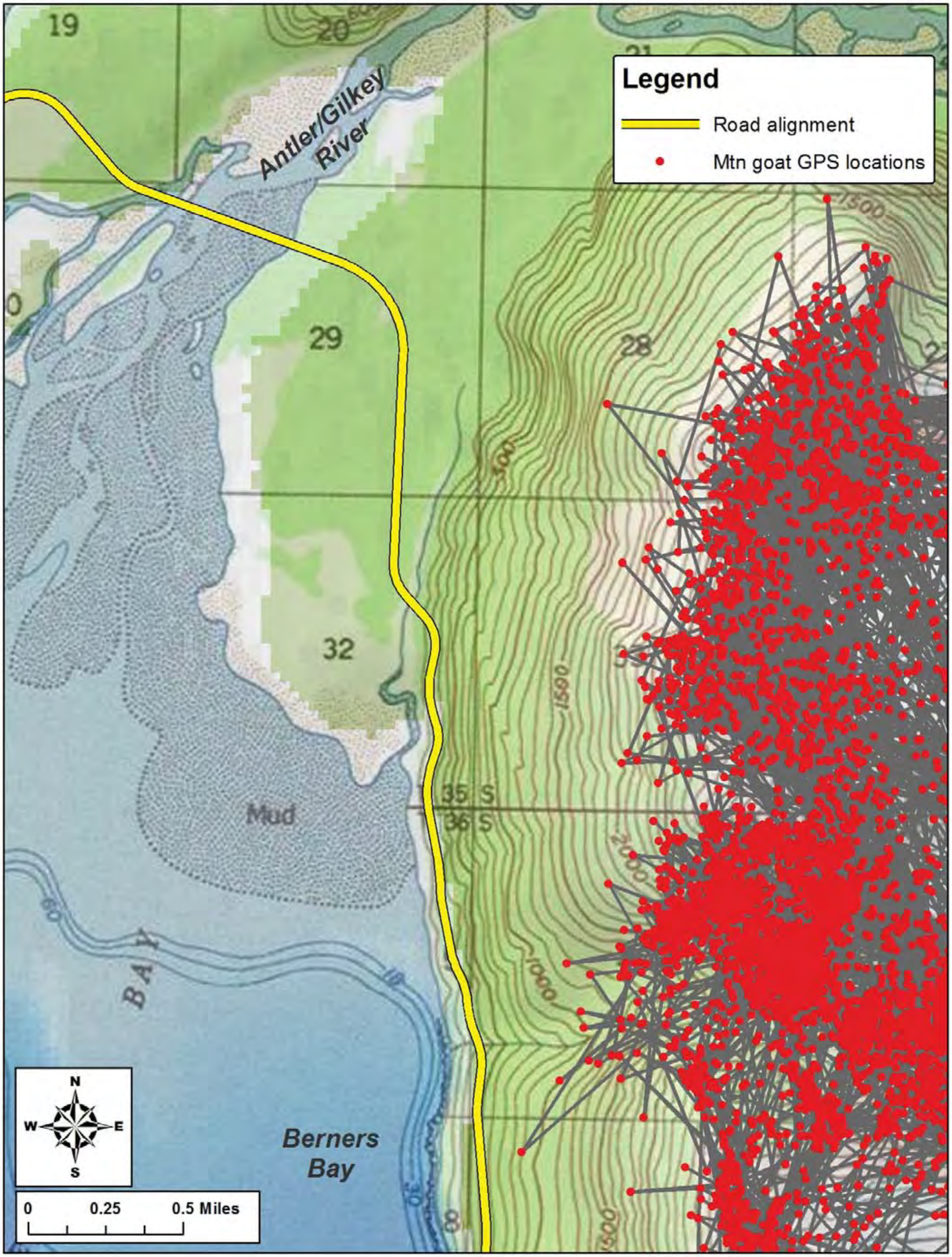
Appendix 18j: Map depicting mountain goat GPS locations in the vicinity of Slate Cove relative to the location of the Juneau Access highway alignment, 2005-2011, Lynn Canal, AK. GPS locations describe use patterns of a sub-set of the population and do not necessarily comprehensively characterize all areas used by mountain goats in local areas.



