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Mountain Goat Movement Patterns and Population Monitoring in the Haines-Skagway Area

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Alaska Department of Fish and Game Division of Wildlife Conservation

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Cover Photo: Photograph taken with a remote camera of two adult females and two kids on Takshanuk ridge, AK. The photograph was taken on March 20, 2013 during late-winter.

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INTRODUCTION

The effects of summer and winter commercial helicopter tourism on mountain goat populations is an issue of conservation concern (Hurley 2004). Mountain goats are sensitive to helicopter overflights and such activities have well documented effects on mountain goat behavior (Cote 1996, Hurley 2004, Goldstein et al. 2005). Disturbance caused by industrial activities is ecologically comparable to predation-risk (Frid 2002) and outcomes of disturbance may not only alter behavior but also habitat selection, reproduction and survival; though the latter topics have not been definitively investigated in scientific studies.

The Haines-Skagway area has experienced substantial growth in commercial helicopter tourism activities in the last 20 years. Helicopter tourism in summer is largely based out of Skagway while winter helicopter recreation has grown over the past decade in Haines. Management and the apparent impacts of these helicopter activities differ in character. During summer (May 15-Sept 25), helicopter tours originating in Skagway travel along pre-defined routes and land at one of 7 pre-approved landing sites (Figure 1). During winter (Feb 1-April 30), helicopter skiing operations originate out of, at least, 3 different locations in the Chilkat valley and travel to several different landing sites and ski across a broad area of designated terrain (Figure 1). Summer helicopter activities are permitted by the Bureau of Land Management (BLM), while winter helicopter landings are permitted by the BLM and the Haines Borough.

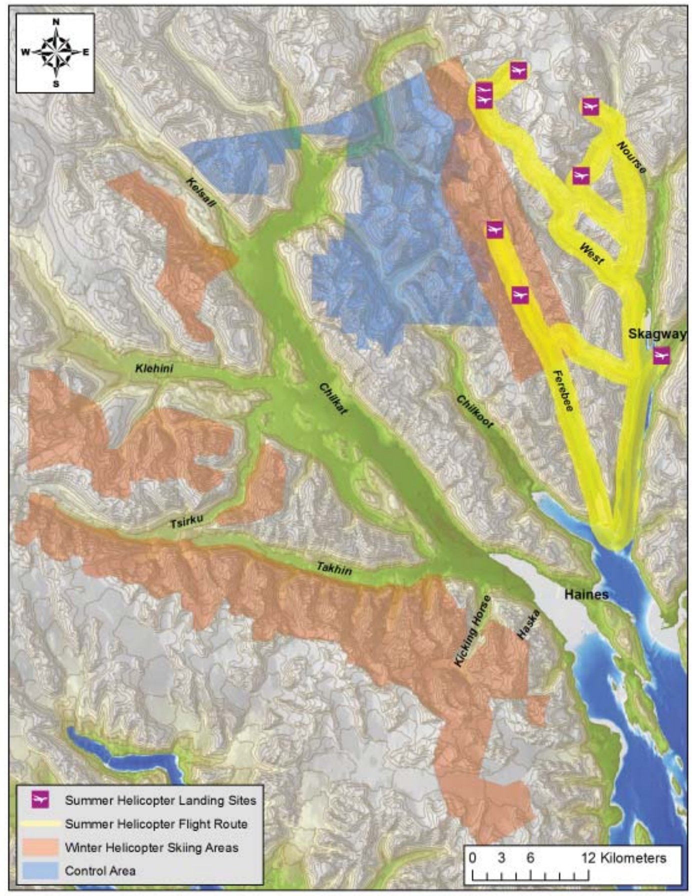

Figure 1: Map of the Haines-Skagway study area. Summer and winter commercial helicopter use areas are described.

Figure 2: Photograph of the Tsirku River and Takhin Ridge depicting the landscape character and conditions observed during an aerial survey in September 2013.

The impact of helicopter tourism activities on local mountain goat populations is not understood but may include alteration of behavior, movement patterns and, ultimately, reproduction and survival (Hurley 2004). During summer, disturbance of adult females and neonates during the kidding season is considered an important conservation concern. During winter, disturbance of mountain goats is likely to have negative effects on animals that are nutritionally stressed at the end of the long northern winter period. Consequently, disturbance during both seasons, while different in character, has the potential to negatively alter local populations if not regulated appropriately.

In response to the above concerns, the Alaska Department of Fish and Game (ADFG) and the BLM have initiated cooperative mountain goat population monitoring activities intended to identify key summer and winter habitats, estimate reproductive and survival rates, and monitor population composition and abundance. Research activities include collection of movement and vital rate data on a sample of radio-marked mountain goats in addition to implementation of annual aerial population abundance and productivity surveys. These efforts are aimed at providing ADFG, BLM and local stakeholder groups with information necessary to appropriately manage and conserve mountain goats in the vicinity of helicopter tourism areas. The three primary objectives of the proposed research project include:

Objectives:

1) Characterize habitat selection patterns of mountain goats and helicopter tourism;

2) Assess reproductive success and survival of mountain goats; and

3) Estimate and monitor mountain goat population abundance and composition.

