Wildlife Research Annual Progress Report

Mountain Goat Assessment and Monitoring along the Juneau Access Road Corridor and near the Kensington Mine, Southeast Alaska.

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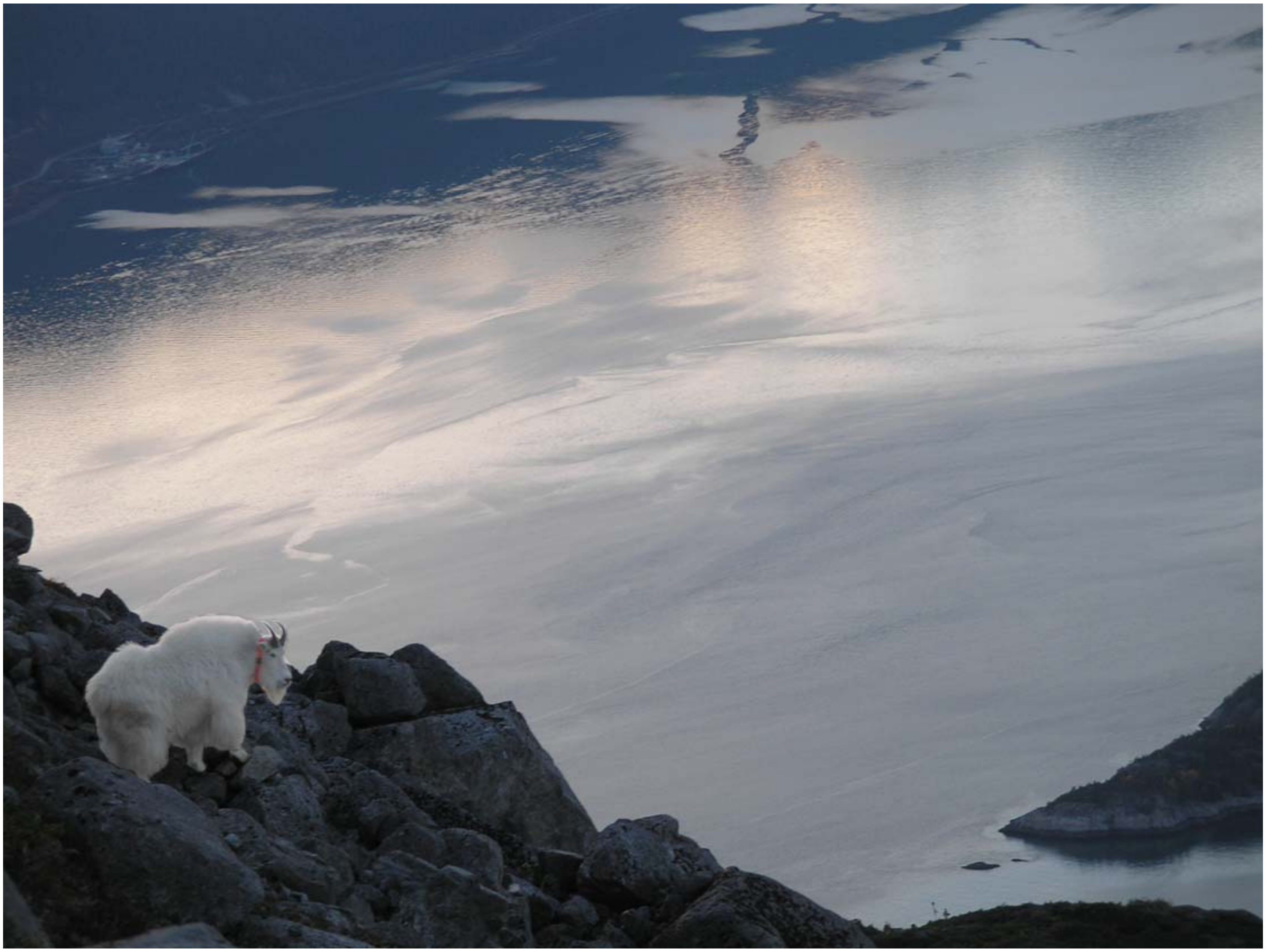

Alaska Department of Fish and Game
Division of Wildlife Conservation

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This report contains preliminary data and should not be cited without permission of the authors.

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Cover photo by Kevin White. Mountain Goat #LG-15 standing near his capture site on the northwest slope of Mt. Villard, overlooking Lynn Canal.

Contents

INTRODUCTION

This annual progress report was prepared to meet the reporting requirements for State of Alaska Department of Transportation and Public Facilities and Coeur Alaska. Funding for this project was made available in September 2005 and this report summarizes activities completed by July 31, 2006.

Background

Coeur Alaska has recently re-initiated development activities at the Kensington mine site, located a short distance northwest of Berners Bay. In addition, the Department of Transportation and Public Facilities is planning to construct an all-season highway between Echo Cove and the Katzehin River (ca. 51 miles in length). Among the wildlife species potentially affected by mine development and road construction activities are mountain goats (*Oreamnos americanus*). 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, since the mine never became operational these objectives could not be achieved, and by 1995 goat monitoring in the area wound down and eventually ended. Now, however, the mine is in the process of re-opening and the Alaska Department of Fish and Game maintains that many of the same concerns that prompted the Robus and Carney (1995) study are still valid and need to be addressed. In addition, large-scale plans for development of the Juneau Access road raise new, potentially more substantial, concerns regarding not just the enlarged “footprint” of industrial development activities in eastern Lynn Canal, but also the cumulative impacts of both development projects.

The affects of mining and road development activities on local mountain goat populations in the vicinity of the Kensington mine and eastern Lynn Canal are not well known or understood at this time. However, 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 needed to determine 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 addition, it is not clear where goats spend non-winter months and, by extension, the spatial extent to which development activities are thereby translated across the landscape.

In response to the above concerns, the Alaska Department of Fish and Game, with funding provided by the Department of Transportation and Public Facilities and Coeur Alaska, has 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 includes 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 Alaska Department of Fish and Game with information necessary to appropriately manage mountain goats in the proposed areas of development.

STUDY OBJECTIVES

This research is designed to investigate the spatial relationships, vital rates and abundance of mountain goats in the Berners Bay and upper Lynn Canal area. The specific objectives are as follows:

1) Determine seasonal movement patterns of mountain goats in the area of the Kensington mine and Juneau Access road corridor;
2) Characterize mountain goat habitat selection patterns and the extent of spatial overlap with areas impacted by Kensington mine and Juneau Access road corridor development activities;
3) Estimate reproductive success and survival of mountain goats in areas near the Kensington mine and Juneau Access road corridor; and
4) Estimate mountain goat population abundance and composition in areas near the Kensington mine and Juneau Access road corridor.

STUDY AREA

Mountain goats were studied in a ca. 600 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 study area is 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 1).

An additional study area located east of Berners Bay was established in spring 2006. This area was not originally included in the study design however recent information about road construction timelines resulted in a re-evaluation of the efficacy conducting research activities in this area. Research efforts in this area will be limited in scope and low intensity sampling in this area is intended to provide managers with baseline information needed to evaluate impacts associated with specific road construction activities (i.e gravel stock-piling and crushing). Additional ADFG funding was allocated to partially offset costs associated with research activities in this area.

Elevation within the study areas range from 6300 feet to sea level. 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 c/fs; USGS, unpublished data) glacial river system that is fed by a tributary of the Juneau Icefield.

The maritime climate in this area is characterized by cool, wet summers and relatively, warm snowy winters. Annual 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 grasses 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 3.0/2.7mg of carfentanil citrate (males/females, respectively; 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 all animals captured. Radio-collars were programmed to collect GPS location data at 6-hour intervals (collar lifetime: 2.5 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).

Habitat Selection and Movement Patterns

Comprehensive analyses of mountain goat habitat use and movement patterns will not be conducted until all GPS location information is collected (i.e. 2009). Nevertheless, preliminary analyses focused on describing altitudinal distribution patterns of mountain goats between September 28, 2005-July 25, 2006 were conducted. These analyses summarize daily average and upper and lower altitudinal extremes for GPS-collared mountain goats. The proportion of GPS locations within different altitudinal categories was also summarized.

Additional analyses were conducted to evaluate seasonal differences in sex-specific patterns of terrain use and movement patterns using a sub-set of the existing GPS location data (i.e. encompassing the period between September 28, 2005-February 10, 2006). These analyses served as the basis for a paper presented at the 15th Biennial Symposium of the Northern Wild Sheep and Goat Council in Kananaskis, Alberta on April 6, 2006 (see Appendix 1).

Reproduction and Survival

Kidding rates and mountain goat survival were determined by monitoring individual study animals during monthly surveys using fixed-wing aircraft (Heliocourier, Cessna 210) equipped for radio-telemetry tracking. During surveys, radio-collared adult female mountain goats were monitored to determine whether they gave birth to kids and, if so, how long they survived. Monitoring kid production and survival was only possible during the non-winter months when animals could be reliably observed in open habitats. Mortality of individual 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. To the extent possible, all mortalities were thoroughly investigated to ascertain the cause of death and relevant biological samples collected.

Population Abundance and Composition Estimation

Aerial Surveys-Population abundance and composition surveys were conducted using fixed-wing aircraft (i.e. Piper PA-18, Heliocourier) in late-summer and fall 2005 (August and October). Because capture efforts began late in the season (due to funding constraints) and few collars had been deployed at the time of aerial surveys it was not possible to estimate mountain goat sightability (i.e. the probability of seeing mountain goats on a given survey) or population abundance using mark-resight techniques, as planned. Nevertheless, aerial surveys were conducted in order to obtain estimates of minimum population size and composition (i.e. % kids in the population).

<u>Ground Surveys</u>-Evaluation of ground-based techniques for estimating mountain goat population size and composition was conducted in a small portion of the Lions Head study area (i.e. 13.2 km^2) . 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.

RESULTS AND DISCUSSION

Mountain Goat Capture

Mountain goat helicopter capture activities summarized in this report were conducted during five days in late-fall 2005 and seven days in summer-fall 2006. Overall, 64 mountain goats (36 males, 28 females) were captured over 12 days of effort (Figure 1, Table 1). Captures were attempted during periods when mountain goats were distributed at high elevations, snow accumulation was minimal (less than 2 feet) 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 adult females and associated neonates. As a result of these constraints, opportunities to capture mountain goats were fairly limited. However, no animals died during capture or handling procedures and evidence of kid abandonment was not observed in cases where adult females with associated kids were captured.

During handling procedures standard biological specimens were collected and morphological measures taken. Specific biological samples collected from study animals included: whole blood (4mL), blood serum (8mL), ear tissue, hair and fecal pellets. Whole blood, serum and fecal pellet sub-samples were sent to Dr. Kimberlee Beckmen (ADFG, Fairbanks, AK) for disease screening. All remaining samples have been archived at Alaska Department of Fish and Game facilities in Douglas, AK. Mountain goat morphological data are summarized in Table 2.

GPS Location Data

Telonics TGW-3590 GPS radio-collars were deployed on all mountain goats captured. However, performance of GPS radio-collars (as of July 26, 2006) was evaluated for only 22 individuals since 41 collars were deployed after the most recent scheduled GPS data download flight. Overall, the remote GPS data collection system used in this study worked as expected. We did not encounter any problems with GPS collar performance nor did 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).

Overall, 20,016 GPS locations were acquired from 22 radio-collared mountain goats between September 26, 2005-July 25, 2006. Locations were subsequently filtered to remove impossible locations (i.e. those in salt water; n = 130), 2-D locations with PDOP values greater than 10 (n = 598). This standard data filtering routine was used to reduce positional bias in GPS location bias (D'Eon et al. 2002, D'Eon and Delparte 2005). In addition, locations collected during the 2-day period following capture were also removed from the data set (n = 175). Overall, GPS fix success was moderately high and remarkably consistent between individual animals (mean±SE : 83±1%; n = 22)(Table 2).

Habitat Use and Movement Patterns

Preliminary analyses indicated that female mountain goats used steeper, more rugged terrain in locations closer to cliffs (i.e. slopes greater than 40º) than males during winter (Appendix 1). However, males and females did not differ with respect to their altitudinal distribution during this period (Appendix 1). In general, both males and females exhibited distinct seasonal movements from high elevation summer ranges and lower elevation winter ranges (Figures 2 & 3). Altitudinal shifts to low elevations were likely related to snow accumulation patterns at high elevations and were initiated during late-September and persisted through mid-November (Figure 2). The highest proportion of use of low elevation habitats occurred between early-January through late-April (Figure 4). The winter of 2005/2006 was atypically mild and warm storm systems originating in tropical regions resulted in significant snow ablation events at high elevations during early-winter (particularly during November 17-25, 2005). Mountain goat altitudinal distribution exhibited substantial variation during these periods presumably in response to associated snow depth fluctuations within individual home ranges.

Mountain goat seasonal movement patterns and home range sizes differed between males and females. In particular, males moved more widely across the landscape and used larger home ranges during the rut (i.e. October 19-November 23) than females (Appendix 1). However, during the fall and post-rut, or winter, period movement rates and home range sizes did not differ between males and females (Appendix 1). Presumably, these differences are linked to variation in behavioral strategies used by males and females to maximize reproductive success and survival.

Survival and Reproduction

Mountain goats were monitored monthly during fixed-wing aerial telemetry flights. Of the 23 animals monitored between October 15, 2005-August 7, 2006, five animals died of various causes. Three animals (2 males and 1 female) died of natural causes during mid-late winter. All three animals were among the oldest monitored and probable causes of death included: a fall from a cliff, avalanche and starvation. One male mountain goat died from a certain unnatural cause involving entanglement in mining debris. An additional female died from injuries relating to a fall (i.e. compound fracture of right femur) approximately two days after it was captured. The preliminary natural mortality rate reported here (i.e. 14.2%) is similar to that documented for mountain goats elsewhere in southeast Alaska (Smith 1986).

Preliminary estimates of adult female kidding rates and kid survival to ca. 2.5-months of age were based on monitoring of 10 females from May 30-August 7, 2006. Of the 10 females monitored, 9 were seen with kids following parturition (ca. May 15); no cases of twins were recorded. The single female that did not have a kid was in the youngest age class monitored (i.e. 4.5 years old). By early-August, two previously parturitient females had lost their kids. Overall, these preliminary estimates of kidding rates and kid survival appear to be high however small sample sizes limit inference from these data.

Population Abundance and Composition

*Aerial Surveys-*Overall, five fixed-wing aerial surveys were conducted in fall 2005 (Lions Head, n = 2, Sinclair Mountain, n = 2, Mount Villard, n = 1); surveys were not attempted in the East Berners study area in 2005 (Table 3, Appendix 2). Survey opportunities were limited in 2005 as a result of weather conditions, mountain goat capture activities and funding constraints. Consequently, it was not possible to conduct three replicate surveys in each area as planned. In addition, mountain goat sightability estimation data were not collected because of the small number of radio-collared goats at the time of survey flights. Due to these constraints, interpretation of aerial survey data is limited. Specifically, population abundance data represent the minimum number of animals present in survey areas (Table 3). Thus, estimates of actual population size and variance are unknown at this time. Nevertheless, estimates of population composition (i.e. % kids in the population) are likely to be reliable given the fairly large number of goats seen and classified (as adults or kids) on surveys (Table 3). Yet, due to limited survey replication it is not possible to statistically compare differences in population composition between study areas.

*Ground-based Surveys-*On June 26, 2006, a ground-based survey was conducted on the north side of Lions Head Mountain. Observers (n = 2) used binoculars and spotting scopes (8X and 25X, respectively) to survey sub-alpine and alpine terrain along a 3.8 kilometer route that enabled survey of a 13.2 km^2 area (Appendix 2).

During this survey it was possible to accurately identify adult males and females, sub-adults and kids with a high degree of confidence. Identification of male and female sub-adults and kids was not possible however with more time and favorable weather conditions it is likely sex-specific identification of sub-adults would be possible. Overall, 15 mountain goats were observed during this survey (Table 4).

On July 2, 2006, a helicopter (Hughes 500) survey was conducted in the ground count area (observers, n = 4) to provide information about possible limitations of ground-based surveys. Ground-based surveys may result in biased estimates of actual abundance because observers are not able to survey areas quickly and unintentional disturbance of goats could result in movement of animals in or out of sampling areas. Helicopter surveys are capable of (nearly) simultaneously surveying small areas, thus alleviating problems mentioned above. In this preliminary assessment, results relating to the total number of adults and kids seen during the helicopter survey were very similar to those derived from ground-based survey efforts (Table 4). However, it was not possible to conduct sex-specific classifications of individuals via helicopter without causing an unacceptable level of disturbance. Overall, these preliminary results indicate that ground-based surveys represent a potentially important means for acquiring detailed population composition data and should be used to complement broad-scale aerial survey efforts.

FUTURE WORK

Study animals 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 the existing GPS location database. Three replicate aerial surveys will be conducted in early-fall 2006, weather permitting, in order to estimate mountain goat sightability, population abundance and composition. Results of these efforts will be summarized and submitted as an annual research progress report on September 1, 2007.

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FIGURES

Figure 1. Location of mountain goat study areas and sites where individual animals were captured (n = 64). Local landmarks and the Juneau Access Road alignment are also referenced.

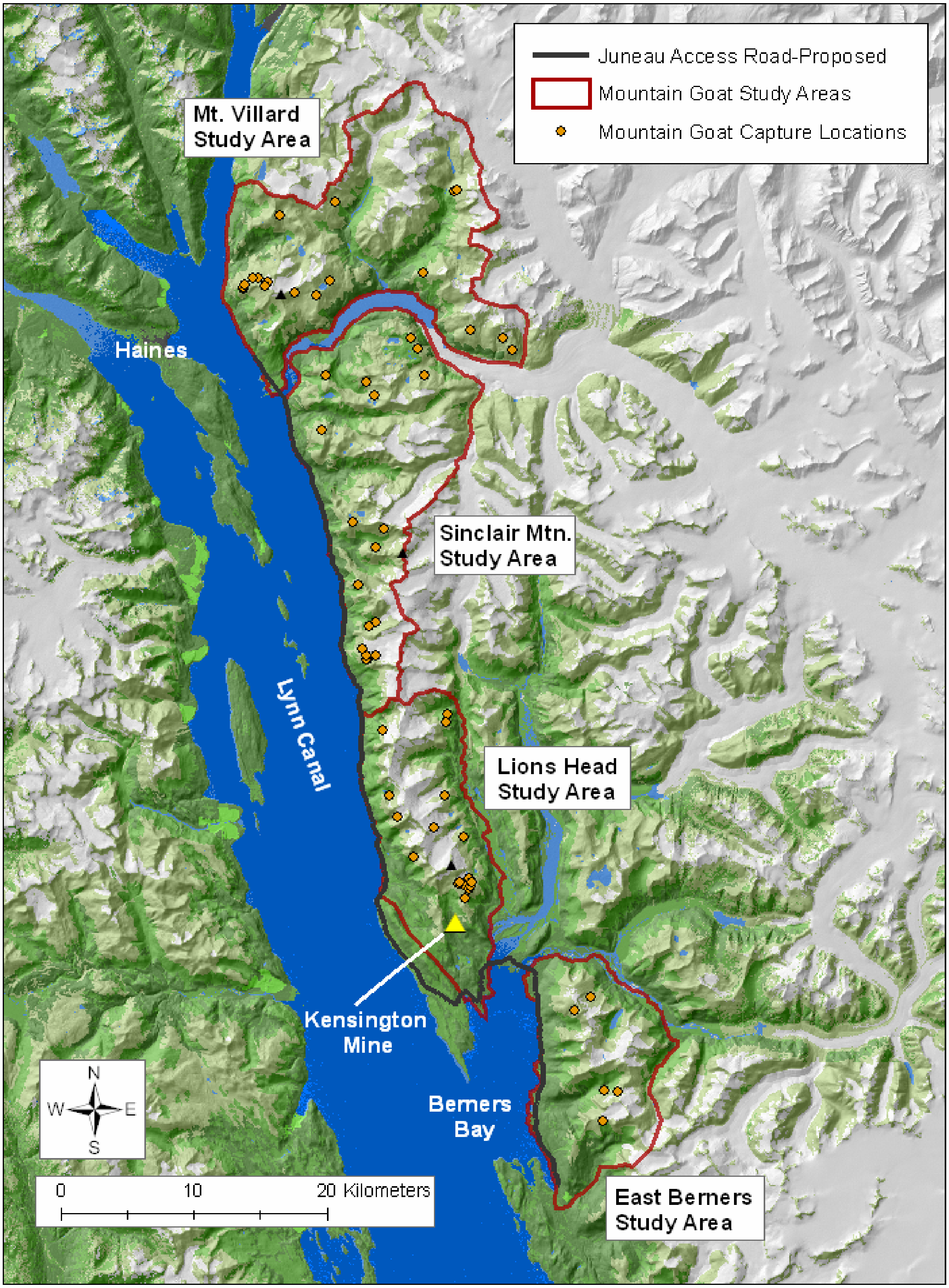


Figure 2. Average daily elevation (±1 SE) of GPS-collared mountain goats (n = 11 males, 11 females) between September 27, 2005-July 25, 2006. Summaries are compiled from daily mean values for individual animals. Maximum and minimum daily elevation trend lines were derived using 7-day moving averages.

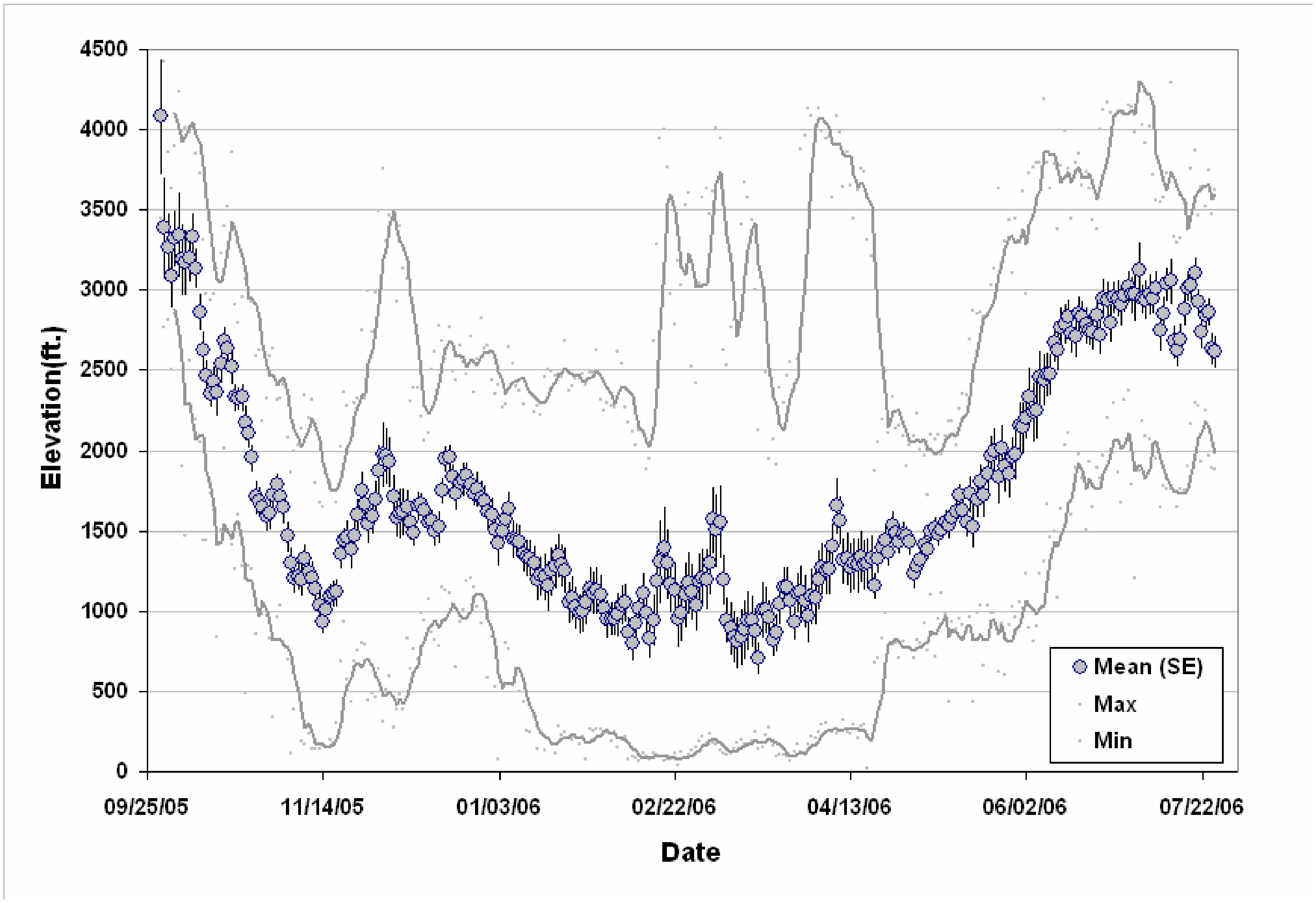
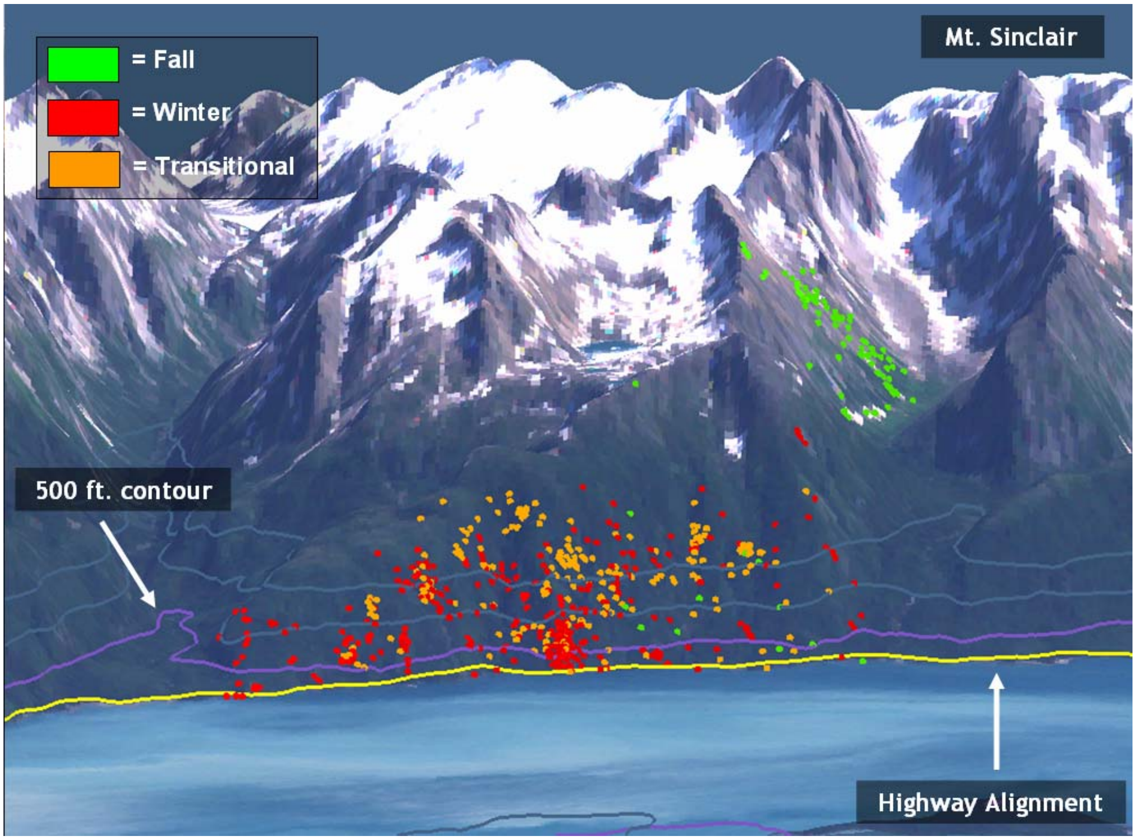


Figure 3. Maps depicting seasonal distribution and movement patterns for a representative adult female mountain goat (LG-04) that over-wintered near the eastern shore of Lynn Canal near Sinclair Mountain (September 27, 2005-May 30, 2006). The Juneau Access Highway alignment is illustrated in yellow.