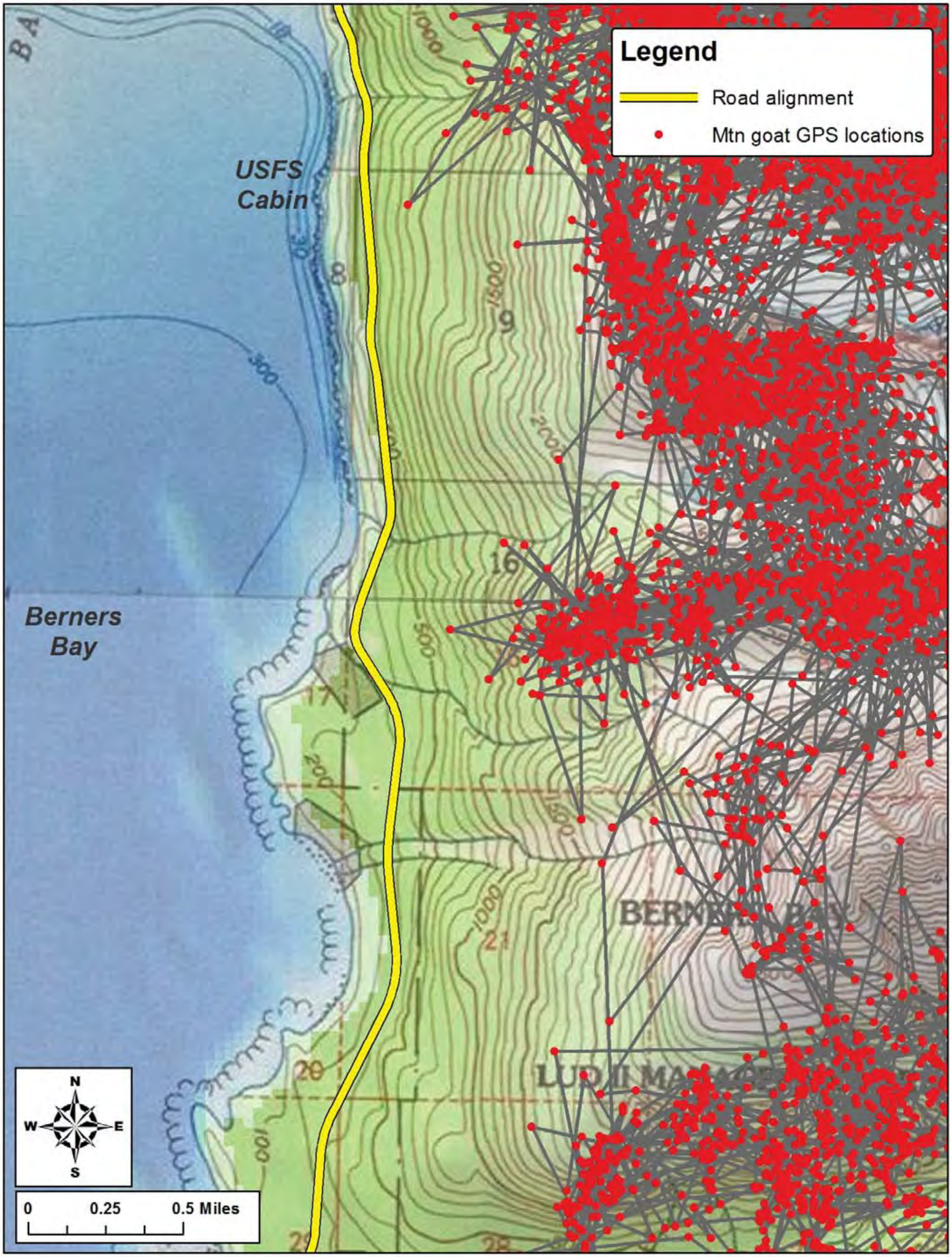
Appendix 18k: Map depicting mountain goat GPS locations in the vicinity of the Berners River relative to the location of the Juneau Access highway alignment, 2005-2011, Lynn Canal, AK. GPS locations describe use patterns of a sub-set of the population and do not necessairly comprehensively characterize all areas used by mountain goats in local areas.