STUDY AREA

Field research activities were concentrated in ca. 1100 km^2 area located in the vicinity of the communities of Haines and Skagway, Alaska (Figure 1). The configuration of the study area is intended to enable collection of field data across an array of locally distinctive habitat complexes inhabited by mountain goats (Figure 2) and within areas where helicopter tourism activities do and do not occur (Figure 1). In addition, since mountain goats are capable of making routine annual movements of 10-15 km (and dispersal movements exceeding 35 km) it was considered necessary to delineate a study area large enough to encompass the area used by mountain goats potentially affected by tourism activities.

METHODS

Mountain Goat Capture

Mountain goats were captured using standard helicopter darting techniques and immobilized by injecting 2.4 - 3.0 mg of carfentanil citrate, depending on sex and time of year (Taylor 2000, White and Barten 2010), 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 (Figure 3). Following handling procedures, the effects of the immobilizing agent was reversed with 100 mg 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, TGW-4500 or TGW-4590 GPS radio-collars (Telonics, Inc., Mesa, AZ) were deployed on all captured animals (Figure 3). In addition, lightweight Telonics MOD-400 VHF radio-collars were also simultaneously deployed on each animal to enable longer-term monitoring opportunities (collar lifespan: ~6 years, May 2016). GPS radio-collars were programmed to collect location data at 6-hour intervals (collar lifetime: 3-4 years for TGW-3590/TGW-4590 and TGW-4500, respectively). 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. For Telonics TGW-3590/TGW-4590

Figure 3: ADFG wildlife biologist, Chad Rice, handling an 7 year old male mountain goat (KG-43; 326 lbs) in the Upper Chilkat River watershed, Takshanuk Ridge, August 2013.

collars (n = 27), GPS location data-sets were remotely downloaded (via fixed-wing aircraft) 3-4 times per year (pre-programmed download "windows" occur twice every 8 weeks). Telonics TGW-4500 radio-collars store all GPS data "on-board" and will not be downloaded until collars automatically release on 6/15/2014 and annually thereafter (depending on deployment date). Location data will be 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).

Climate and Snow Monitoring

To characterize general climate conditions in the Haines-Skagway area, data were acquired from the National Weather Service, which currently maintains weather stations in four local areas of interest. Also, in order to characterize spatial variation in snow depth, snow monitoring devices were deployed in the Chilkat valley at one location during November 2010 and 5 locations during October 2011. Low-cost snow depth monitoring devices were constructed using commercially available components. Specifically, ibutton temperature sensors were vertically attached to 6 ft. tall PVC conduit at 12 in. intervals. Each sensor was deployed at a standard elevation (1100-1500 ft) in an area free of canopy cover along a spatial gradient between the coast and the Canadian border. The sensor data will be manually downloaded at 2 year intervals (the first download will occur in summer 2013). Data will be interpreted based on the expectation that temperature sensors under the snow pack will exhibit less daily variation than those above the snow pack and thereby enable determination of the snow depth based on the incremental configuration of sensors on the snow pole. In order to validate our data analysis approach, we also deployed an ibutton snow depth sensor at the Eaglecrest Ski Area (Juneau, AK), a location where independent daily measurements of snow depth are recorded manually throughout the year.

Ultimately, data are expected to provide a metric of snow depth profiles at specific sites and enable understanding of how snow depth varies spatially across a coastal-interior climate gradient and also between years at specific localities.

Movement Patterns and Habitat Use

In order to gather a basic understanding of mountain goat wintering strategies, preliminary analyses of elevational distribution patterns, activity and movement patterns were conducted using of a sub-set of GPS radio-marked mountain goats. Specifically, mean daily elevation was calculated for each animal for which data was available and examined to ascertain the range of elevations used by given animals during the winter period. Otherwise, complete analyses of GPS location data to characterize movement patterns and habitat use of mountain goats will not be conducted until data have been downloaded for GPS collars (i.e., 2014).

Reproduction and Survival

Kidding rates and subsequent survival was estimated by monitoring radio-marked females during surveys using fixed-wing aircraft (Piper PA-18 Super Cub) equipped for radio-telemetry tracking. During surveys, radio-collared adult female mountain goats were observed 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. 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 evaluating activity sensor data embedded in GPS location data and/or by detecting radio-frequency pulse rate changes during routine monitoring surveys. In cases where mortalities were detected, efforts were made to investigate sites as soon as possible via ground, helicopter or boat. To the extent possible, all mortalities were thoroughly investigated to ascertain the cause of death and relevant biological samples collected. Annual survival of radio-collared animals was estimated using the Kaplan-Meier methodology (Pollock et al. 1989). This procedure allows for staggered entry and exit of newly captured or deceased animals, respectively.