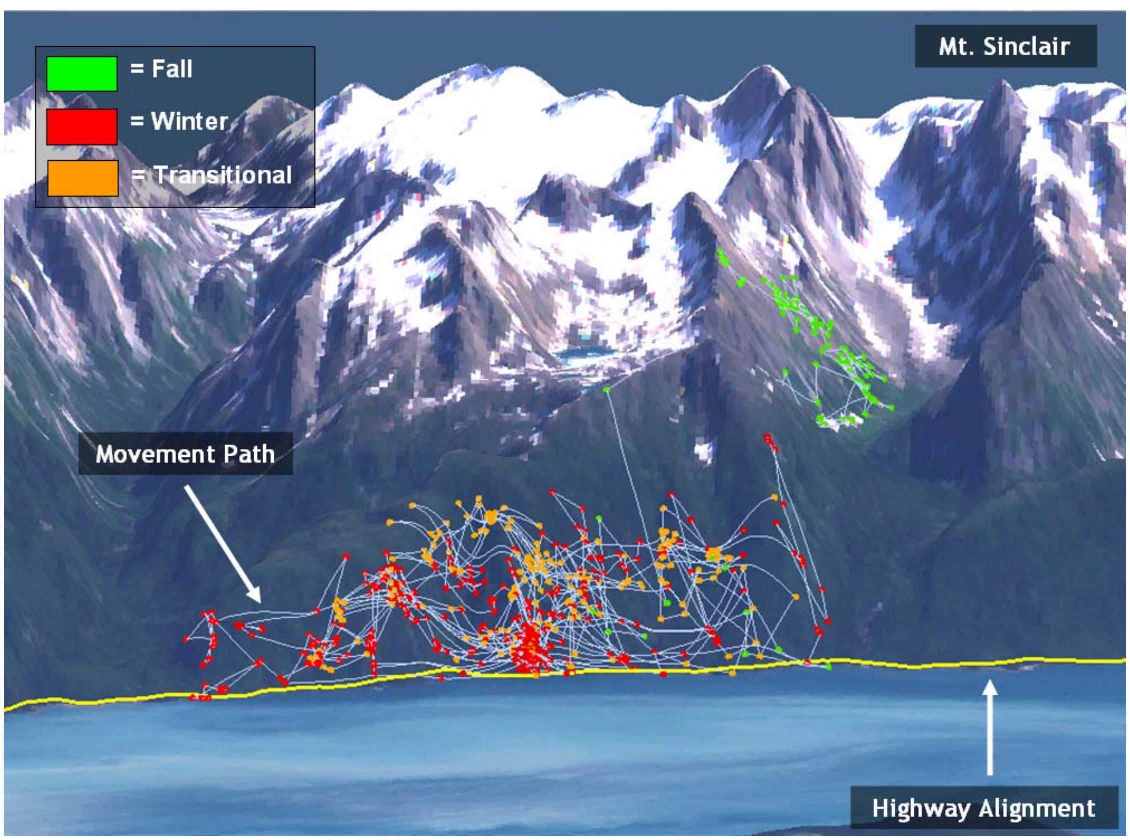
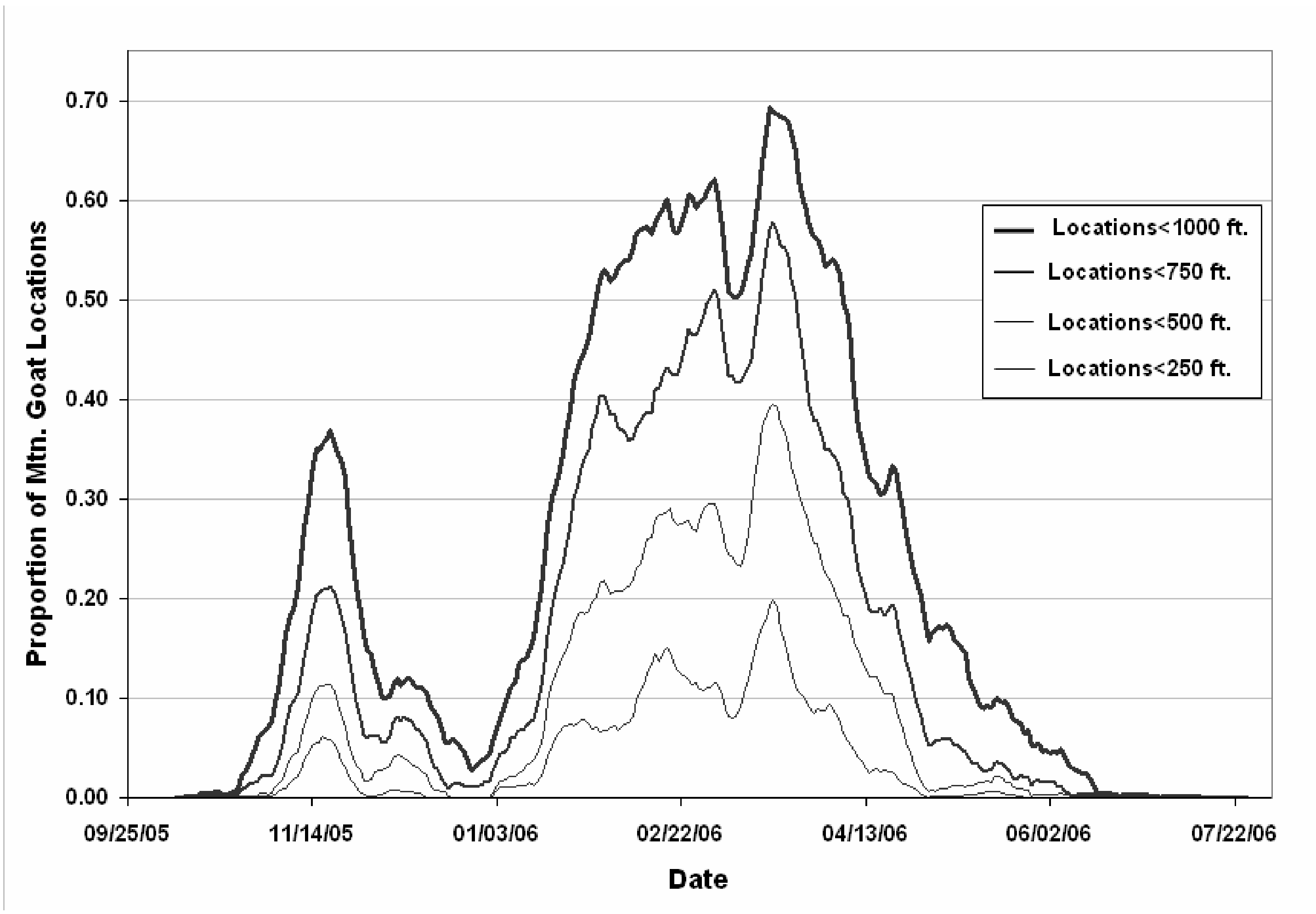


Figure 4. Proportion of mountain goat GPS locations (n = 19,113 locations) located in different elevation categories (September 27, 2005-July 25, 2006).



TABLES

Table 1. Summary of sex, age class and survival information for GPS-collared mountain goats. GPS-collar performance data is summarized for the period between September 28, 2005-October 13, 2006.

					GPS Fix Attempts[1]				
Mtn Goat ID	Study Area	Capture Date	Sex	Est. Age	Total Fixes	Successful Fixes	% 2D Fixes	% 3D Fixes	Comments
LG-01	Mt. Sinclair	09/26/05	M	9.5	812	695	41.9	43.7	Died: 4/17/06
LG-02	Mt. Sinclair	09/26/05	F	10.5	809	573	50.9	19.9	Died: 4/16/06
LG-03	Mt. Sinclair	09/26/05	F	6.5	1208	1077	46.0	43.1	
LG-04	Mt. Sinclair	09/26/05	F	6.5	1207	989	48.9	33.1	
LG-05	Mt. Sinclair	09/26/05	M	8.5	1207	971	50.1	30.3	
LG-06	Lions Head	10/02/05	M	7.5	524	426	34.0	47.3	Died: 2/10/06
LG-07	Lions Head	10/02/05	M	2.5	1184	960	48.3	32.8	
LG-08	Lions Head	10/02/05	F	4.5	1184	962	45.9	35.4	
LG-09	Lions Head	10/02/05	F	9.5	1183	967	50.5	31.2	
LG-10	Mt. Sinclair	10/03/05	F	6.5	1180	943	49.4	30.5	
LG-11	Mt. Sinclair	10/0305	M	8.5	1179	967	44.4	37.6	
LG-12	Mt. Villard	10/03/05	F	7.5	1180	971	45.8	36.5	
LG-13[2]	Mt. Villard	10/03/05	F	8.5	--	--	--	--	Died: 10/06/05
LG-14	Mt. Villard	10/03/05	F	4.5	1180	987	47.5	36.2	
LG-15	Mt. Villard	10/03/05	M	5.5	1179	998	47.1	37.6	
LG-16	Mt. Sinclair	10/14/05	M	4.5	1136	971	51.1	34.3	
LG-17	Mt. Villard	10/14/05	F	6.5	1136	966	49.7	35.3	
LG-18	Mt. Villard	10/14/05	M	3.5	1135	959	49.3	35.2	
LG-19	Lions Head	10/15/05	M	5.5	1017	852	50.2	33.5	Died: 6/26/06
LG-20	Lions Head	10/15/05	M	8.5	1132	936	45.9	36.7	
LG-21	Lions Head	10/15/05	F	4.5	1132	919	50.1	31.1	
LG-22	Lions Head	10/15/05	F	8.5	1132	986	40.9	46.2	
LG-23	Lions Head	10/15/05	M	9.5	1132	941	47.4	35.7	
LG-24[3]	Lions Head	07/28/06	M	2.5	--	--	--	--	
LG-25	Lions Head	07/28/06	F	5.5	--	--	--	--	
LG-26	Lions Head	07/28/06	M	5.5	--	--	--	--	
LG-27	Lions Head	07/28/06	M	9.5	--	--	--	--	
LG-28	Lions Head	07/28/06	M	7.5	--	--	--	--	
LG-29	Mt. Sinclair	07/28/06	F	6.5	--	--	--	--	
LG-30	Mt. Sinclair	07/28/06	F	7.5	--	--	--	--	
LG-31	East Berners	07/28/06	M	11.5	--	--	--	--	
LG-32	East Berners	07/28/06	F	3.5	--	--	--	--	
LG-33	East Berners	07/29/06	M	8.5	--	--	--	--	
LG-34	East Berners	07/29/06	M	5.5	--	--	--	--	
LG-35	East Berners	07/29/06	F	4.5	--	--	--	--	
LG-36	Lions Head	07/29/06	M	5.5	--	--	--	--	
LG-37	Lions Head	07/29/06	M	3.5	--	--	--	--	
LG-38	Lions Head	07/29/06	F	3.5	--	--	--	--	

[1]GPS location data summarized as of 7/25/06

[2]LG-13 died before adequate GPS location data could be collected

[3]LG-24 to LG-38 were deployed with GPS collars following the last scheduled GPS download flight

Table 1. Continued.

Mtn Goat ID	Study Area	Capture Date	Sex	Est. Age	GPS Fix Attempts[1] Total Fixes	Successful Fixes	% 2D Fixes	% 3D Fixes	Comments
LG-39	Mt. Sinclair	08/29/06	F	9.5	--	--	--	--	
LG-40	Mt. Sinclair	08/29/06	M	7.5	--	--	--	--	
LG-41	Mt. Sinclair	08/29/06	F	4.5	--	--	--	--	
LG-42	Mt. Villard	08/29/06	F	2.5	--	--	--	--	
LG-43	Mt. Villard	08/29/06	F	3.5	--	--	--	--	
LG-44	Mt. Villard	08/29/06	M	11.5	--	--	--	--	
LG-45	Mt. Sinclair	09/25/06	F	5.5	--	--	--	--	
LG-46	Mt. Villard	09/25/06	M	7.5	--	--	--	--	
LG-47	Mt. Villard	09/25/06	M	10.5	--	--	--	--	
LG-48	Mt. Villard	09/25/06	M	11.5	--	--	--	--	
LG-49	Mt. Villard	09/25/06	M	5.5	--	--	--	--	
LG-50	Lions Head	10/07/06	M	7.5	--	--	--	--	
LG-51	Mt. Sinclair	10/07/06	F	1.5	--	--	--	--	
LG-52	Mt. Sinclair	10/07/06	F	2.5	--	--	--	--	
LG-53	Lions Head	10/07/06	M	2.5	--	--	--	--	
LG-54	Mt. Villard	10/12/06	M	6.5	--	--	--	--	
LG-55	Mt. Villard	10/12/06	F	11.5	--	--	--	--	
LG-56	Mt. Villard	10/12/06	M	8.5	--	--	--	--	
LG-57	Mt. Villard	10/12/06	F	7.5	--	--	--	--	
LG-58	Mt. Villard	10/12/06	M	3.5	--	--	--	--	
LG-59	Mt. Villard	10/12/06	F	4.5	--	--	--	--	
LG-60	Mt. Sinclair	10/13/06	M	4.5	--	--	--	--	
LG-61	Mt. Sinclair	10/13/06	M	9.5	--	--	--	--	
LG-62	Mt. Sinclair	10/13/06	M	9.5	--	--	--	--	
LG-63	Mt. Sinclair	10/13/06	M	9.5	--	--	--	--	
LG-64	Mt. Sinclair	10/13/06	M	3.5	--	--	--	--	

[1]GPS location data summarized as of 7/25/06

[2]LG-13 died before adequate GPS location data could be collected

[3]LG-24 to LG-64 were deployed with GPS collars following the last scheduled GPS download flight

Table 2. Summary of selected morphological data collected for mountain goats captured between September 27-October 15, 2005.

	Females			Males		
	mean	SE	n	mean	SE	n
Est. Age	6.0	0.5	28	7.0	0.5	36
Weight (lbs.)	176.3	4.6	22	280.2	9.6	32
Body Length (cm)	159.0	2.2	26	179.3	2.2	36
Girth (cm)	106.2	1.3	26	126.9	1.6	36
Neck (cm)	42.1	0.5	24	49.9	0.6	36
Hind Foot (cm)	22.7	0.2	25	25.0	0.2	33
Horn Length (in)	8 10/16	3/16	26	9	2/16	36
Horn Circumference (in)	4 1/16	1/16	26	5 4/16	1/16	36

Table 3. Summary of mountain goat aerial survey data collected during August-October 2005. Totals represent the number of animals seen on surveys not actual population estimates.

Study Area	Date	Survey Time (min)	Area Surveyed (km^2)	Adults	Kids	Total	% Kids	Goats/km^2	Temp (F)	Weather	Aircraft	# of Observers
Lions Head	8/11/2005	35	55.8	35	5	40	12.5	0.72	70	Clear	PA-18	2
Lions Head	10/3/2005	57	77.7	55	8	65	12.3	0.84	45	Clear	Heliocouirer	3
Sinclair Mtn.	8/11/2005	77	111.5	77	17	94	18.1	0.84	70	Clear	PA-18	2
Sinclair Mtn.	10/3/2005	93	111.5	159	30	189	15.9	1.69	45	Clear	Heliocouirer	3
Mt. Villard	8/12/2005	85	133.3	23	4	27	14.8	0.20	68	Clear	PA-18	2

Table 4. Summary of mountain goat survey data collected during ground-based and helicopter surveys on June 26 & July 2, 2006. Totals represent the number of animals seen on surveys not actual population estimates.

Study Area	Survey Type	Date	Area Surveyed (km^2)	Survey Time (min)	Adults Males	Adults Females	Adults Unk.	Subadults	Kids	Total	% Kids	Goats/km^2	Temp (F)	Weather	# of Observers
Lions Head	Ground	6/26/2006	13.2	181	3	5	--	2	5	15	33.3	1.13	60	Cloudy	2
Lions Head	Helicopter	7/2/2006	9.5	11	--	--	10	--	6	16	37.5	1.68	65	Clear	4

APPENDIX 1.

Proceedings of the 15th Biennial Symposium of the Northern Wild Sheep and Goat Council, 15:000-000. (In Review)

SEASONAL AND SEX-SPECIFIC VARIATION IN TERRAIN USE AND MOVEMENT PATTERNS OF MOUNTAIN GOATS IN SOUTHEASTERN ALASKA: PRELIMINARY FINDINGS

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Abstract: Fundamental differences in fitness requirements between male and female individuals result in sex-linked ecological variation within many species of large mammals. Determining the extent to which sex-specific requirements alter behavioral strategies and subsequent spatial use patterns has important implications for conservation and management of species such as mountain goats (*Oreamnos americanus*). In this study, location data were collected from 22 GPS radio-collared mountain goats (11 males, 11 females) during September 2005-February 2006. These data were integrated with terrain data layers in a GIS framework to address questions about sex-specific variation in movement patterns and terrain use across a 600 km^2 study area located in northern Southeast Alaska. Male mountain goats exhibited greater rates of movement than females during the rut but not during fall or winter. As a result, male home ranges were significantly larger than females during this period. Both males and females moved to lower elevations with the onset of winter but did not differ with respect to altitudinal distribution. Following the rut, the period when sexual aggregation occurs, females used areas in which slope was steeper, distance to escape terrain was less and terrain ruggedness was greater than areas used by males. Overall, these preliminary findings detail differences in terrain and spatial use patterns between male and female mountain goats and suggest that vulnerability to anthropogenic disturbance factors may be sex-specific.

INTRODUCTION:

Elucidating patterns of resource use and movement play an important role in our understanding of the ecology and conservation of many species. While many factors may influence variation in these fundamental ecological characteristics, the sex of individuals in a population represents one variable of principal interest (Clutton-Brock et al. 1982, Main et al. 1996). This is particularly evident among polygynous ruminants that display pronounced sex-specific contrasts in morphology, social behavior and life history strategies (Clutton-Brock et al. 1982). These patterns arise because natural selection acts on males and females in disparate ways as a result of fundamental differences in their reproductive characteristics (Darwin 1871).

Mountain goats provide an interesting example for evaluating sex-mediated differences in patterns of resource use and movement as a result of sexual body size dimorphism, social organization and narrow constraints on habitat use requirements (Côté and Festa-Bianchet 2003). Adult male mountain goats are 40-60% larger than females (Houston et al. 1989). As a result, males are expected to experience greater nutritional requirements but may also be less prone to predation. In addition, energetic resources required for successful reproduction are partitioned differently between males and females. In particular, polygynous males do not participate in rearing of young and maximize reproductive success by utilizing behavioral strategies that optimize their ability to mate with many high quality females during a limited 4-6 week rutting season (Brandborg 1955, Geist 1964). Females, on the other hand, maximize their reproductive success by selectively breeding with a single high quality male (Brandborg 1955) and, perhaps more importantly, optimizing foraging and habitat use decisions that enable acquisition of adequate nutritional resources required for survival and successful rearing of young (Cote 2001); a period that may span at least 10 months (Chadwick 1977).

Largely unique among North American ungulates, mountain goats exhibit distinct morphological adaptations that enable them to live in steep, rugged mountain environments characterized by extreme climate conditions. It is widely recognized that the preferential for use of such habitat types is primarily linked to the avoidance of predation (Schaller 1979, Smith 1983, Fox and Streveler 1986). At smaller spatial scales, these environments are composed of a mosaic of forage-rich alpine meadows and barren cliffs that provide escape terrain. Because of this juxtaposition of habitat types, mountain goats likely face trade-offs between utilizing forage-rich but relatively dangerous alpine meadows and forage-poor but safe cliff habitats. Such sex-specific trade-offs in habitat use have been documented in other mountain ungulate species (Bleich et al. 1997) and provide a framework for interpreting resource use patterns in mountain goats.

In this paper two principal research questions were addressed: (1) do adult male and female mountain goat home range and movement patterns differ during and outside of the rut?, and (2) do adult male and female mountain goats differ in their use of “safe” terrain features during periods outside of the breeding season?

STUDY AREA:

Mountain goats were studied in a 600 km^2 study 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 study area is 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 (Figure 1). Elevations range from 6300 feet to sea level. 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 study area is bisected by the Katzehin river, a moderate volume (ca. 1500 c/fs; USGS, unpublished data) glacial river system that is fed by a tributary of the Juneau Icefield.

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

During September-October 2005, we captured 22 adult mountain goats (11 male, 11 female) using standard helicopter darting techniques (Taylor 2000). Mountain goats were immobilized by injecting 3.0/2.7mg of carfentanil citrate (males/females, respectively) 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 measures 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 Radio-collaring-

Telonics TGW-3590 GPS radio-collars (Telonics, Inc., Mesa, AZ) were deployed on all animals captured. Radio-collars were programmed to collect GPS location data at 6-hour intervals. 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) was 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).

Defining Seasonality-

Seasons were defined by using remotely collected activity sensor data a as proxy for defining behaviorally mediated changes in seasonal activity patterns. Specifically, GPS collars were deployed with mercury tip switches programmed to record the proportion of 1-second switch transitions that occurred over a 15 minute period coordinated with GPS location attempts (ie. 6-hour intervals). Previous research on comparable species has documented reliable linkages between actual animal behavior and remotely collected activity switch data (Coulombe et al. 2006). As a result, I assumed that the proportion of switch transitions was positively correlated with animal activity. Thus, distinct changes in activity patterns were used to define biologically relevant seasons for mountain goats.

GIS Analyses-

Mountain goat GPS location data were integrated into a GIS (ArcView 3.2, ArcGIS 9, ESRI, Redlands, CA) in order to derive spatial attribute information for each data point. Digital elevation models (30-m resolution; NASA 2004) were used to estimate elevation (m), slope (degrees), distance (m) to slopes greater than 40 degrees (hereafter "distance to cliffs") and standard deviation of elevation within a 60m radius of point locations (hereafter "topographic roughness"). Distance moved between successive locations was calculated at different time steps (1-day and 5-day intervals). Fixed-kernel home ranges (95% isopleths) were calculated using the least-squares cross validation (LCSV) technique to parameterize the smoothing function (Seaman and Powell 1999, Seaman et al. 1999). Both movement distance and home range area were calculated using surface area rather than planimetric area functions (following Jenness 2004). This approach enabled more precise estimates of space use parameters; planimetric area calculations tended to underestimate actual space use by 20.3%, on average (K. White, unpublished).

Statistical Analyses-

To compare seasonal and inter-sexual differences in male and female home range sizes I used analysis of variance (ANOVA) and Tukey HSD pair-wise comparisons (Zar 1999). To evaluate seasonal and sex-specific differences in movement distances (1-day and 5-day intervals), elevation, slope, distance to cliffs and topographic roughness, daily mean values were estimated for each sex category. Confidence intervals (±95%) were calculated using individual animal mean values pooled across each biologically relevant season in order to determine whether sex-specific differences occurred between parameter estimates (Steel and Torrie 1980). This analysis employed a variable estimation procedure that differs from explicit hypothesis testing approaches; however, this approach was used because it provided a more descriptive assessment of variability in male-female differences at short time intervals.