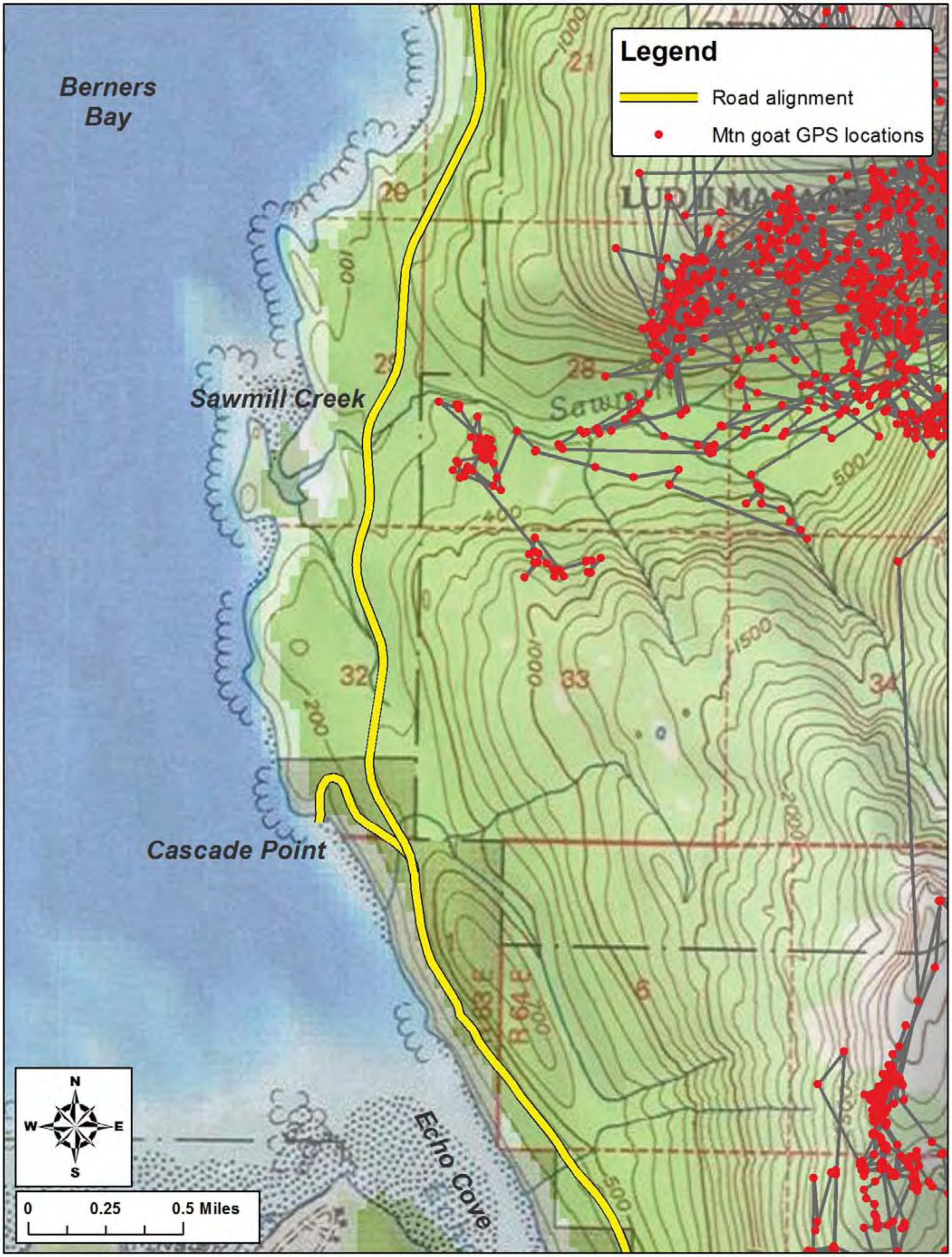
Appendix 18l: Map depicting mountain goat GPS locations east of Antler Slough relative to the location of the Juneau Access highway alignment, 2005-2011, Lynn Canal, AK. GPS locations describe use patterns of a sub-set of the population and do not necessairly comprehensively characterize all areas used by mountain goats in local areas.



Appendix 18m: Map depicting mountain goat GPS locations north of Sawmill Creek relative to the location of the Juneau Access highway alignment, 2005-2011, Berners Bay, AK. GPS locations describe use patterns of a sub-set of the population and do not necessarily comprehensively characterize all areas used by mountain goats in local areas.



Appendix 18n: Map depicting mountain goat GPS locations in the vicinity of Sawmill Creek relative to the location of the Juneau Access highway alignment, 2005-2011, Lynn Canal, AK. GPS locations describe use patterns of a sub-set of the population and do not necessarily comprehensively characterize all areas used by mountain goats in local areas.



Appendix 18o: Map depicting mountain goat GPS locations in the vicinity of Echo Cove relative to the location of the Juneau Access highway alignment, 2005-2011, Lynn Canal, AK. GPS locations describe use patterns of a sub-set of the population and do not necessarily comprehensively characterize all areas used by mountain goats in local areas.