RESULTS

Mountain Goat Capture and GPS Data Acquisition-

During September 27-October 15, 2005, 22 adult mountain goats (11 male, 11 female) were captured and deployed with GPS radio-collars. Subsequently, complete GPS location data sets (including successful and unsuccessful fixes) were remotely downloaded (via fixed-wing aircraft) from all study animals. Between September 27, 2005-February 10, 2006 a total of 8576 GPS locations (mean ± SE = 389 ± 4 locations/animal) were acquired and used in subsequent analyses, following data filtering routines (see methods).

Defining Seasons:

As defined by the proportion of switch transitions, male and female mountain goat activity patterns were similar except between October 18-November 23, 2005 (Figure 2). During this period male activity patterns were significantly less than females. Based on observations reported by Geist (1964), that males are less active than females during the rut, I assumed that this period of reduced male activity coincided with the rut. The period between September 27-October 18 was defined as fall while the period between November 23, 2005-February 10, 2006 was defined as winter (Figure 2).

Movement Rates and Home Range Size Differences-

Movement rates for males and females were similar during fall and winter; however, rates significantly deviated during the rut. Specifically, movement rates were significantly greater for males than females, particularly when analyzed over 5-day time intervals (figure 3, 4). During the shorter, 1-day time step movement rate overlap between males and females was evident for brief periods but overall was greater for males despite greater variability in estimates at this time scale (Figure 5).

Significant differences were detected in seasonal home range estimates for males and females ($r^2 = 0.32$, $F_{5,52} = 12.71$, $P < 0.001$; Figure 6, 7). Specifically, males used larger home ranges than females during the rut; however, home range estimates did not differ by sex during other seasons.

Terrain Use Comparisons-

Altitudinal distribution did not differ between males and females during the period of study (Figure 8). Yet, an overall decline in mean elevation of all goats occurred with the onset on winter conditions at high elevations, though variability was evident in this relationship and coincided with the occurrence of an abnormally warm, late-season storm system (i.e. November 17-25, 2005).

Overall, we estimated that mean differences in slope, distance to cliffs and terrain ruggedness were significantly different between males and females during the post-rut, winter period (Figure 9-11). Specifically, our findings indicate that females used steeper slopes that were more rugged and closer to cliffs than males. No differences were detected in terrain use comparisons between males and females during the breeding aggregation period, or rut.

Discussion:

Adult male and female mountain goats are faced with differential selection pressure as a consequence of variation in morphology and associated life history strategies. By comparing behavioral differences between males and females during the breeding season it is possible characterize mechanisms that males and females employ to maximize chances for increasing their individual fitness.

Similar to previous research in southeast Alaska (Schoen and Kirchhoff 1982, Smith and Raedeke 1982), male and female mountain goats in this study exhibited substantial differences in movement rates and home range sizes. Males moved widely across the landscape during the breeding season, presumably in search of receptive females, while females used relatively small areas and moved less. These differences in space use and movement patterns suggest males exhibit behavioral strategies during the rut that enable increased chances to successfully breed with as many females as possible. Females, on the other hand, exhibit space use strategies that encompass relatively small areas that, possibly, maximize chances of discovery by high quality males during the breeding season.

Since body size of males is substantially larger than females, females may be potentially more vulnerable to attacks by large mammalian predators (Curio 1976). Additionally, females are also more likely to be associated with related young or sub-adults, than males; a factor that further predisposes them to increased predation-risk. Findings from this study, consistent with previous mountain goat research in southeast Alaska (Schoen and Kirchhoff 1982), suggest females use safe terrain features to a greater extent than males. This pattern was specifically evident during the post-rut period when females used steeper more rugged terrain in areas closer to cliffs than did males. While largely consistent with expectations associated with predation-mediated habitat-use trade-offs, the documented affinity for use of steep, rugged terrain by females in this study may also be due to lower snow depths in these habitat types during winter (Fox 1983).

In coastal mountain regions mountain goats typically migrate from high elevation summer ranges to lower elevation, forested winter ranges (Herbert and Turnbull 1977, Fox et al. 1987). However, whether males and females maintain similar altitudinal distributions during winter in southeast Alaska is less clear (Schoen and Kirchhoff 1982, Smith 1986). In this study we documented sex-independent altitudinal migrations by mountain goats that coincided with the onset of the first winter storms. Overall, 80% of all winter locations were at elevations less than 2000’ above sea-level. These findings represent an interesting contrast to those of

Hundertmark et al. (1983) which documented mountain goats inhabiting an upper tributary of the Chilkat river valley, approximately 35 miles north, wintered primarily in windswept, high elevation habitats. Consequently, it appears that over-wintering strategies of mountain goats can vary over relatively small spatial scales and are unlikely to be related to differences in the composition of males and females in each population.

The extent to which the sexes segregate or employ different strategies for utilizing resources in their environment and avoiding mortality have important implications for conservation and management of species. For instance, differences in sex-specific movement patterns during the rut are likely to result in increased vulnerability of males to hunting pressure as a consequence of their increased movement and visibility during this period. Disparities in visibility of males relative to females may also alter the likelihood of observing animals during routine population monitoring surveys. Thus, acquisition of information about sex-specific variability in habitat use and movement patterns may offer potential for resolving certain key challenges associated with management and conservation of mountain goats.

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TABLES AND FIGURES:

Figure 1. General location of 600 km^2 mountain goat study area, located between Juneau and Haines along the east side of Lynn Canal, AK.

Figure 2. Radio-collar activity patterns for male and female mountain goats between Sept. 27, 2005-Feb. 10, 2006. Activity data were derived from tip-switch sensors located on Telonics TGW-350 GPS radio-collars attached to mountain goats. Data are summarized as daily mean values ± 95% confidence intervals.

Figure 3. Example of differences in 1-day interval movement patterns for 2 representative radio-collared male and female mountain goats during the rut (Oct. 18- Nov. 23, 2005).

Figure 4. Distance moved (feet/meters) at 5-day intervals by male and female mountain goats between Sept. 27, 2005-Feb. 10, 2006. Data are summarized as 5-day mean distances ± 95% confidence intervals.

Figure 5. Distance moved (feet/meters) at 1-day intervals by male and female mountain goats between Sept. 27, 2005-Feb. 10, 2006. Data are summarized as daily mean distances ± 95% confidence intervals.

Figure 6. Example of differences in 95% fixed kernel home range sizes for 2 radio-collared male and female mountain goats during the rut (Oct. 18-Nov. 23, 2005).

Figure 7. Home range sizes (95% fixed kernel) for male and female mountain goats during different seasons. Data reported as seasonal mean values ± SE.

Figure 8. Mean daily elevation (feet/meters) for male and female mountain goats between Sept. 27, 2005-Feb. 10, 2006. Data are summarized as daily mean values ± 95% confidence intervals.

Figure 9. Mean daily slope (%) used by male and female and mountain goats between Sept. 27, 2005-Feb. 10, 2006. Data are summarized as daily mean values ± 95% confidence intervals.

Figure 10. Mean daily distance to cliffs (i.e. 40º slope) for male and female mountain goats between Sept. 27, 2005-Feb. 10, 2006. Data are summarized as daily mean values ± 95% confidence intervals.

Figure 11. Mean daily terrain ruggedness used by male and female mountain goats between Sept. 27, 2005-Feb. 10, 2006. Data are summarized as daily mean values ± 95% confidence intervals.

Figure 1.

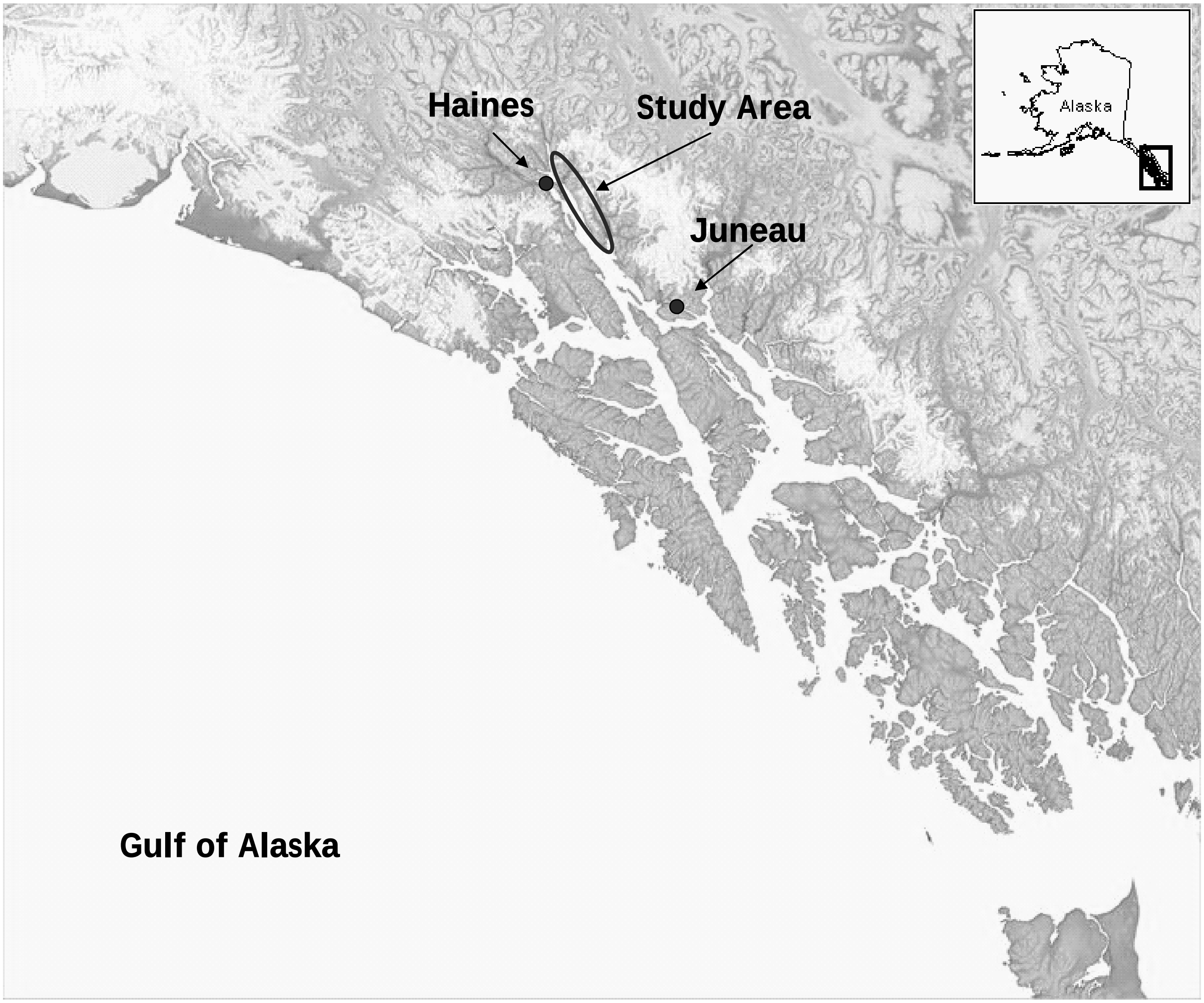


Figure 2.

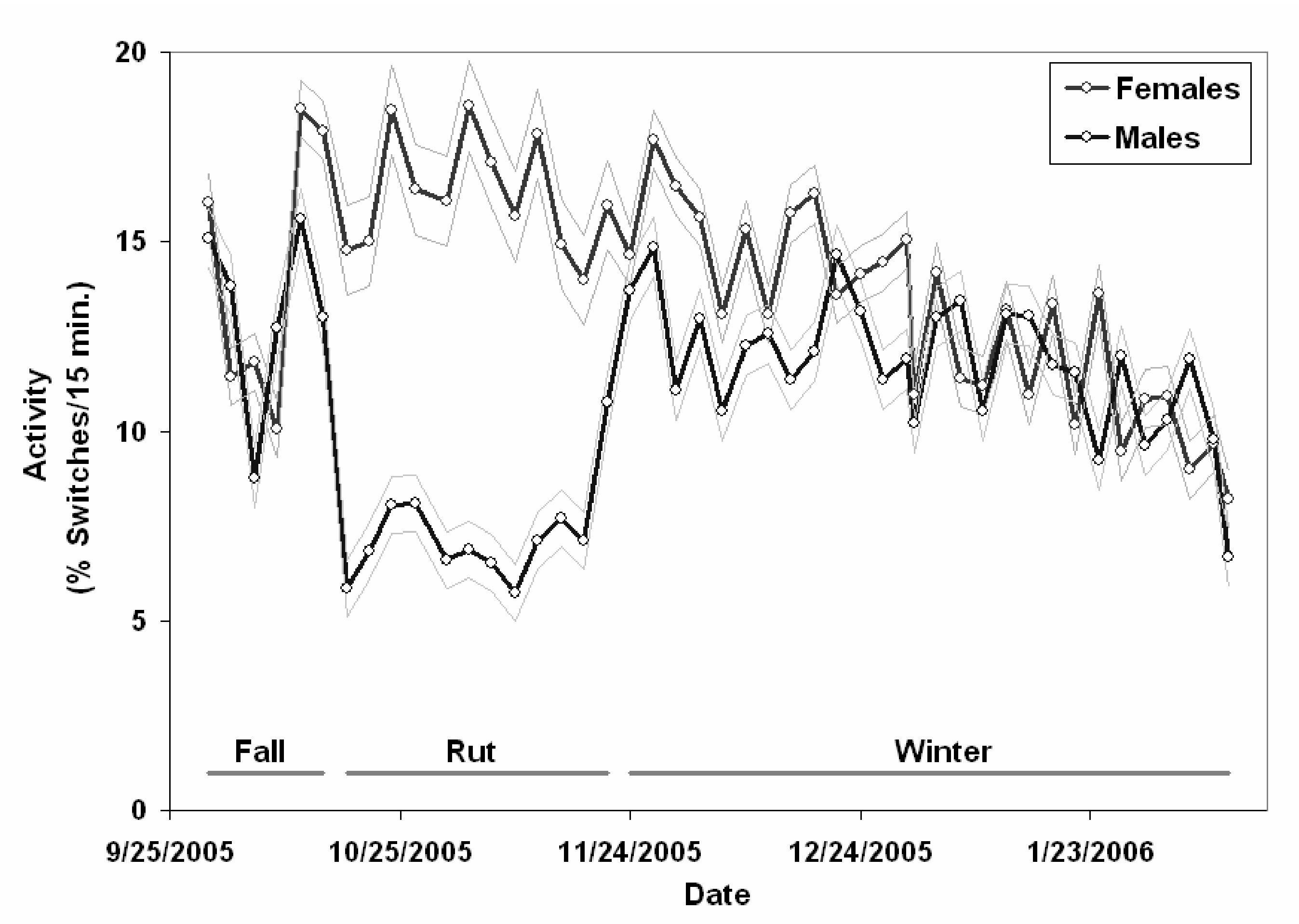

Females
Males
Activity
(% Switches/15 min.)
20
15
10
5
0
Fall
Rut
Winter
9/25/2005
10/25/2005
11/24/2005
12/24/2005
1/23/2006
Date

Figure 3.

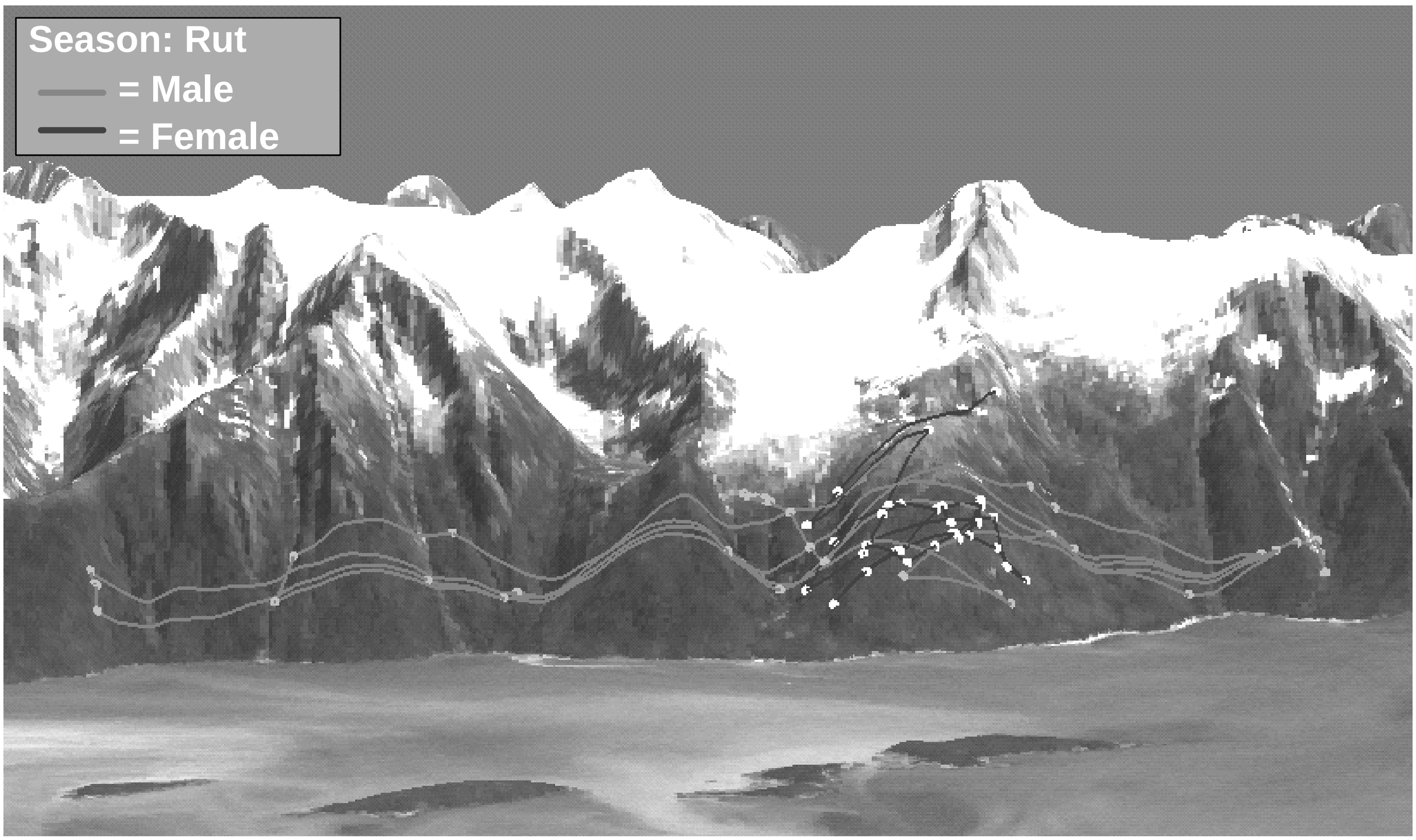


Figure 4

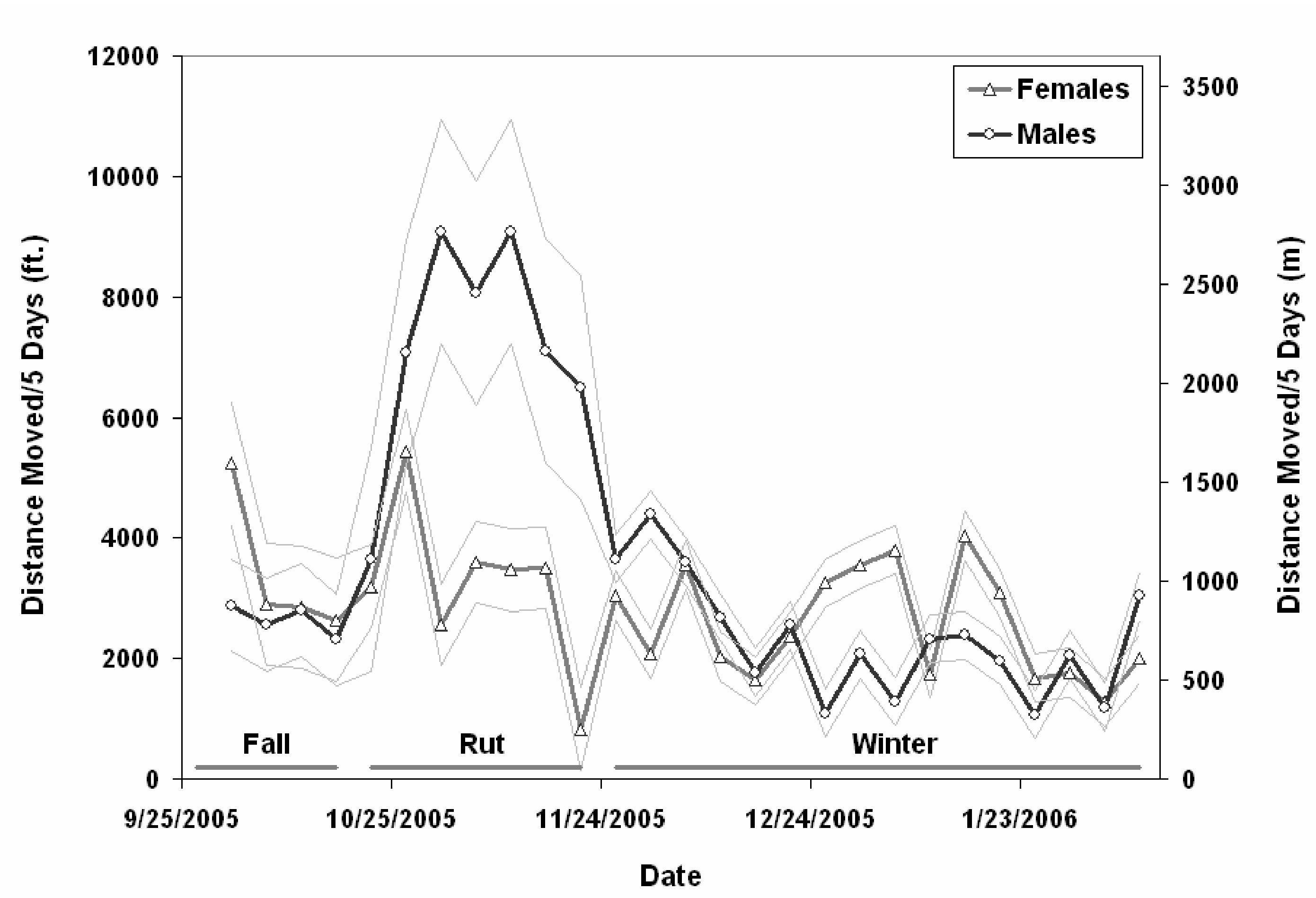

Females
Males
Distance Moved/5 Days (ft.)
Distance Moved/5 Days (m)
12000
10000
8000
6000
4000
2000
0
3500
3000
2500
2000
1500
1000
500
0
Fall
Rut
Winter
9/25/2005
10/25/2005
11/24/2005
12/24/2005
1/23/2006
Date

Figure 5.

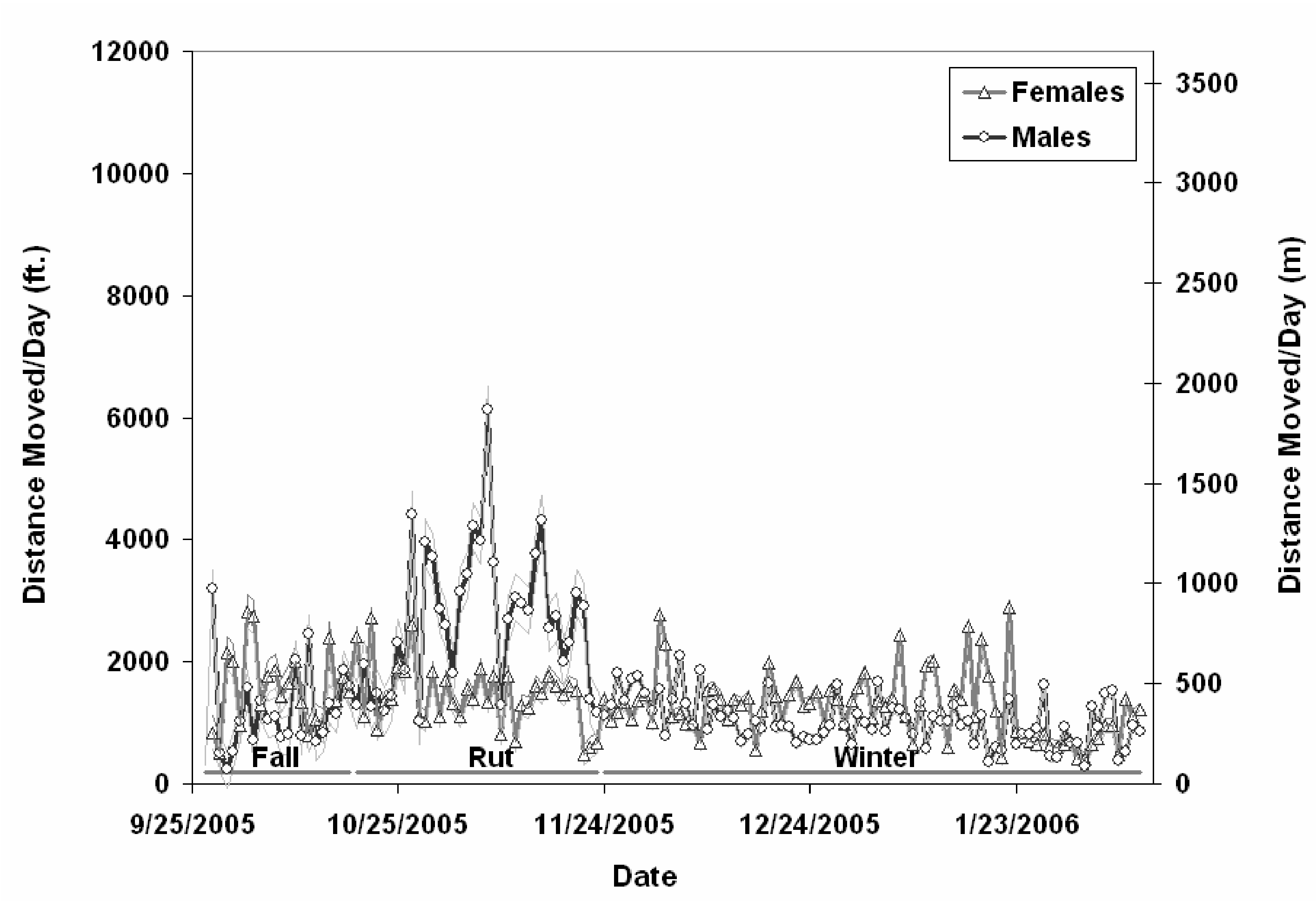

Females
Males
Distance Moved/Day (ft.)
Distance Moved/Day (m)
12000
10000
8000
6000
4000
2000
0
3500
3000
2500
2000
1500
1000
500
0
Fall
Rut
Winter
9/25/2005
10/25/2005
11/24/2005
12/24/2005
1/23/2006
Date

Figure 6.

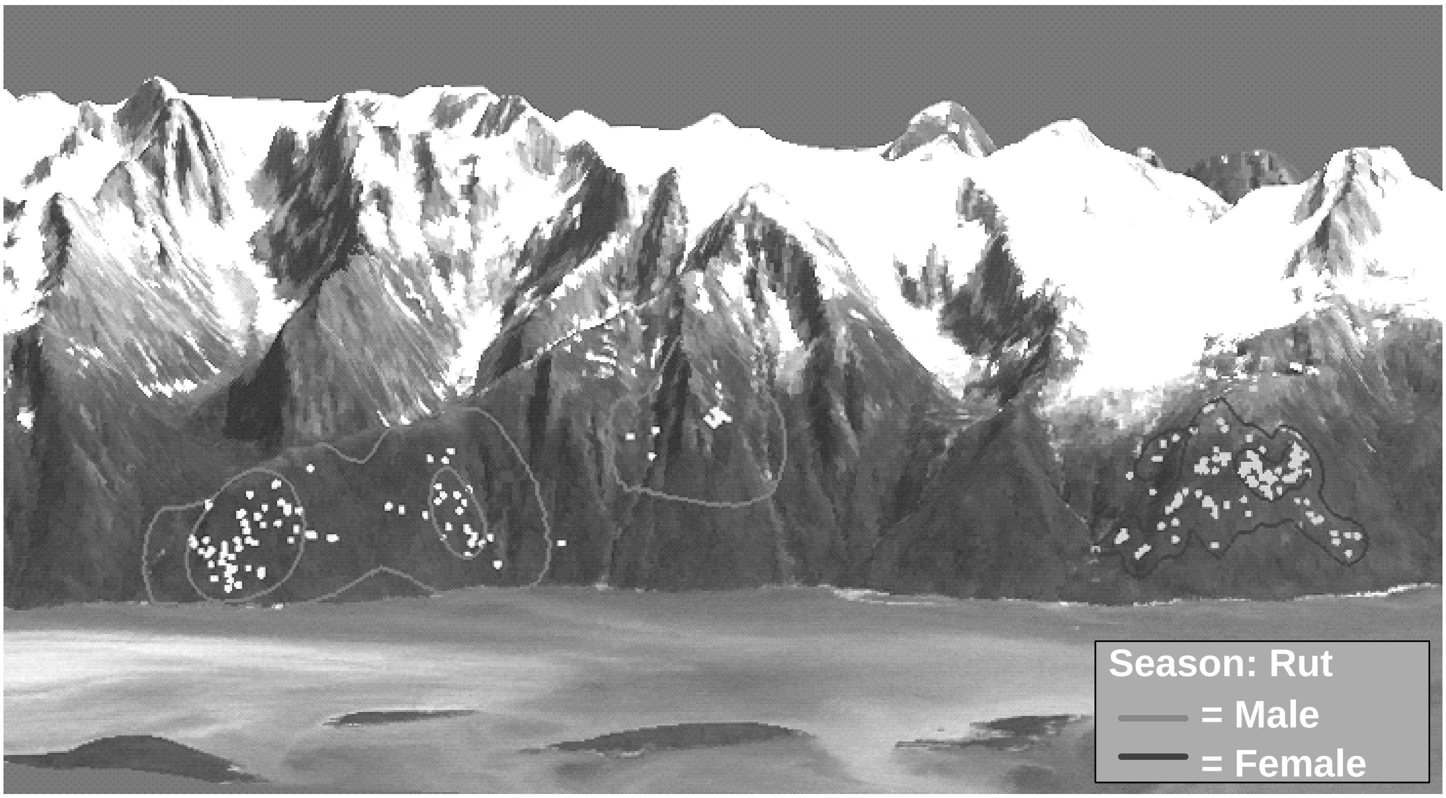
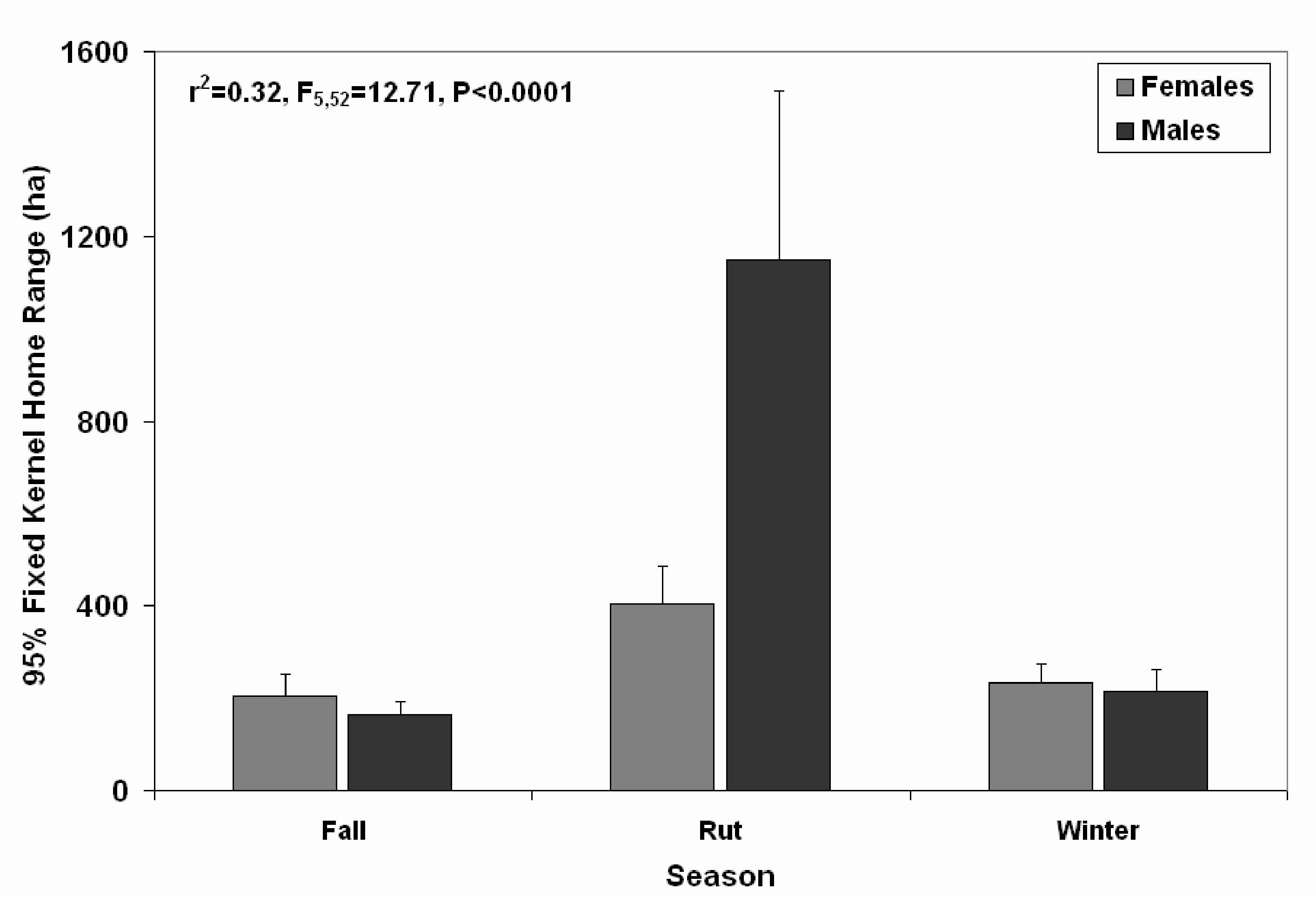
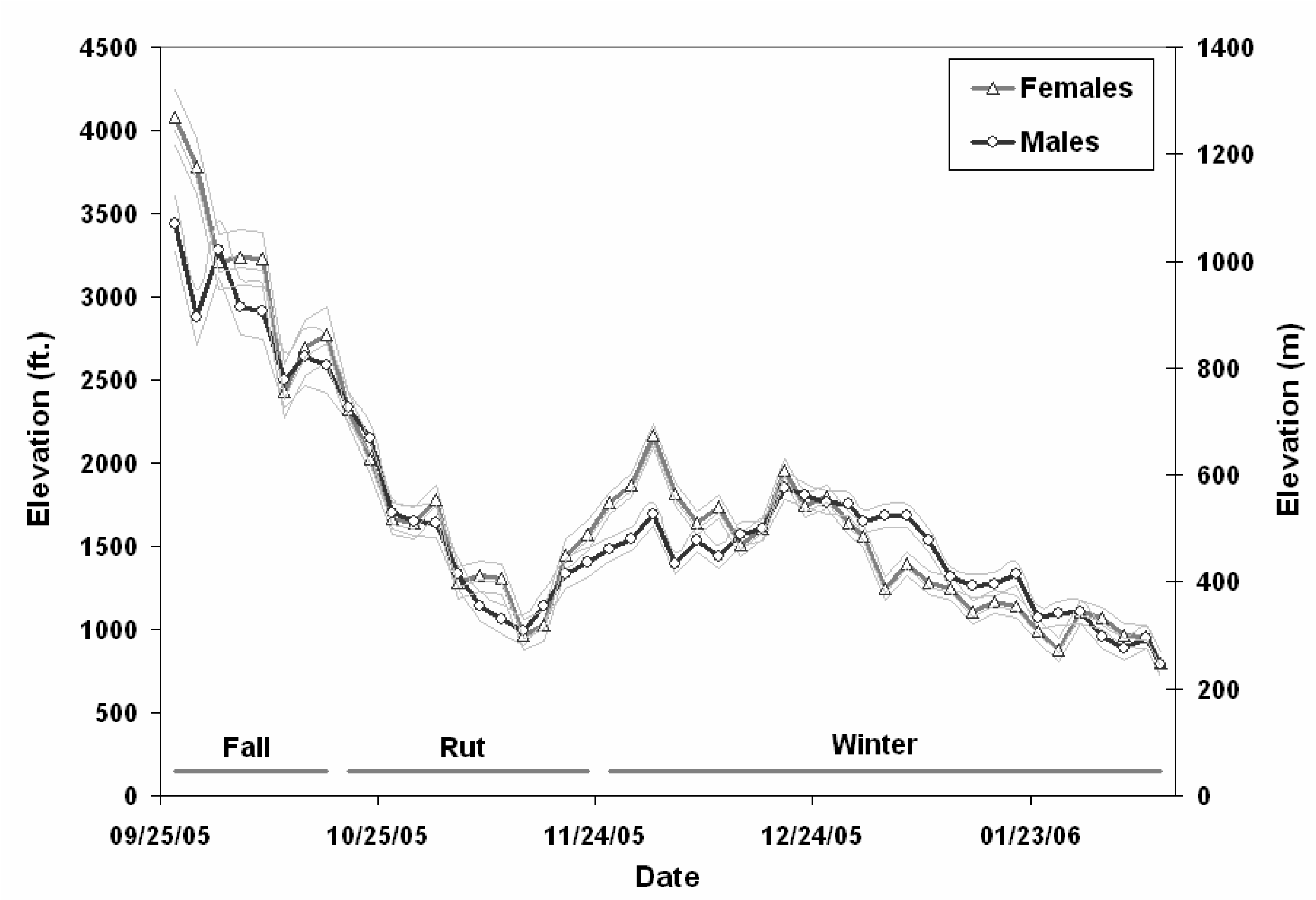


Figure 7.



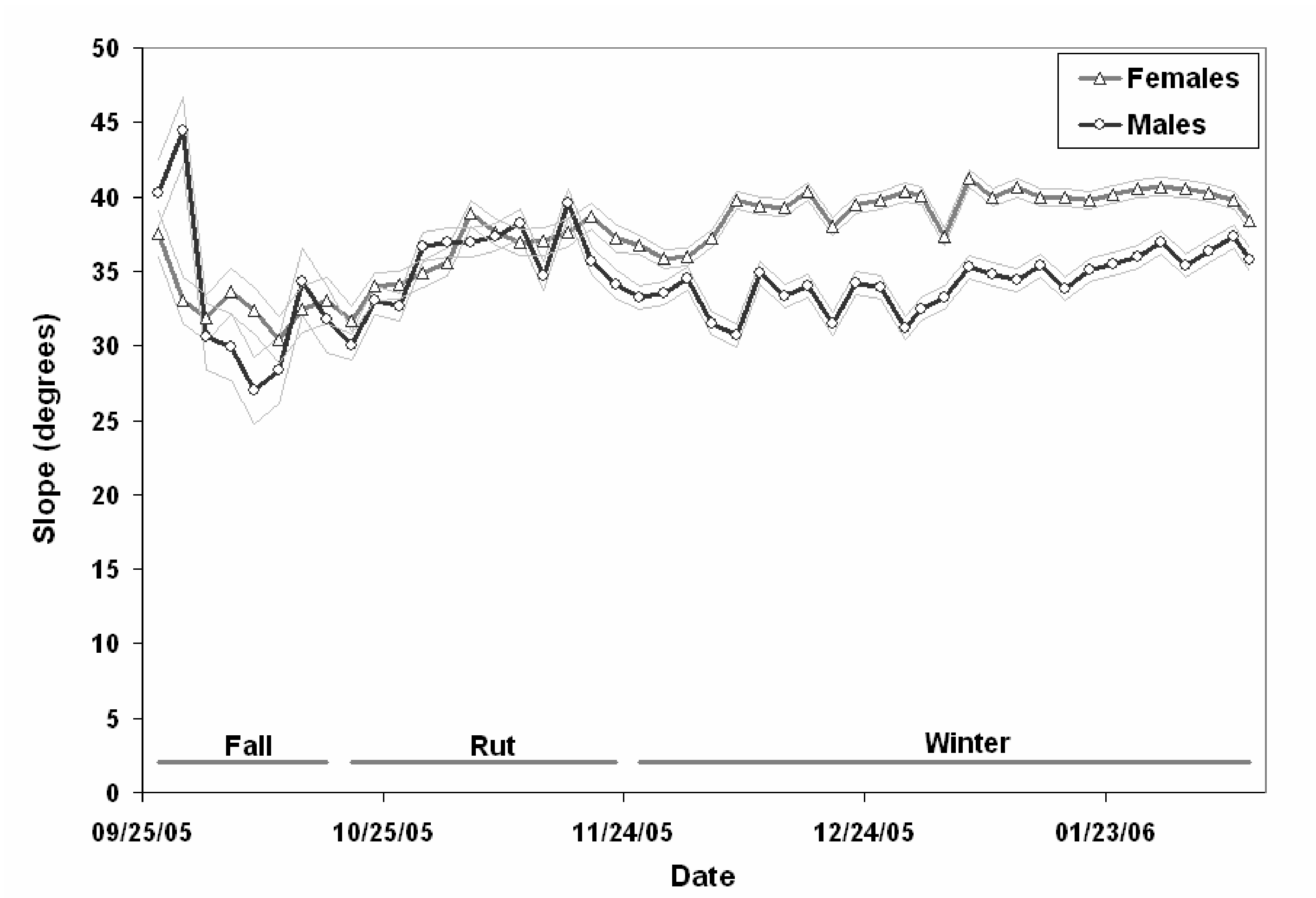
r^2=0.32, $F_{5,52}$=12.71, P<0.0001
Females
Males
95% Fixed Kernel Home Range (ha)
1600
1200
800
400
0
Fall
Rut
Winter
Season

Figure 8.



Females
Males
Elevation (ft.)
Elevation (m)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1400
1200
1000
800
600
400
200
0
Fall
Rut
Winter
09/25/05
10/25/05
11/24/05
12/24/05
01/23/06
Date

Figure 9.



Females
Males
Fall
Rut
Winter
Slope (degrees)
50
45
40
35
30
25
20
15
10
5
0
09/25/05
10/25/05
11/24/05
12/24/05
01/23/06
Date

Figure 10.

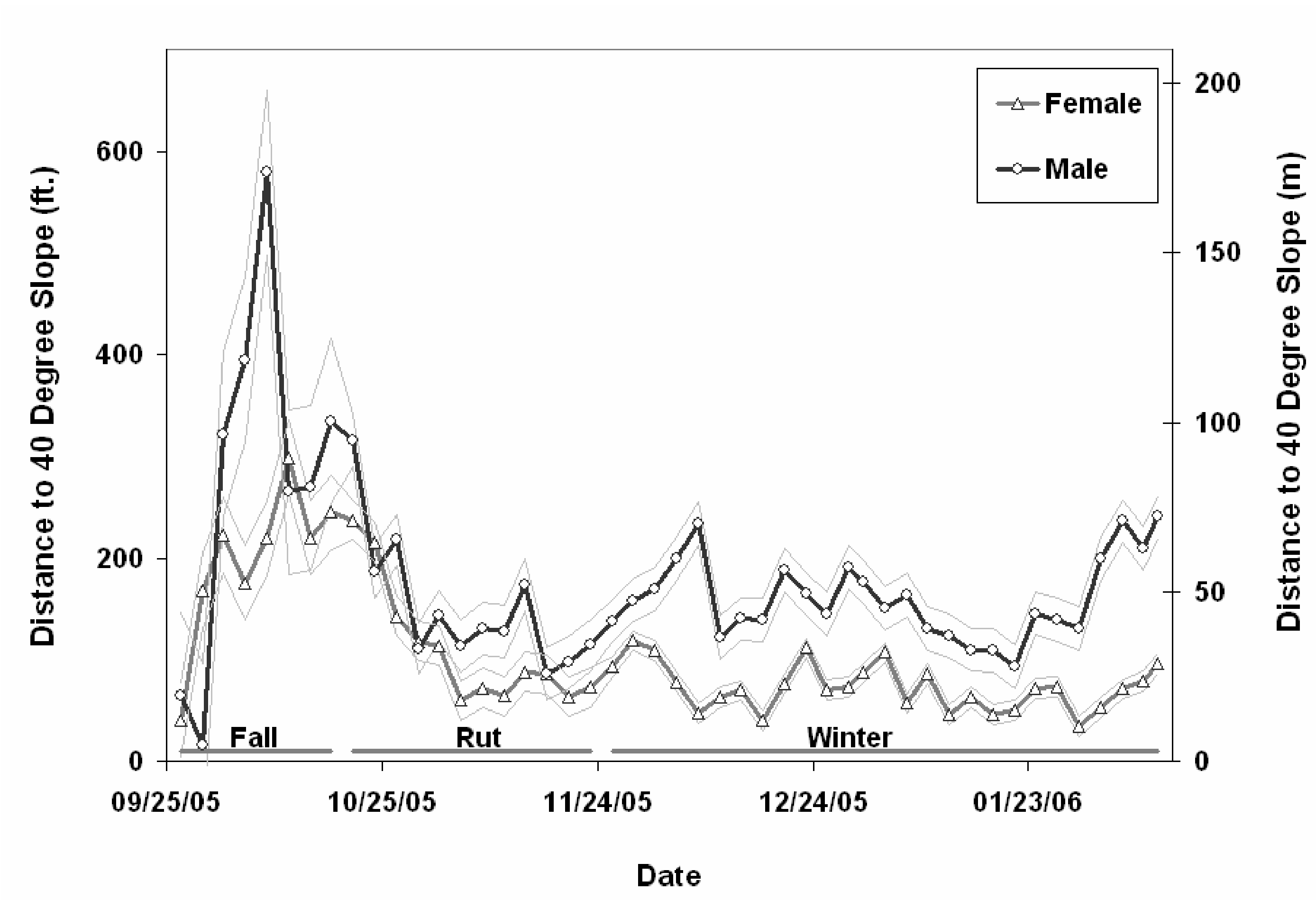
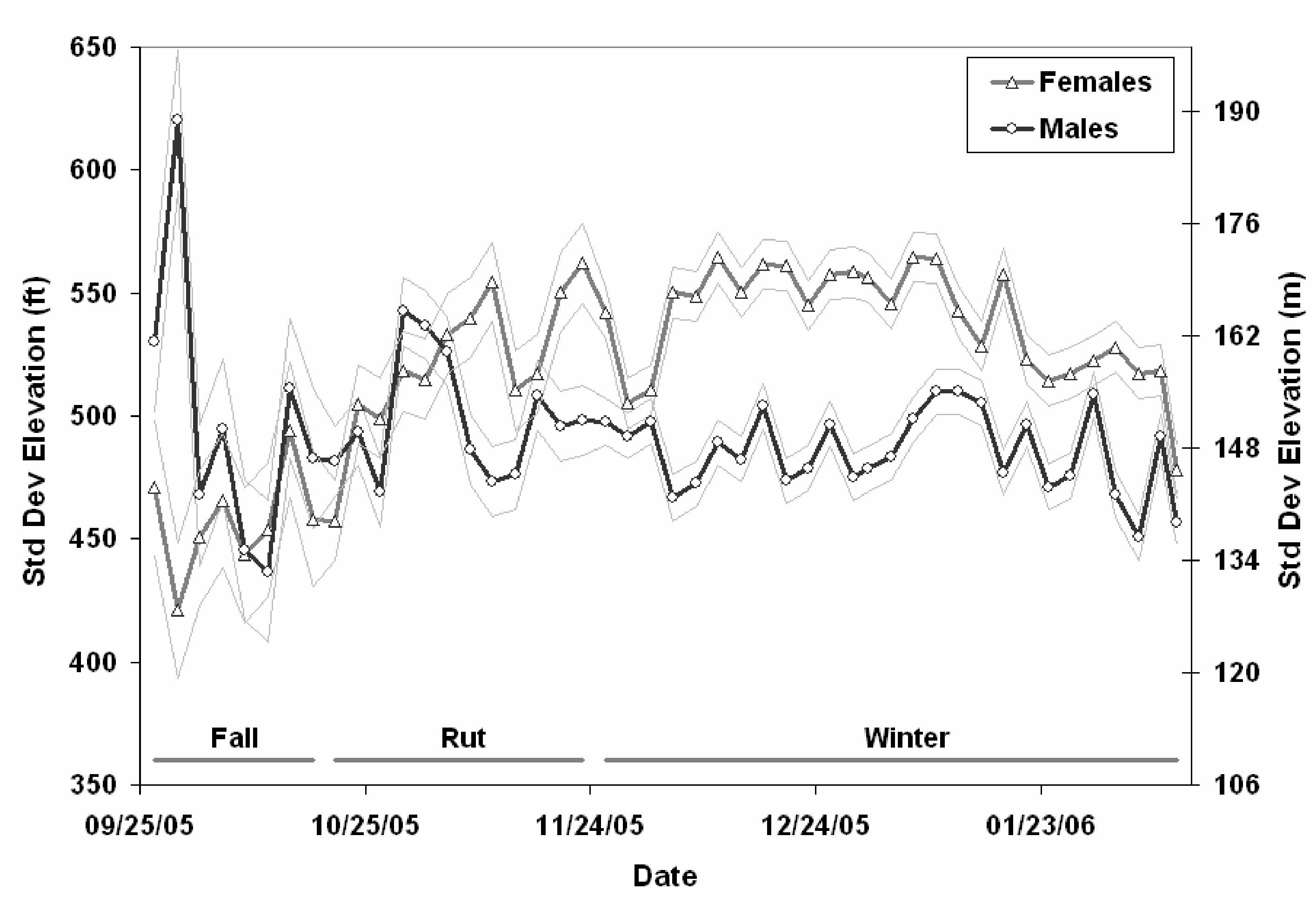

Female
Male
Distance to 40 Degree Slope (ft.)
Distance to 40 Degree Slope (m)
0
200
400
600
0
50
100
150
200
Fall
Rut
Winter
09/25/05
10/25/05
11/24/05
12/24/05
01/23/06
Date

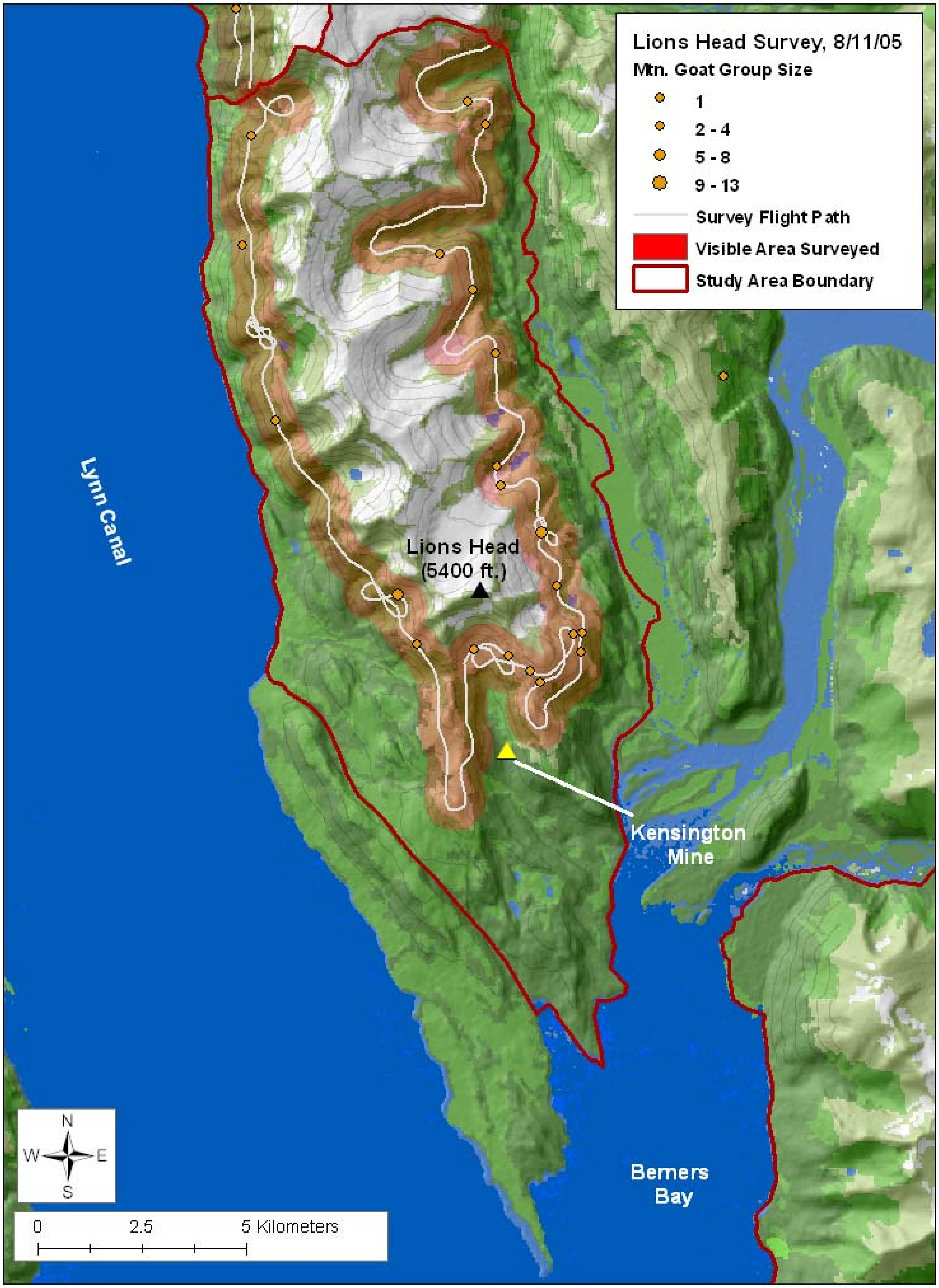
Figure 11.

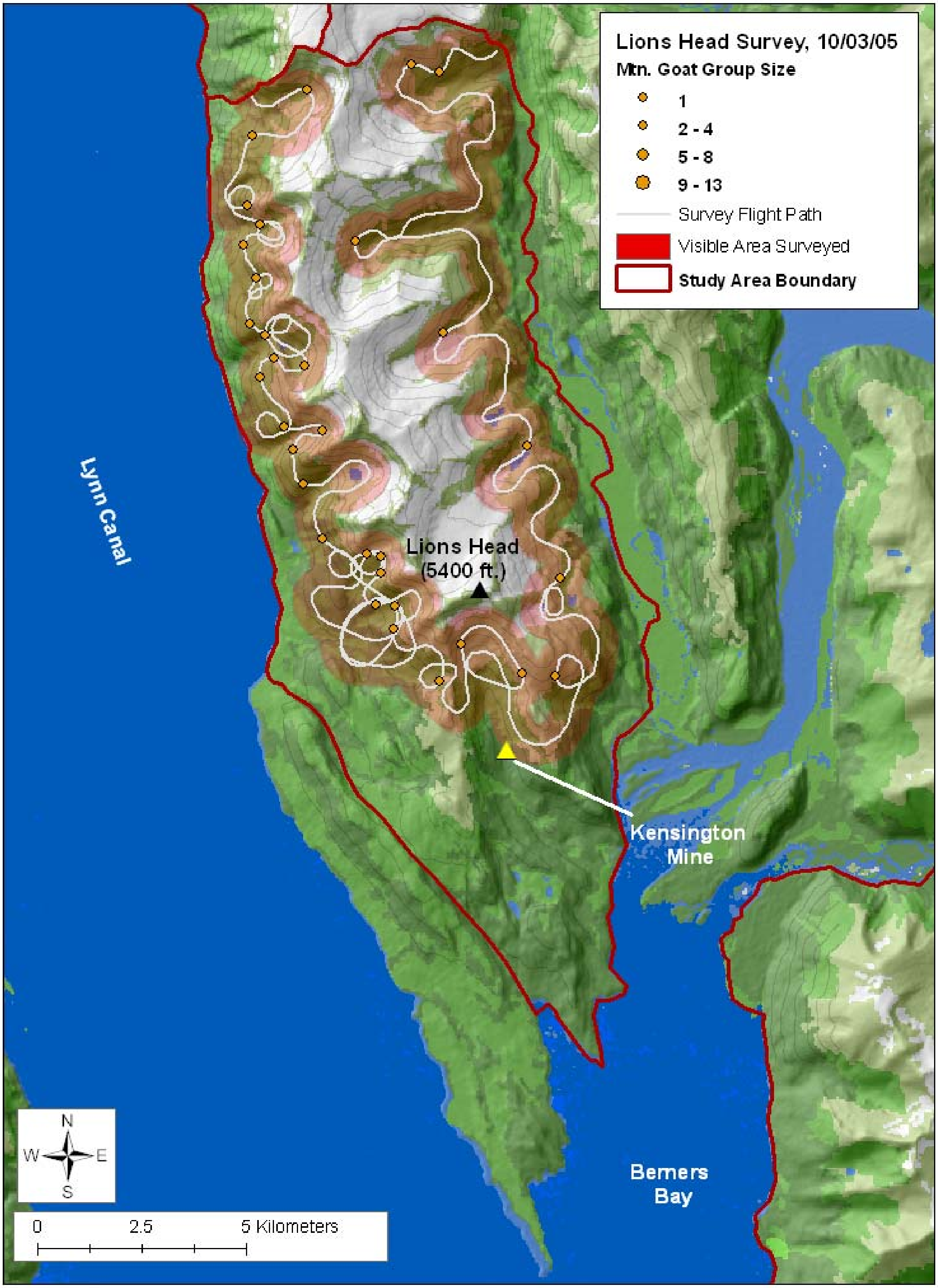


650
600
550
500
450
400
350
190
176
162
148
134
120
106
Std Dev Elevation (ft)
Std Dev Elevation (m)
Females
Males
Fall
Rut
Winter
09/25/05
10/25/05
11/24/05
12/24/05
01/23/06
Date

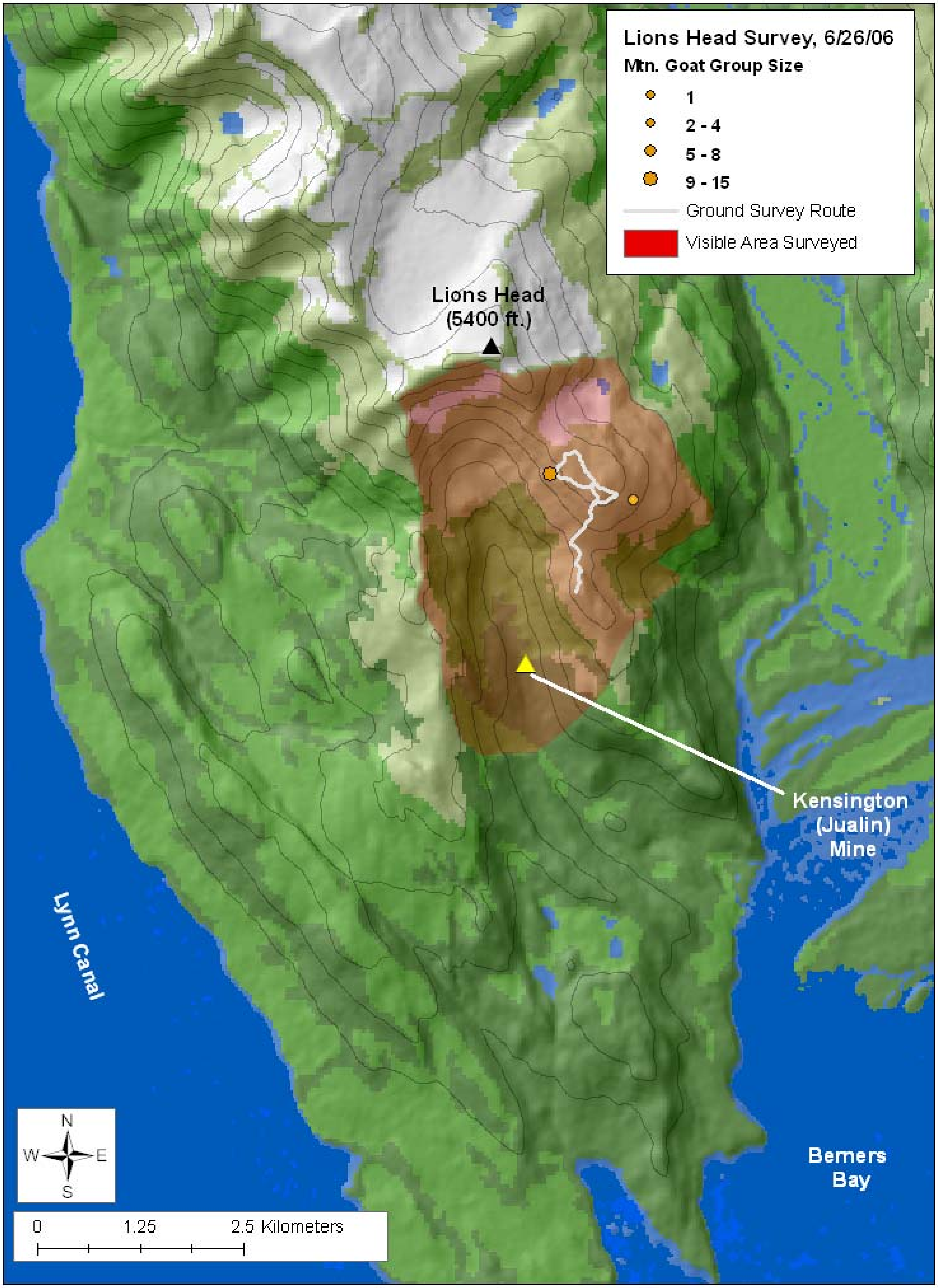
Appendix 2.

Geographical summary of mountain goat aerial survey activities conducted between August 11, 2005-July 2, 2006. Maps describe survey routes, estimated visible area surveyed and location of mountain goat groups recorded.

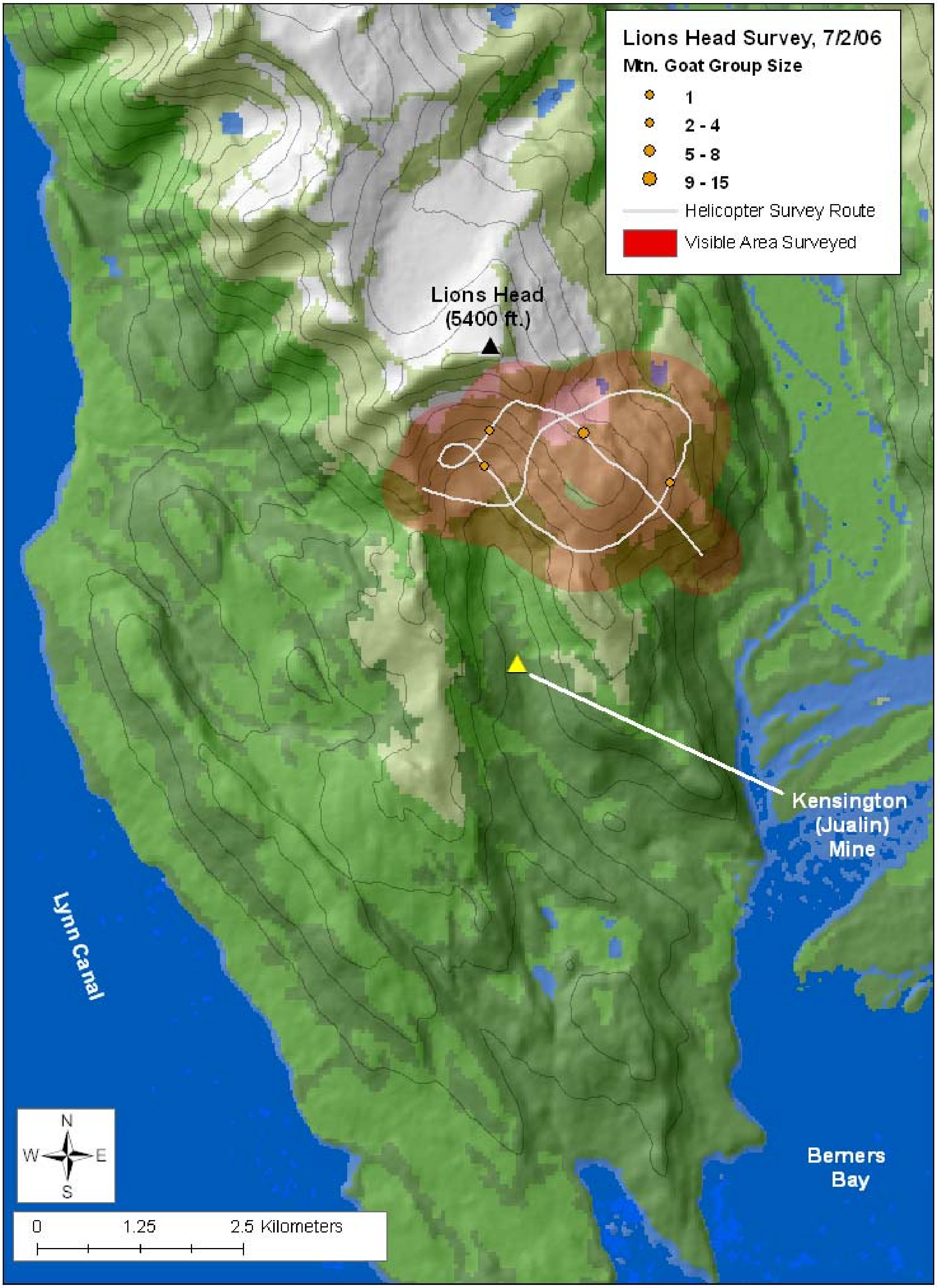




Lions Head Survey, 10/03/05
Mtn. Goat Group Size
1
2 - 4
5 - 8
9 - 13
Survey Flight Path
Visible Area Surveyed
Study Area Boundary
Lynn Canal
Lions Head
(5400 ft.)
Kensington
Mine
Berners
Bay
N
W
E
S
0
2.5
5 Kilometers



Lions Head Survey, 6/26/06
Mtn. Goat Group Size
1
2 - 4
5 - 8
9 - 15
Ground Survey Route
Visible Area Surveyed
Lions Head
(5400 ft.)
Kensington
(Jualin)
Mine
Lynn Canal
Berners
Bay
N
W
E
S
0
1.25
2.5 Kilometers



Lions Head Survey, 7/2/06
Mtn. Goat Group Size
1
2 - 4
5 - 8
9 - 15
Helicopter Survey Route
Visible Area Surveyed
Lions Head
(5400 ft.)
Kensington
(Jualin)
Mine
Lynn Canal
Berners
Bay
N
W
E
S
0
1.25
2.5 Kilometers

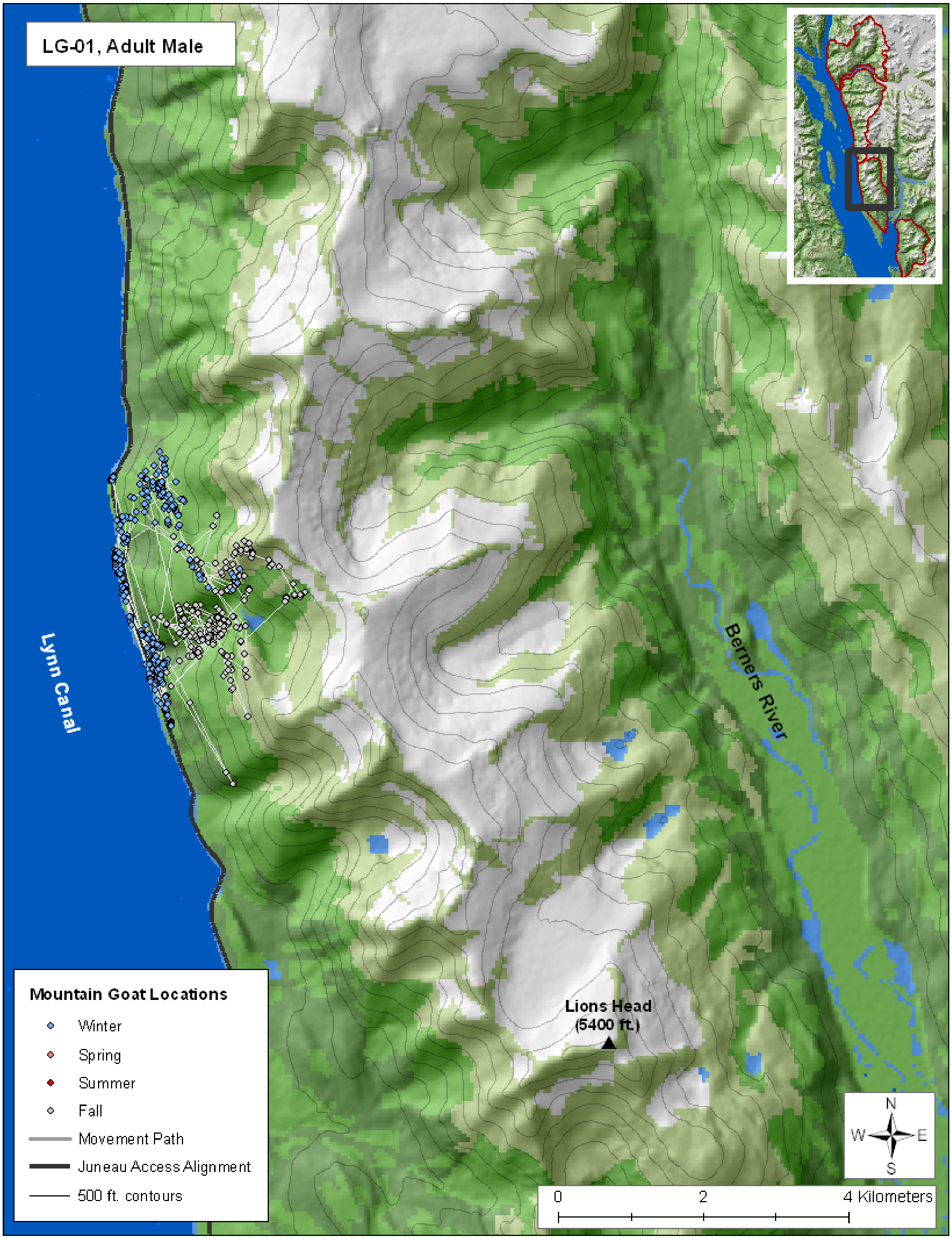

Katzehin River
Lynn Canal
Sinclair Mtn.
(6300 ft.)
Sinclair Mtn. Survey, 8/11/05
Mtn. Goat Group Size
1
2 - 3
4 - 8
9 - 13
Survey Flight Path
Visible Area Surveyed
Study Area Boundary
N
W
E
S
0
2
4 Kilometers

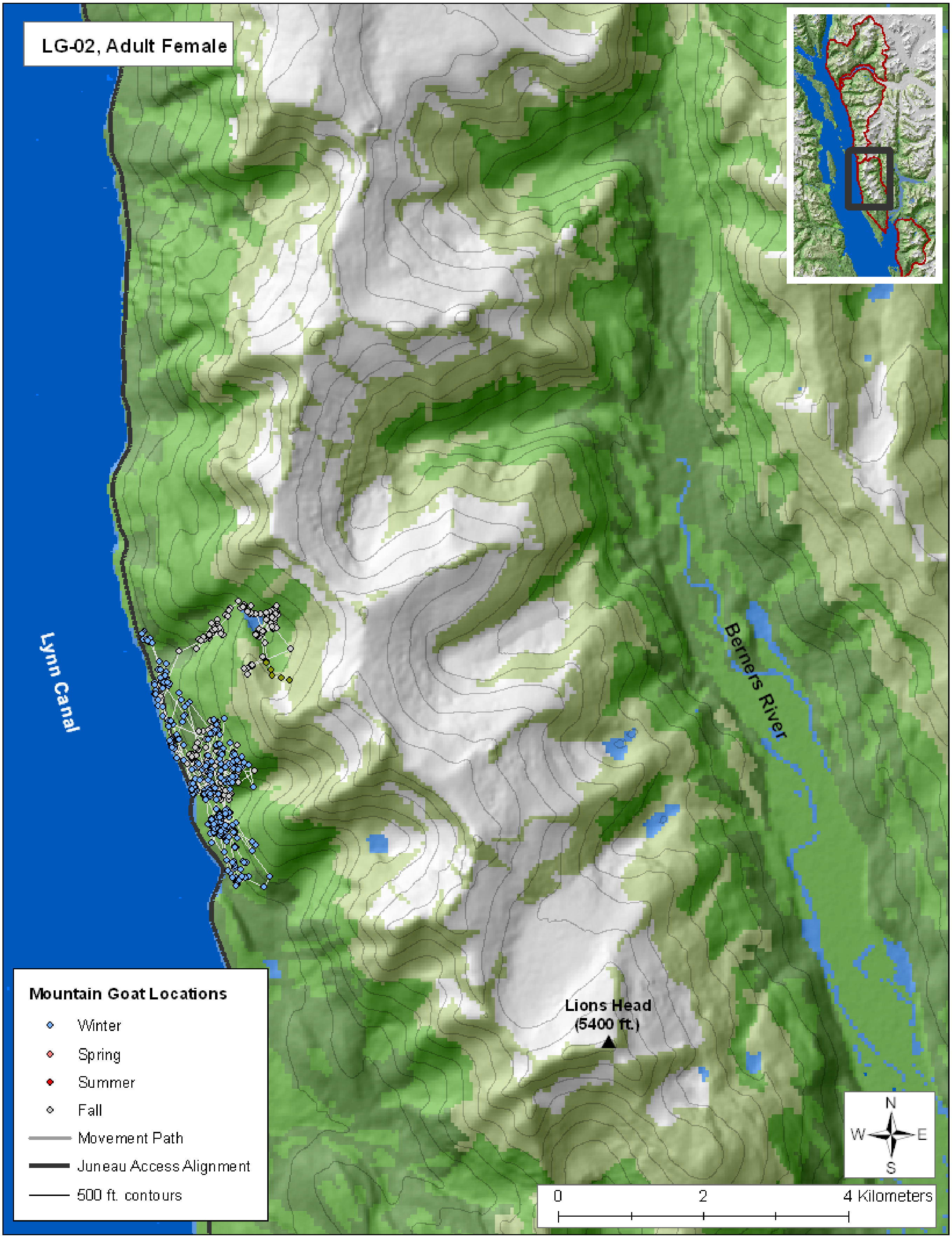

Katzehin River
Lynn Canal
Sinclair Mtn.
(6300 ft.)
Sinclair Mtn. Survey, 10/03/05
Mtn. Goat Group Size
1
2 - 3
4 - 6
7 - 12
Approx. Visible Area Surveyed
Study Area Boundary
N
W
E
S
0
2
4 Kilometers

Mt. Villard
(4990 ft.)
Katzehin River
Lynn Canal
Mt. Villard Survey, 8/12/05
Mtn. Goat Group Size
1
2 - 3
4 - 8
9 - 13
Survey Flight Path
Visible Area Surveyed
Study Area Boundary
N
W
E
S
0
2
4 Kilometers

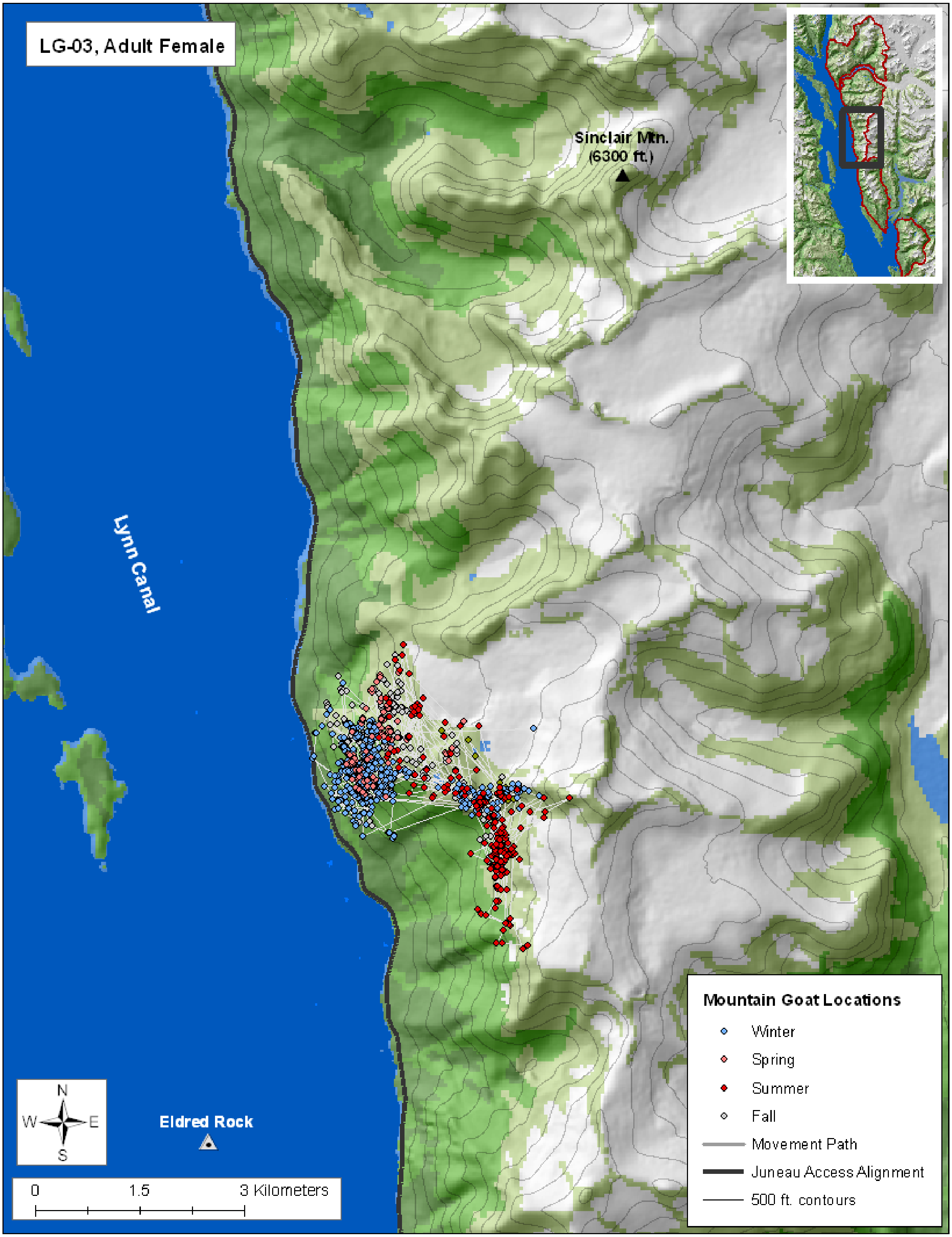
Appendix 3.

Geographical description of GPS-collared mountain goat distribution between September 28, 2005-July 25, 2006. Maps illustrate all GPS locations collected for each of the 22 individual mountain goats captured before July 25, 2006.

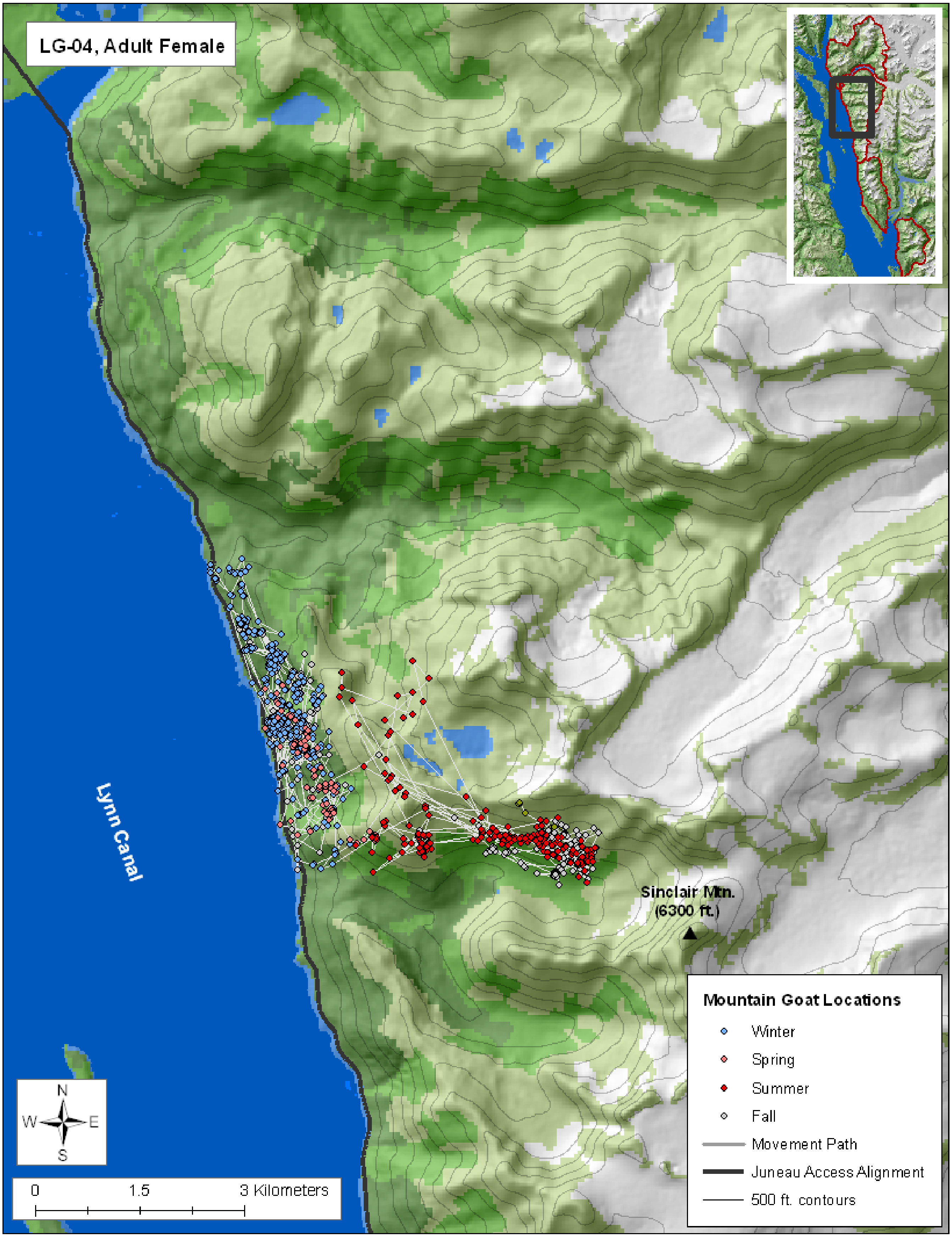




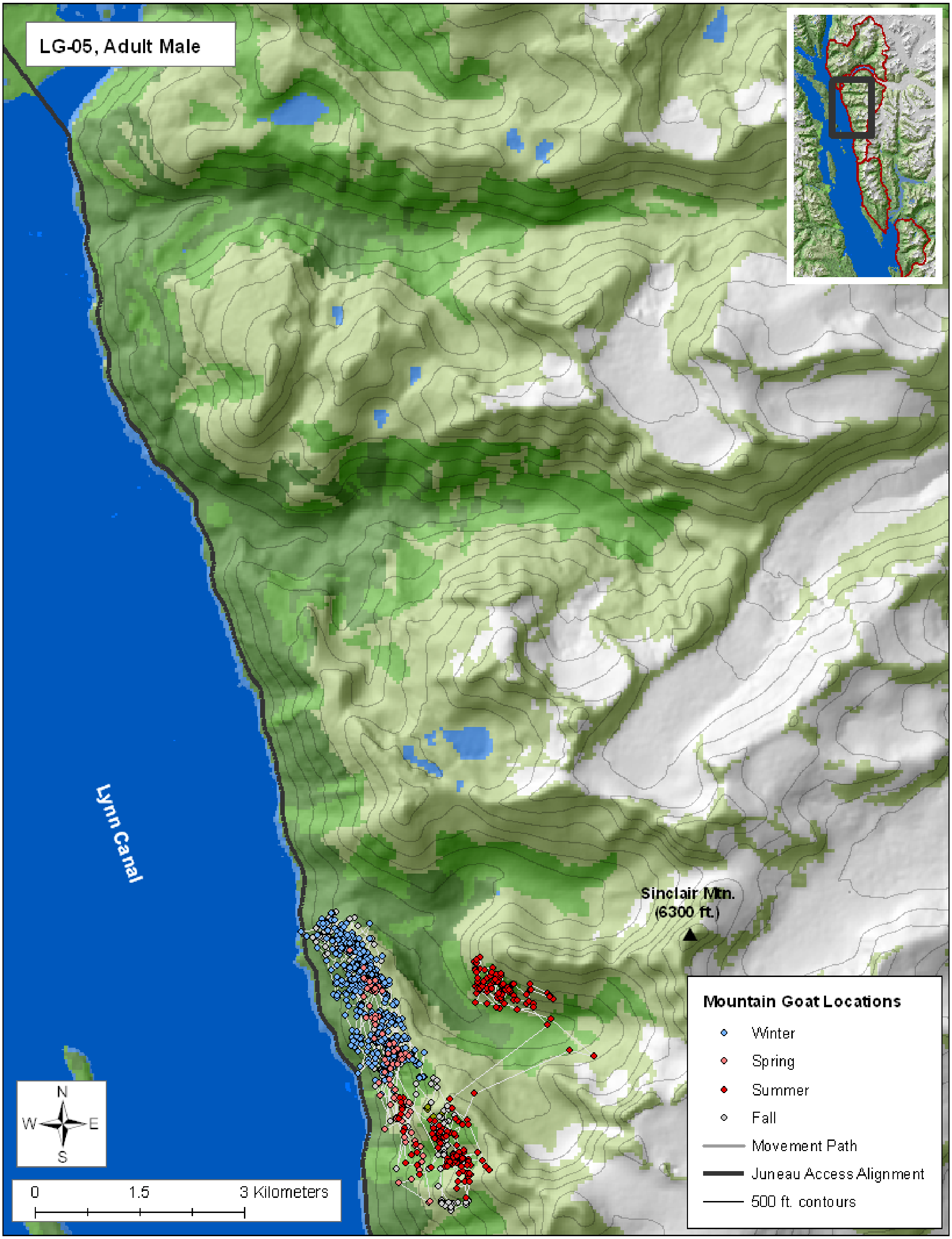
LG-02, Adult Female
Lynn Canal
Berners River
Lions Head
(5400 ft.)
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours
N
W
E
S
0
2
4 Kilometers



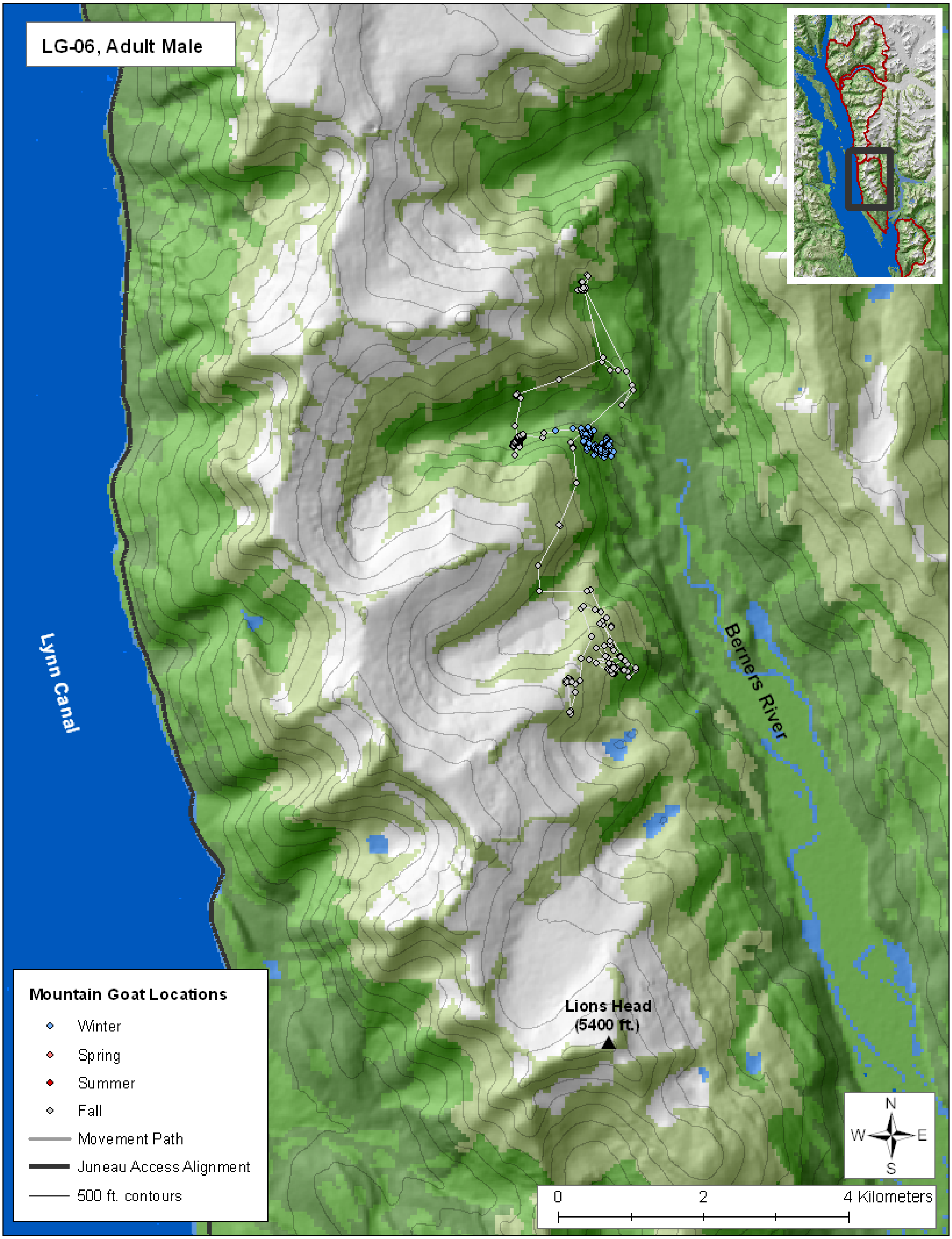
LG-03, Adult Female
Sinclair Mtn.
(6300 ft.)
Lynn Canal
Eldred Rock
N
W
E
S
0
1.5
3 Kilometers
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours

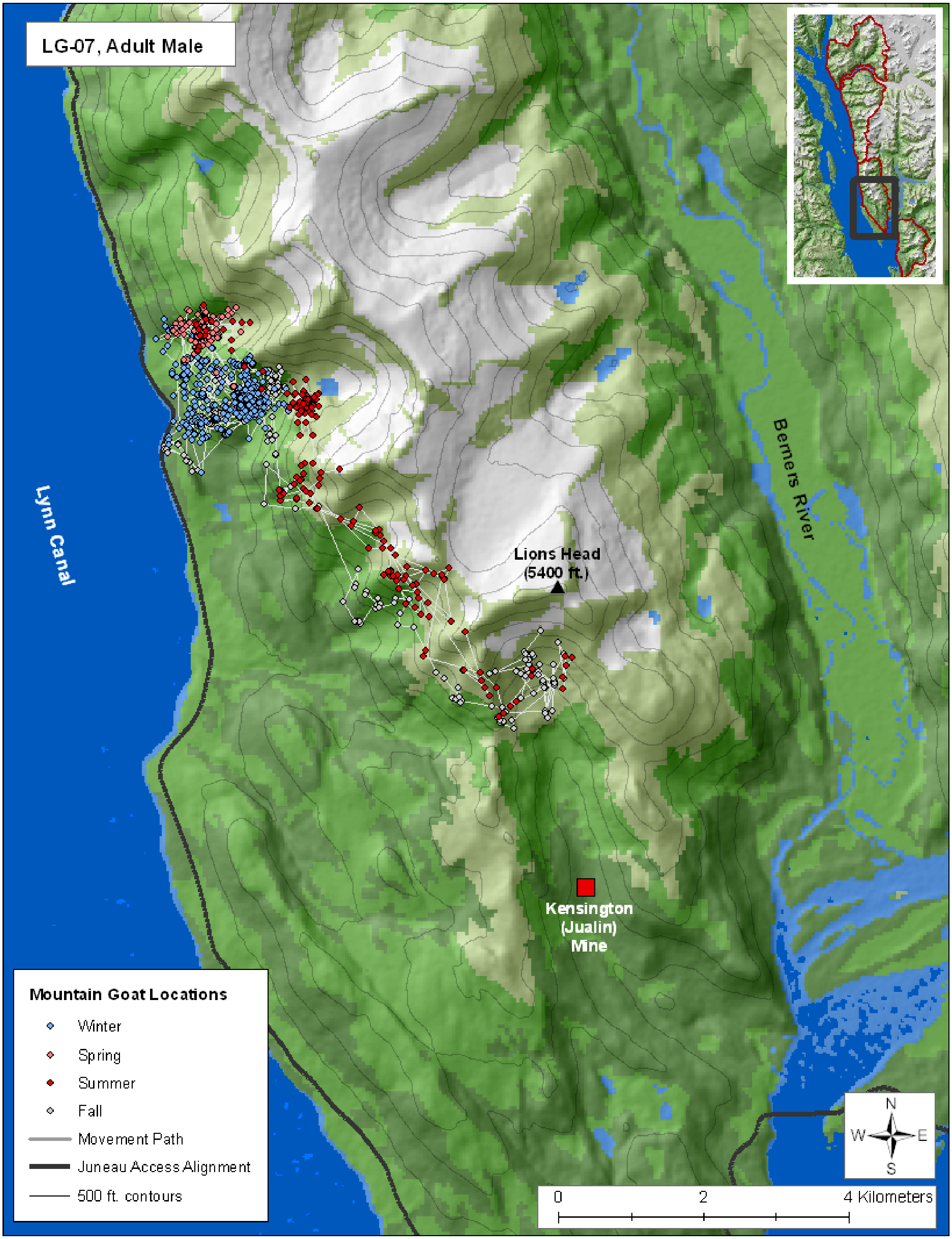


LG-04, Adult Female
Lynn Canal
Sinclair Mtn.
(6300 ft.)
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours
N
W
E
S
0
1.5
3 Kilometers

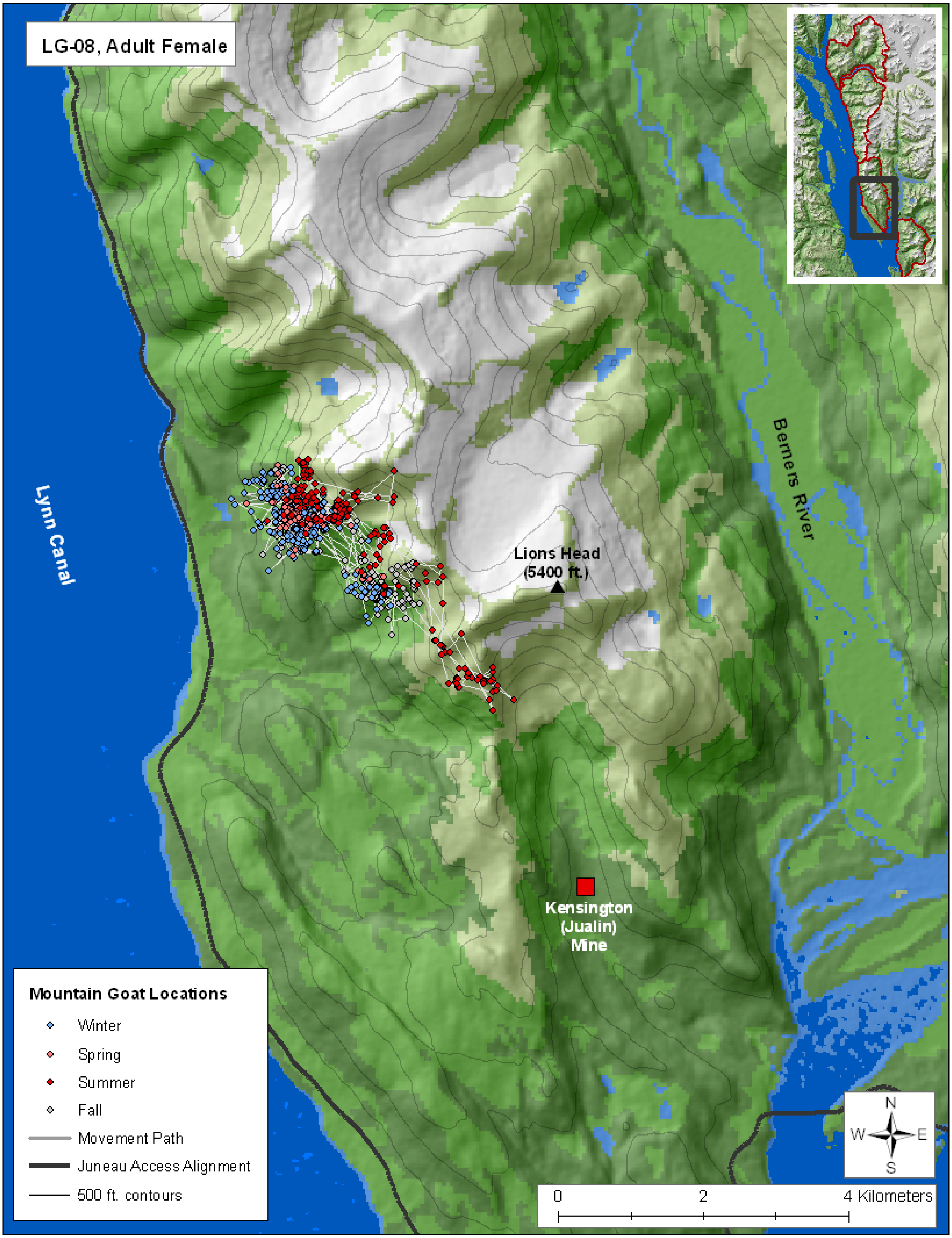


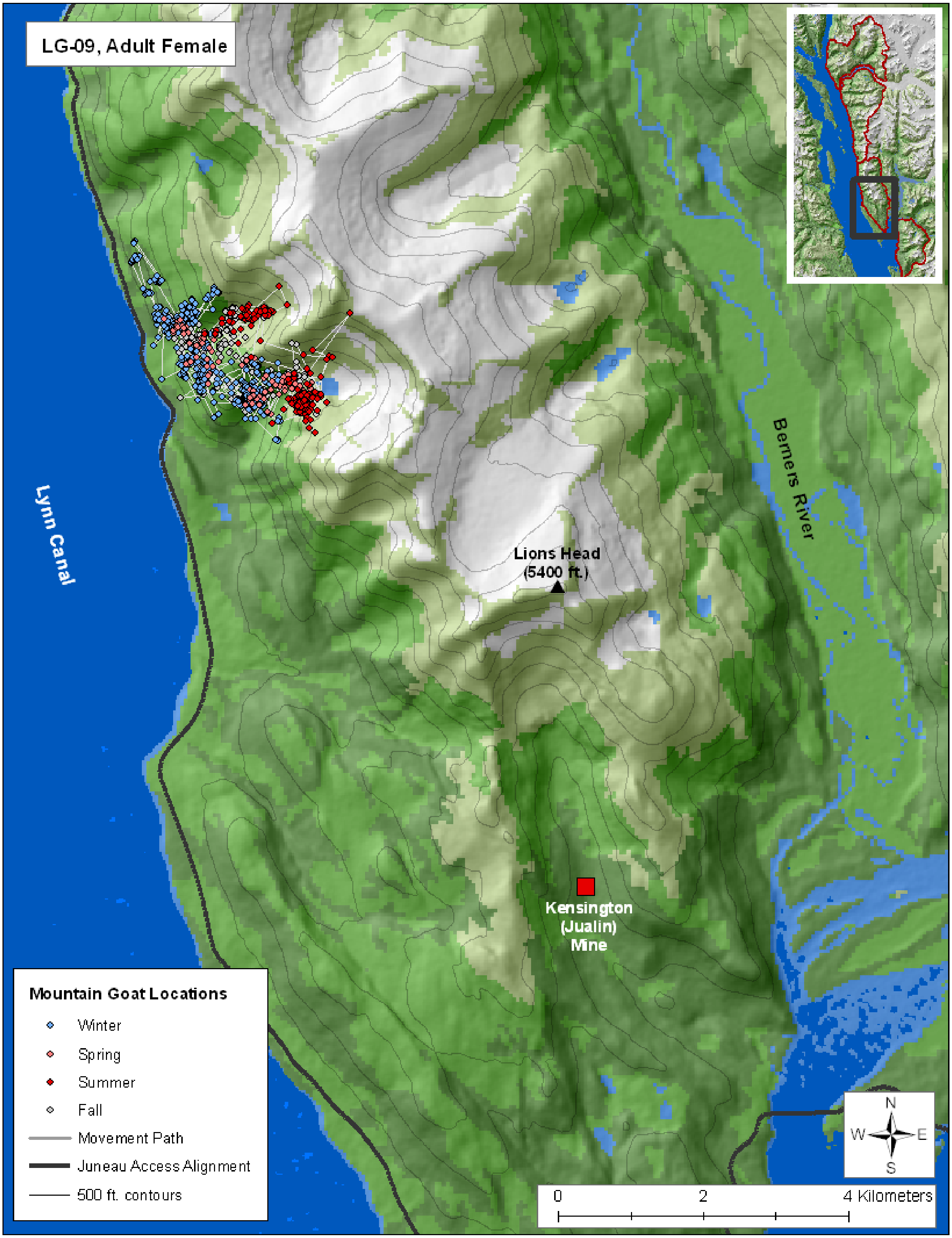
LG-05, Adult Male
Lynn Canal
Sinclair Mtn.
(6300 ft.)
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours
N
W
E
S
0
1.5
3 Kilometers


LG-06, Adult Male
Lynn Canal
Berners River
Lions Head
(5400 ft.)
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours
N
W
E
S
0
2
4 Kilometers

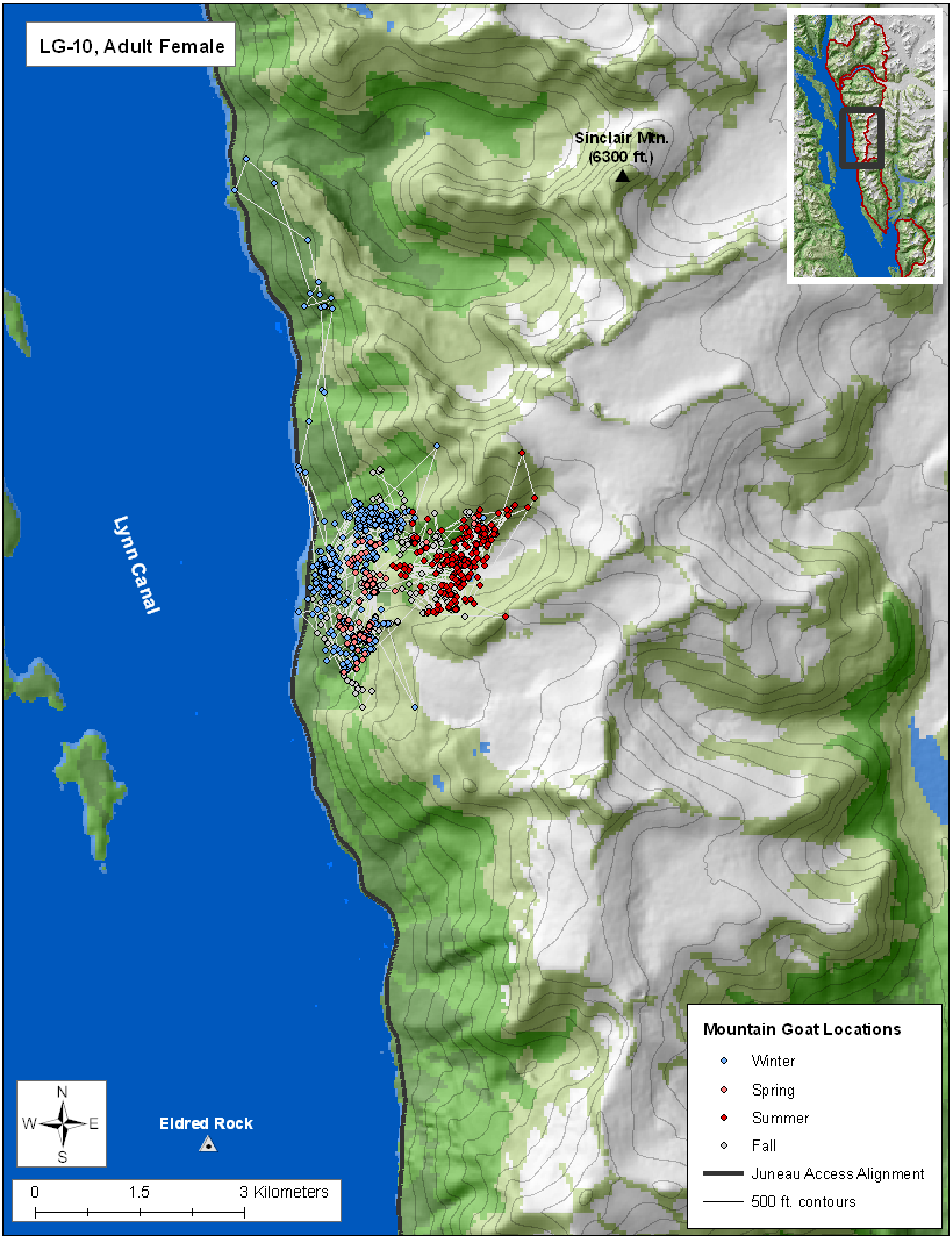


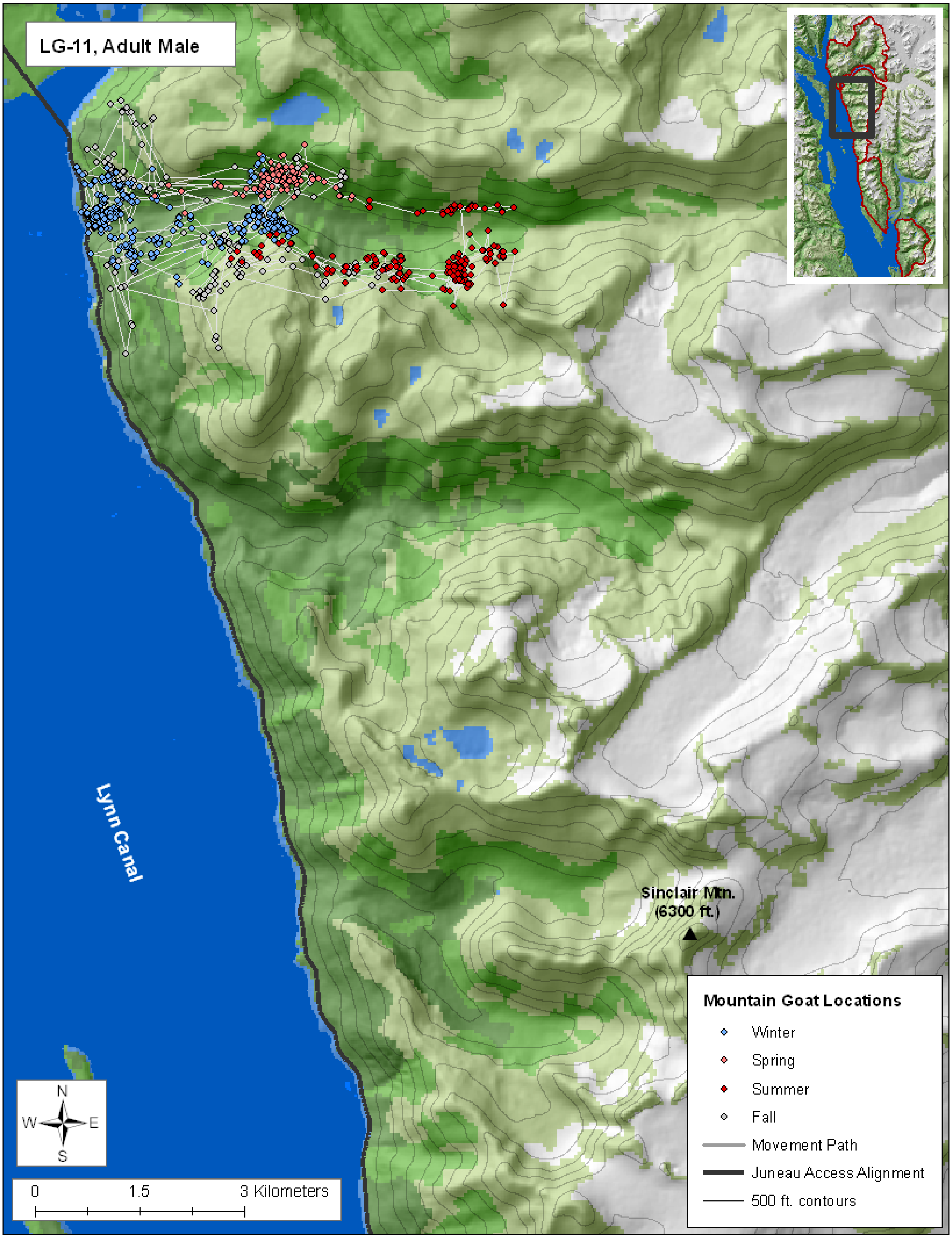
LG-07, Adult Male
Lynn Canal
Berners River
Lions Head
(5400 ft.)
Kensington
(Jualin)
Mine
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours
N
W
E
S
0
2
4 Kilometers


LG-08, Adult Female
Lynn Canal
Berners River
Lions Head
(5400 ft.)
Kensington
(Jualin)
Mine
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours
N
W
E
S
0
2
4 Kilometers

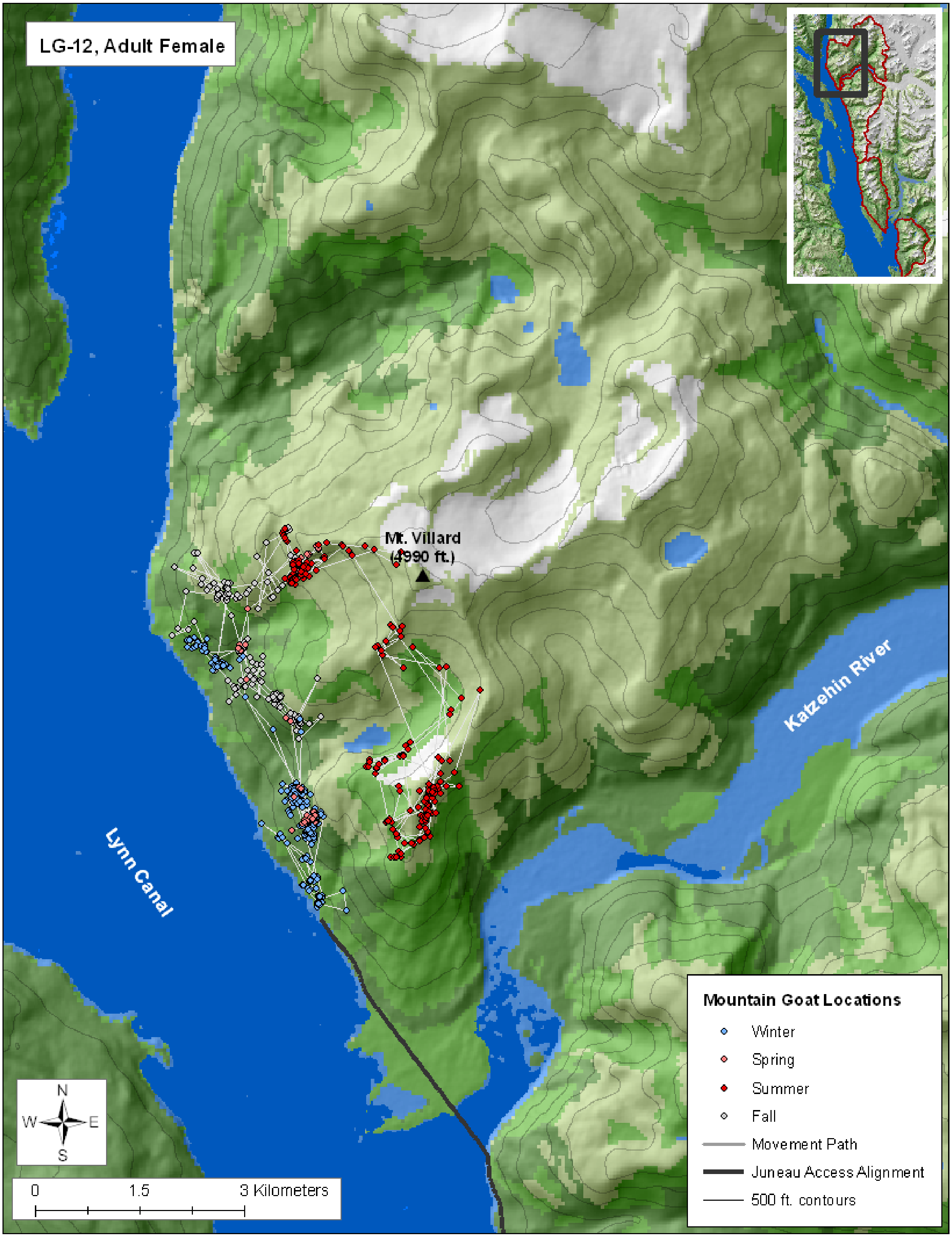


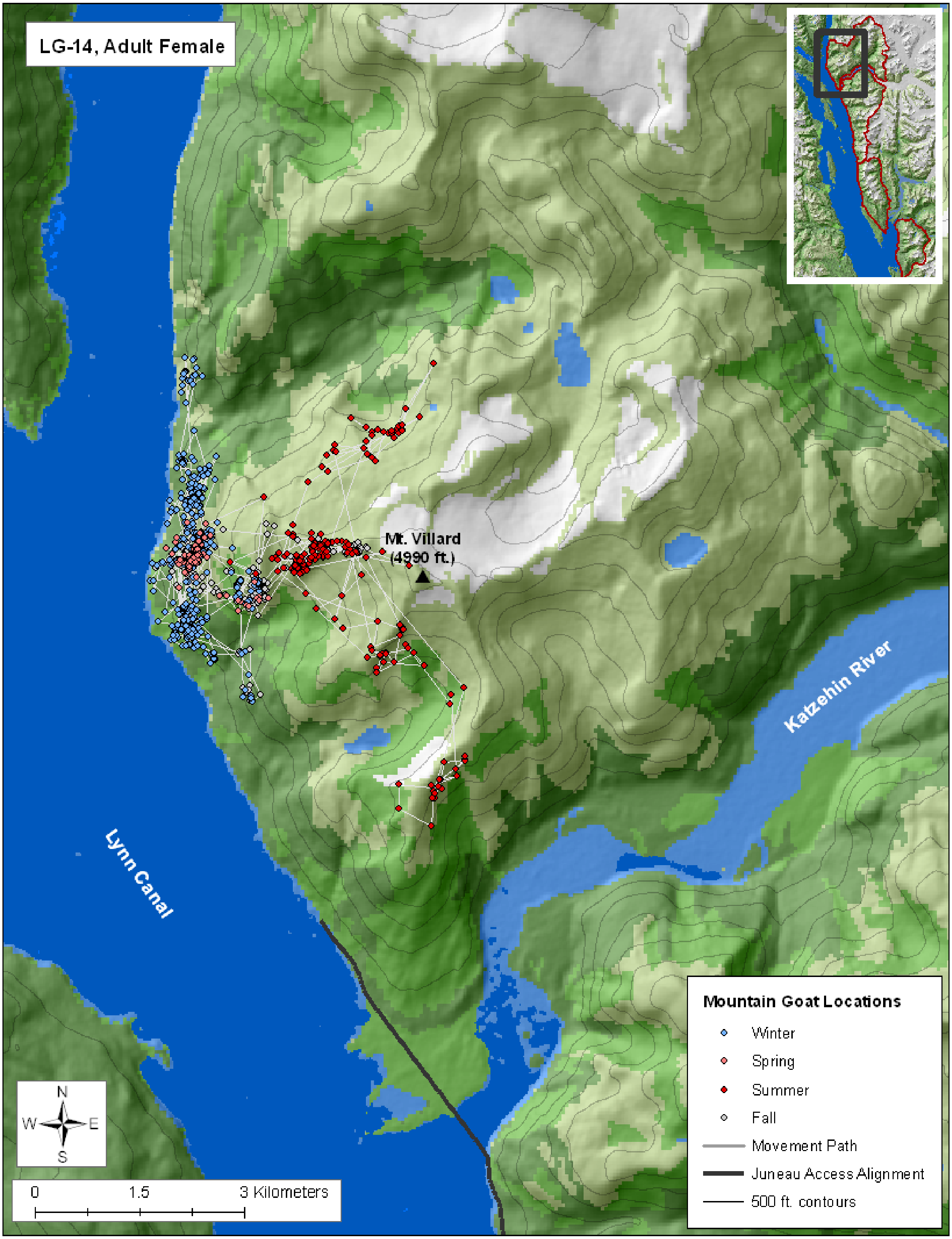
LG-09, Adult Female
Lions Head
(5400 ft.)
Berners River
Lynn Canal
Kensington
(Jualin)
Mine
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours
N
W
E
S
0
2
4 Kilometers


LG-10, Adult Female
Sinclair Mtn.
(6300 ft.)
Lynn Canal
Eldred Rock
N
W
E
S
0
1.5
3 Kilometers
Mountain Goat Locations
Winter
Spring
Summer
Fall
Juneau Access Alignment
500 ft. contours

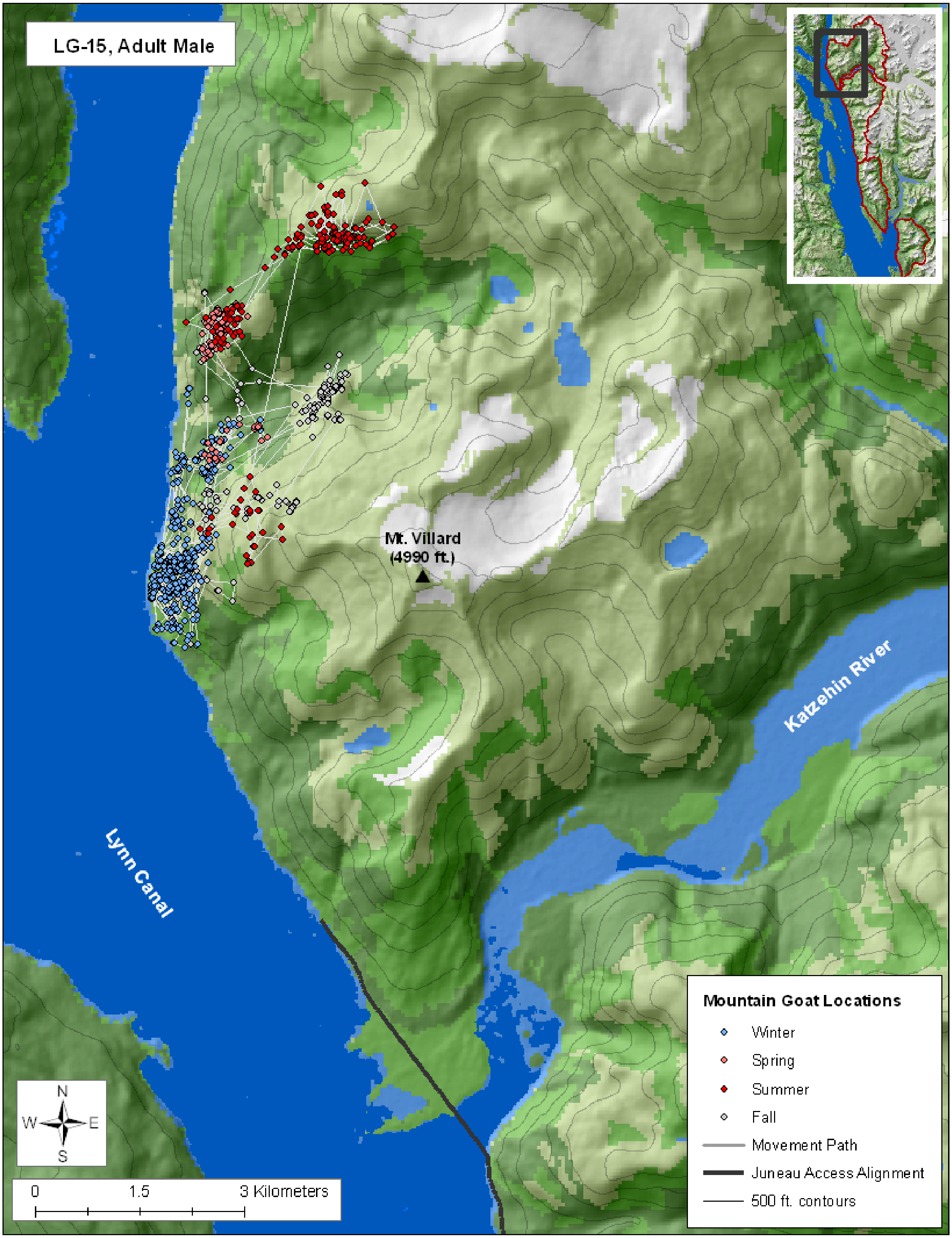


LG-11, Adult Male
Lynn Canal
Sinclair Mtn.
(6300 ft.)
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours
N
W
E
S
0
1.5
3 Kilometers

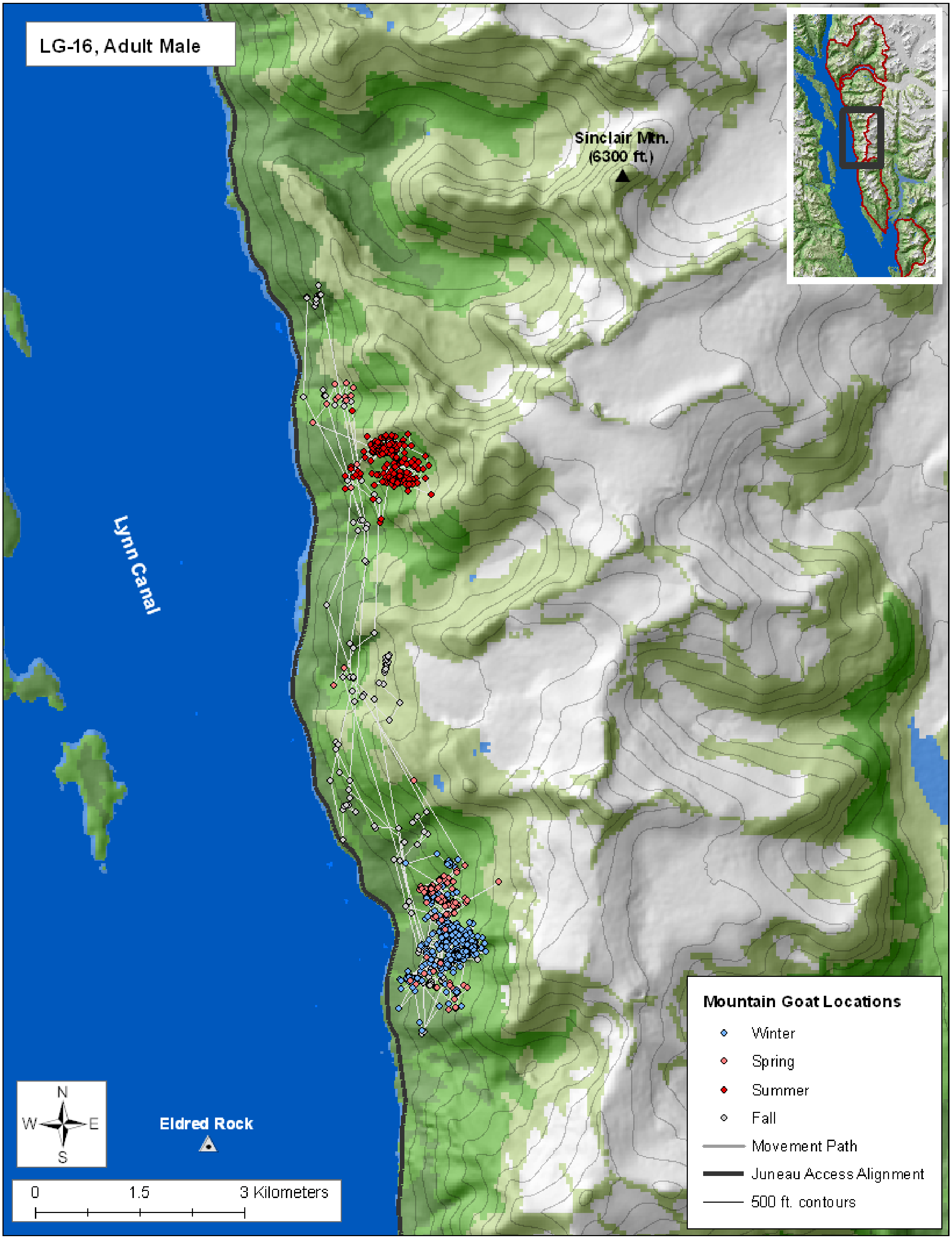

LG-12, Adult Female
Mt. Villard
(4990 ft.)
Katzehin River
Lynn Canal
N
W
E
S
0
1.5
3 Kilometers
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours



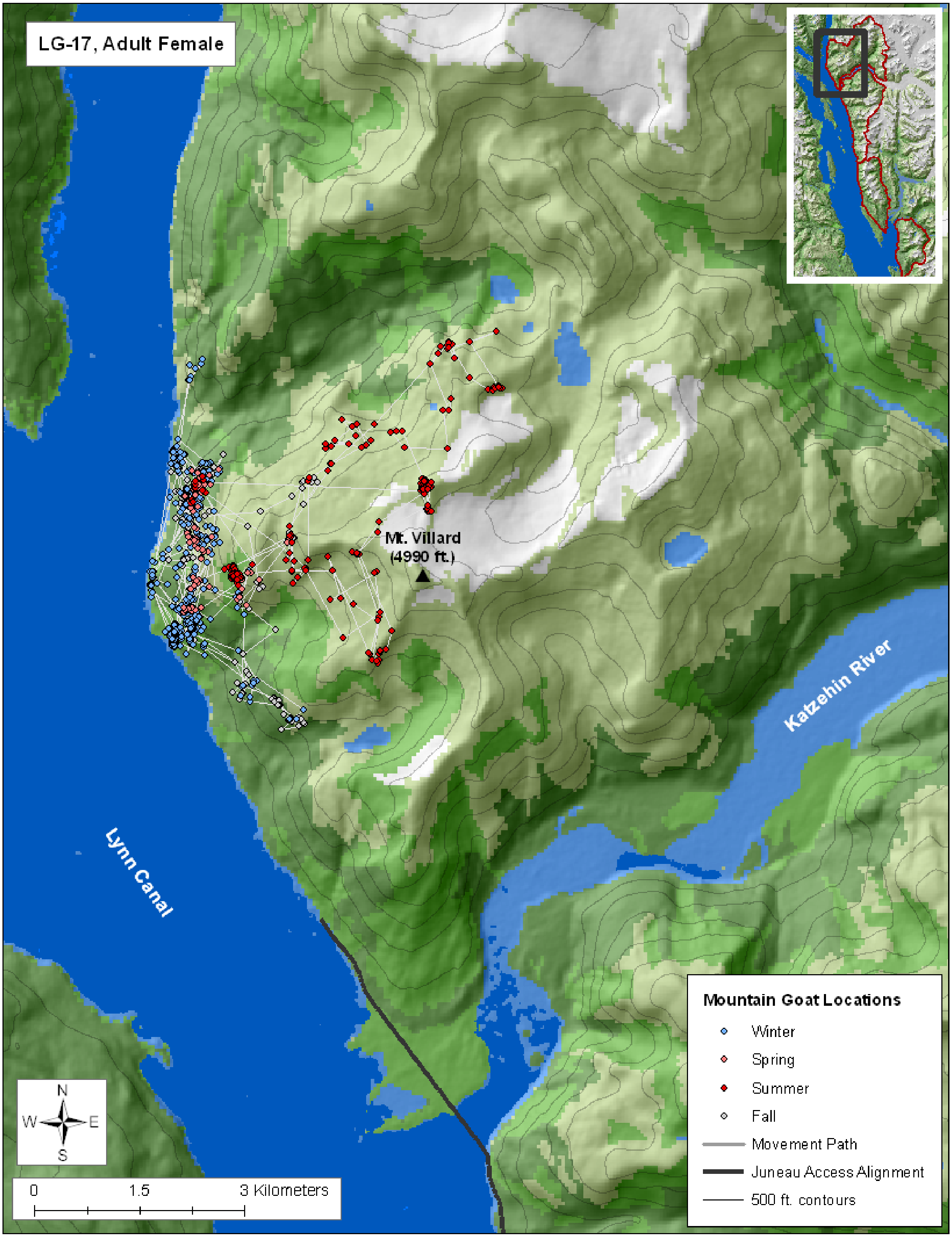
LG-14, Adult Female
Mt. Villard
(4990 ft.)
Katzehin River
Lynn Canal
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours
N
W
E
S
0
1.5
3 Kilometers



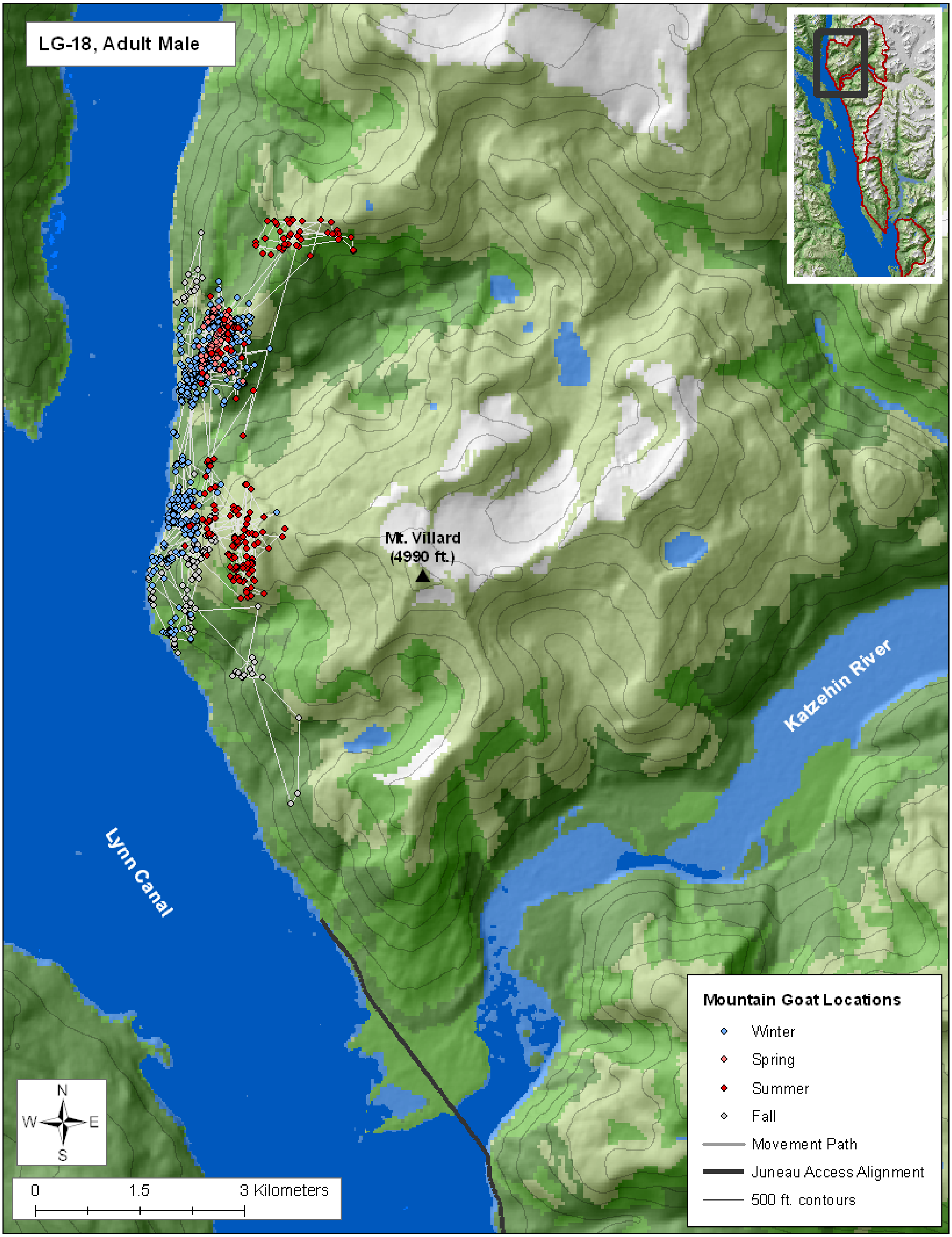
LG-15, Adult Male
Mt. Villard
(4990 ft.)
Katzehin River
Lynn Canal
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours
N
W
E
S
0
1.5
3 Kilometers

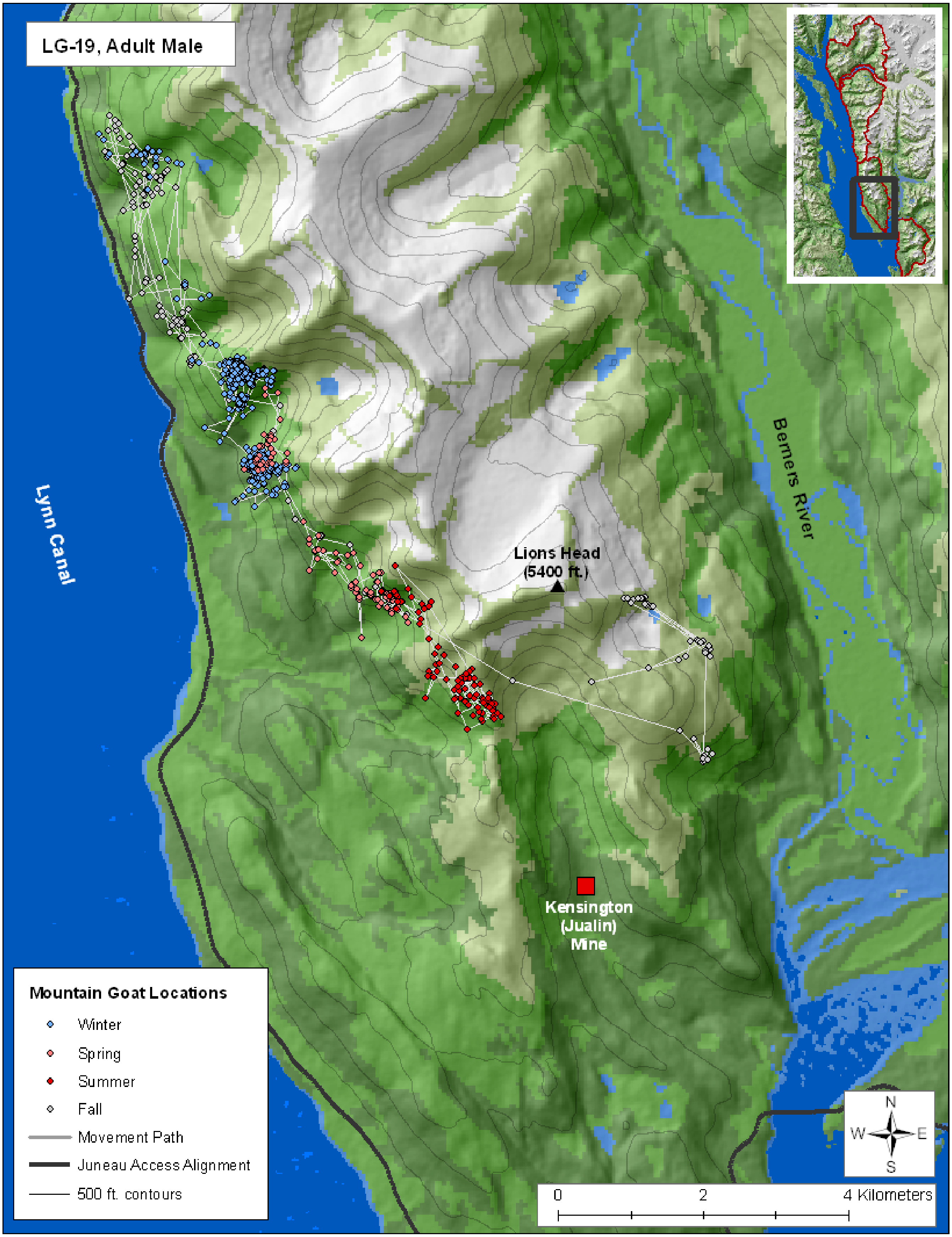


LG-16, Adult Male
Sinclair Mtn.
(6300 ft.)
Lynn Canal
Eldred Rock
N
W
E
S
0
1.5
3 Kilometers
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours

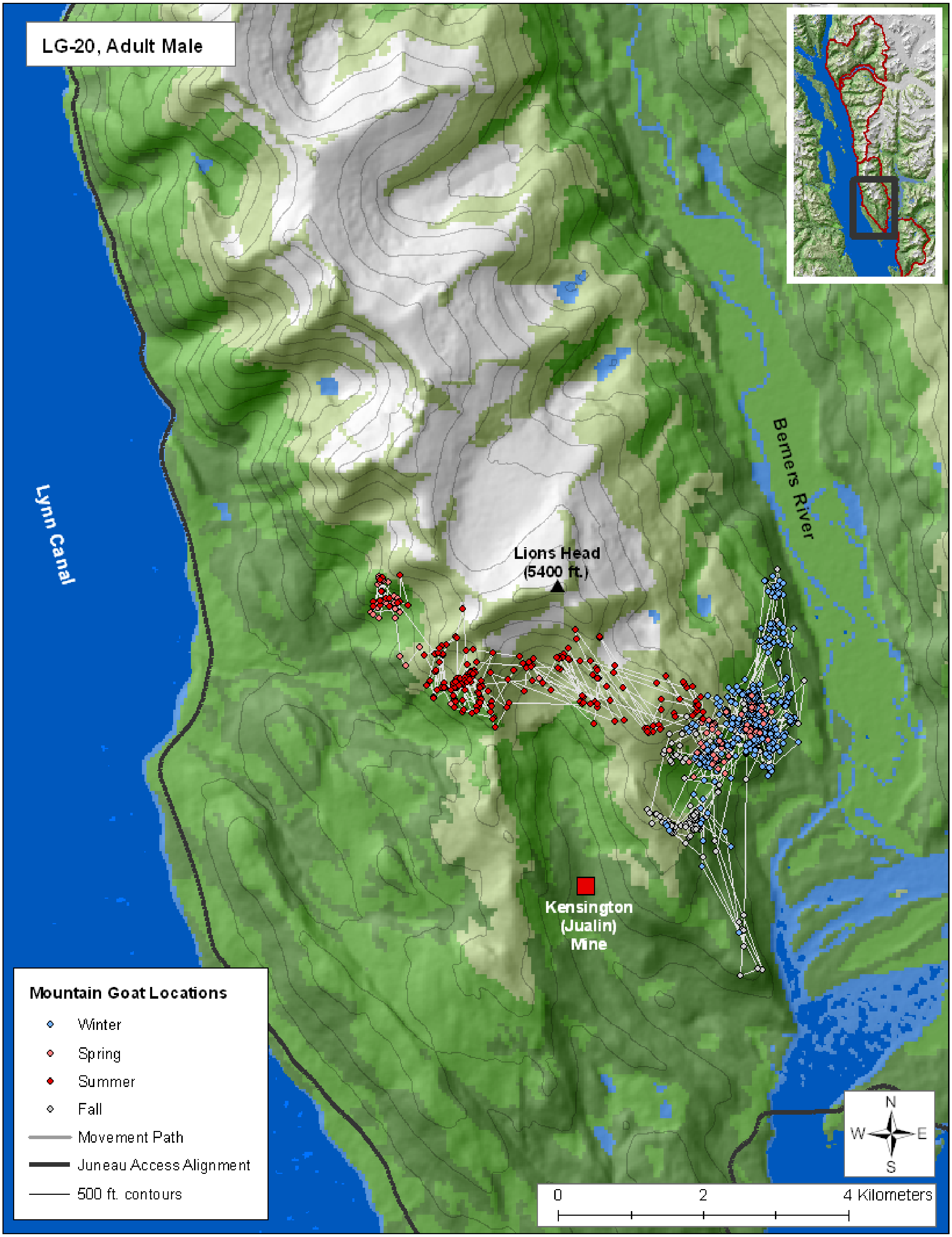


LG-17, Adult Female
Mt. Villard
(4990 ft.)
Katzehin River
Lynn Canal
N
W
E
S
0
1.5
3 Kilometers
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours

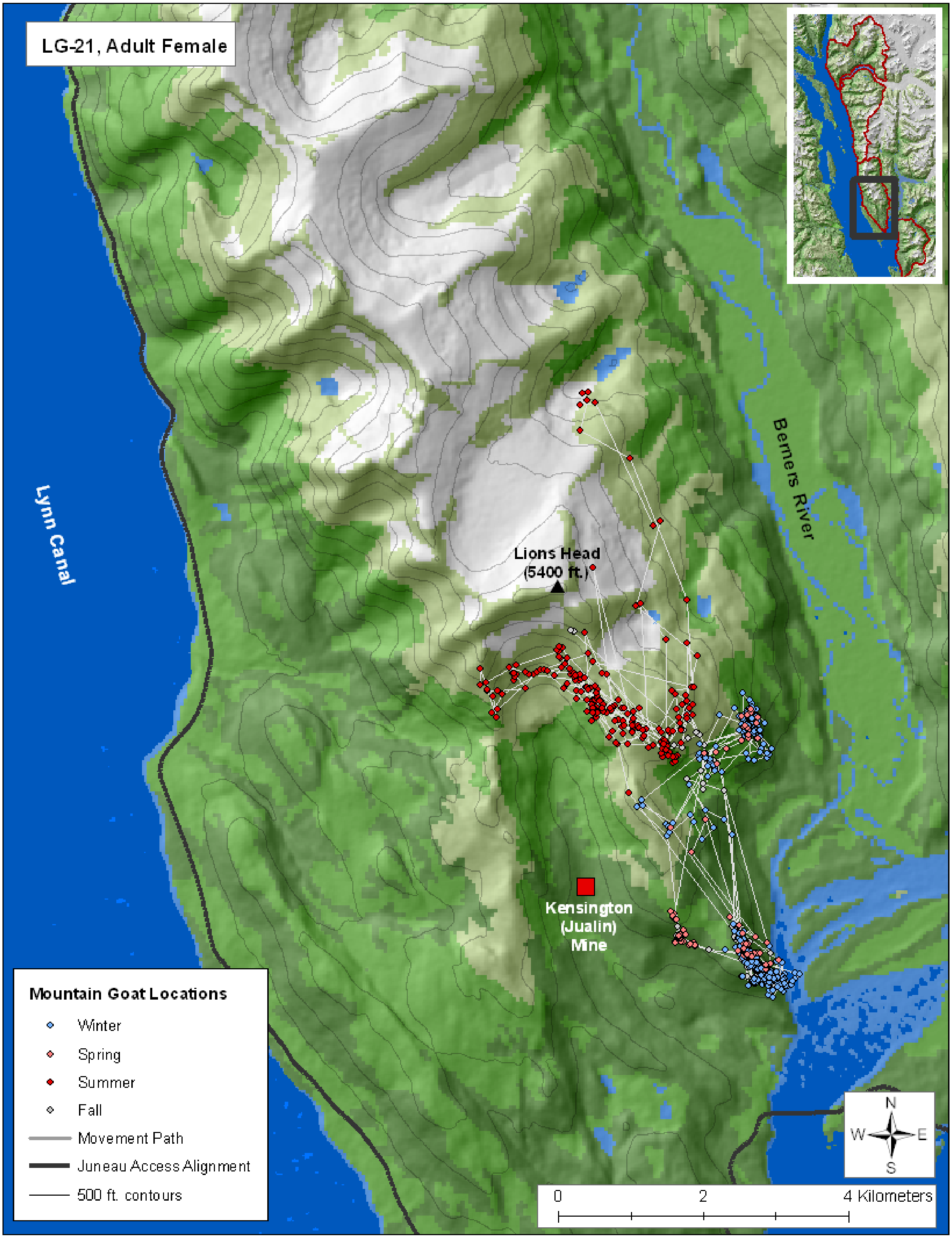

LG-18, Adult Male
Mt. Villard
(4990 ft.)
Katzehin River
Lynn Canal
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours
N
W
E
S
0
1.5
3 Kilometers



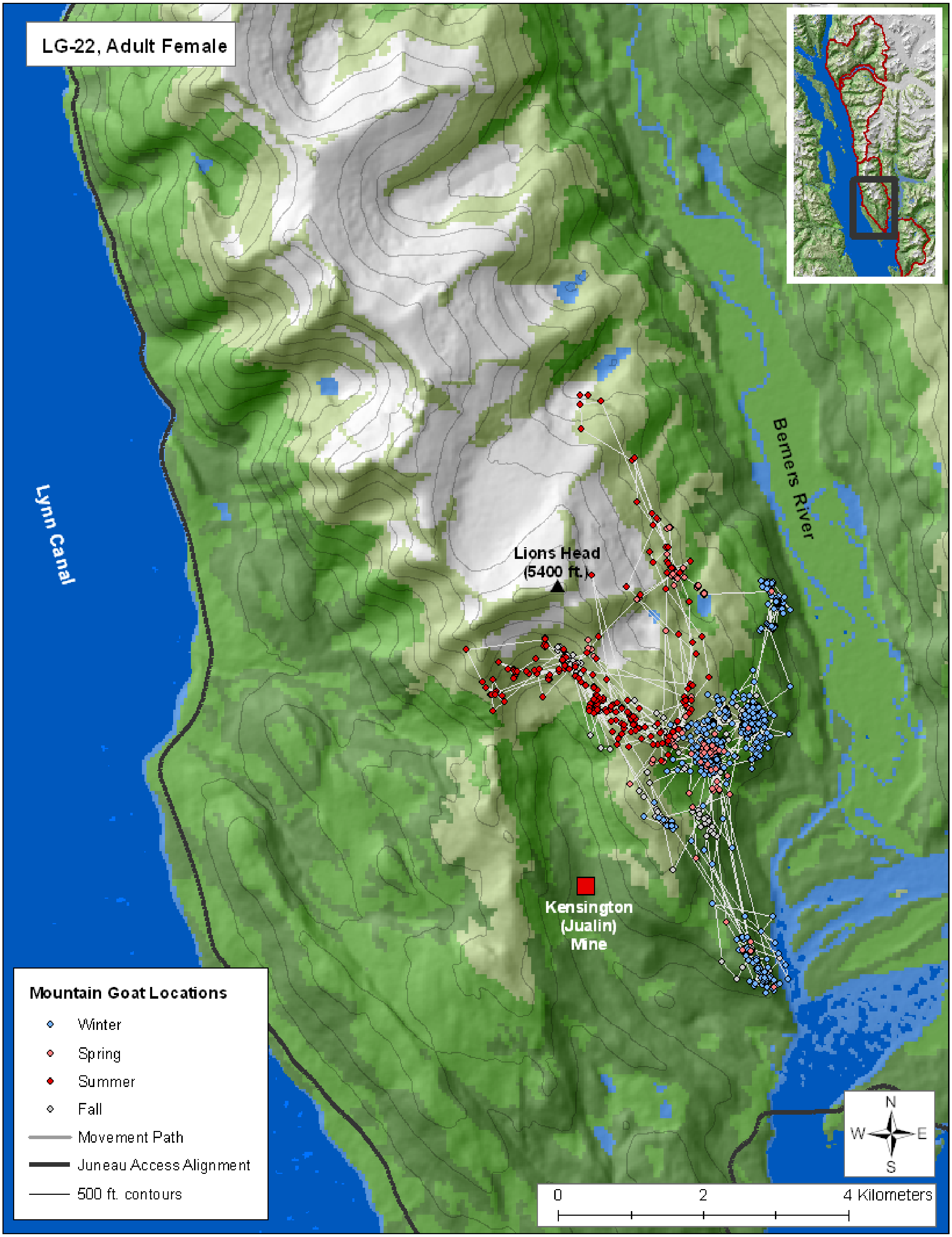
LG-19, Adult Male
Lynn Canal
Berners River
Lions Head
(5400 ft.)
Kensington
(Jualin)
Mine
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours
N
W
E
S
0
2
4 Kilometers

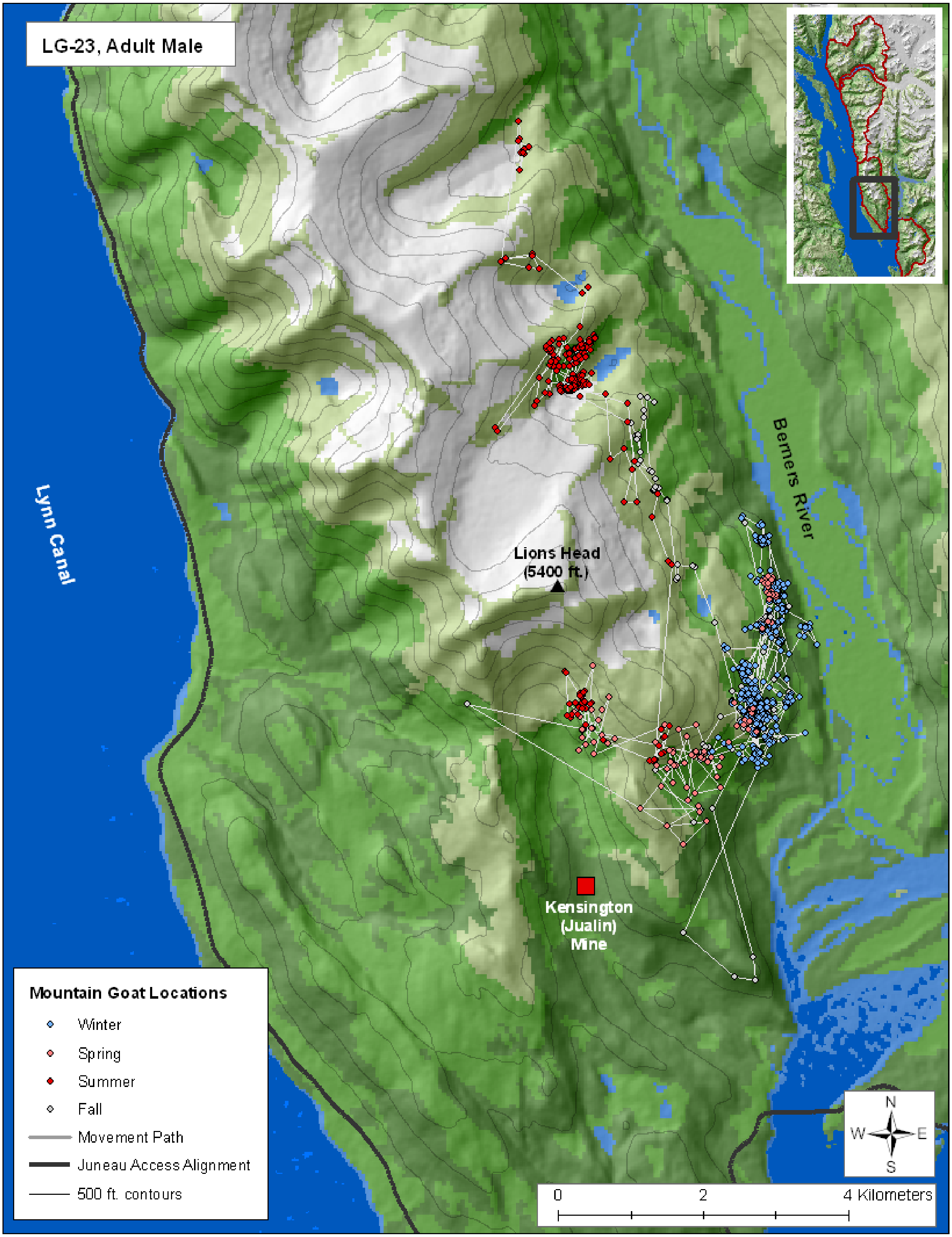


LG-20, Adult Male
Lynn Canal
Berners River
Lions Head
(5400 ft.)
Kensington
(Jualin)
Mine
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours
0
2
4 Kilometers
N
W
E
S



LG-21, Adult Female
Lynn Canal
Berners River
Lions Head
(5400 ft.)
Kensington
(Jualin)
Mine
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours
N
W
E
S
0
2
4 Kilometers


LG-22, Adult Female
Lynn Canal
Berners River
Lions Head
(5400 ft.)
Kensington
(Jualin)
Mine
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours
N
W
E
S
0
2
4 Kilometers



LG-23, Adult Male
Lynn Canal
Berners River
Lions Head
(5400 ft.)
Kensington
(Jualin)
Mine
Mountain Goat Locations
Winter
Spring
Summer
Fall
Movement Path
Juneau Access Alignment
500 ft. contours
N
W
E
S
0
2
4 Kilometers