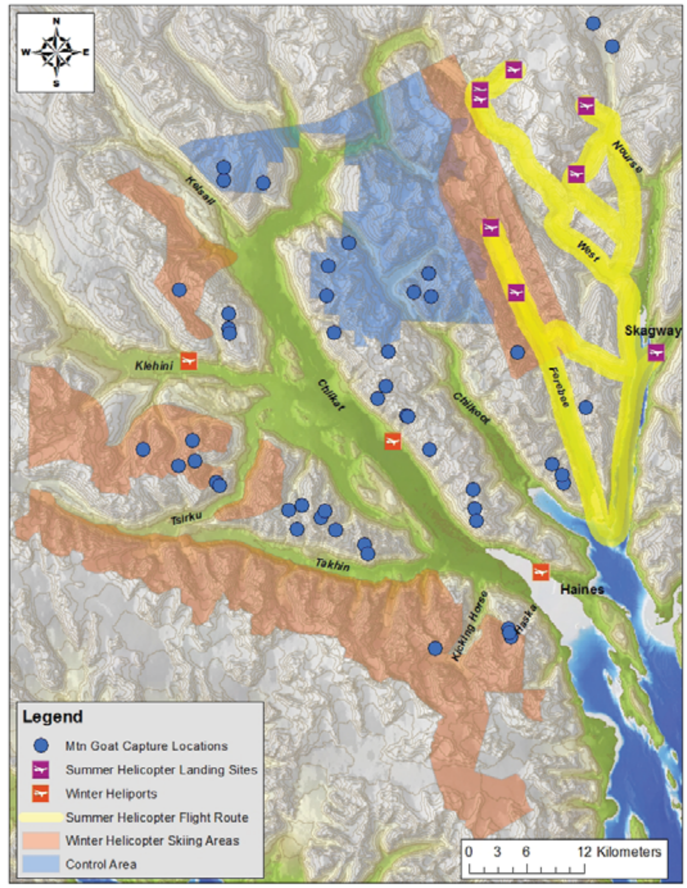

Figure 4: Location of mountain goat capture sites in the Haines-Skagway area, August-September 2010-2013. Key geographic localities and helicopter management zones are also identified.

Population Abundance and Composition Estimation

Aerial Surveys.—Population abundance and composition surveys were conducted using fixed-wing aircraft. 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, and 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 GPS-collared animals were present. Flight conditions, terrain complexity and animal behavior often complicated efforts to determine whether observed mountain goats were collared. As a result, the number of adults for which collar presence could be ascertained with a high degree of confidence was also recorded for each group observed. Further, for each collared animal seen or not seen during surveys, ancillary data were collected to characterize behavioral and habitat conditions expected, a priori, to influence sighting probabilities.

Preliminary estimates of mountain goat population size were calculated using standard Lincoln-Peterson mark-resight methods. In the future, estimates will be revised using more complex models (see White and Pendleton 2012). The entire study area was subdivided into geographically discrete survey areas (Appendix 1) in order to gain insight into patterns of spatial variability.

Results and Discussion:

Mountain Goat Capture and Handling

Capture Activities.—Mountain goats were captured during nine days in August-October 2010-2013. Overall, 48 animals (17 females and 31 males) were captured and deployed with GPS radio collars using standard helicopter darting methods (Appendix 2). Each animal was deployed with a Telonics TGW-3590 (n = 21), TGW-4500 (n = 13) or TGW-4590 (n = 14) GPS radio-collar and a lightweight Telonics MOD-400 VHF radio-collar (370g; Figure 5). Double-collaring animals was conducted to extend to period of time individual animals could be monitored (lifespan, GPS: 3-4 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 had to be captured. Overall, the combined weight of radio-collars attached to animals comprises 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.

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 was limited. As a result of these constraints, opportunities to capture mountain goats were fairly limited. While we were able to meet our sample size objectives during 2010-2012, the distribution of collar deployments was less uniform than desired with a majority of collar deployments being concentrated on the western side of the study area. This occurred because the density of animals in the Skagway area was less than expected and offered extremely limited capture opportunities, particularly in the West Creek-Nourse River areas.

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

Figure 5: Photo of an adult male mountain goat (KG-41) deployed with a TGW-4590 and MOD-410 radio collar on northern Takshanuk Ridge, August 2013.

disease screening and trace mineral analyses or archived at ADFG facilities in Douglas, AK.

Disease Testing.—Blood serum samples collected from captured animals were also tested for a suite of 15 different diseases relevant to ungulates (Appendix 3). Of particular interest was contagious ecthyma (CE), a viral disease previously documented among mountain goats in Juneau, Haines and other areas of southeastern 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 26 animals successfully tested for CE, three animals tested positive for CE-specific antibodies; a comparable prevalence relative to other southeastern Alaska populations tested in 2005-2012 (Appendix 3). Otherwise, antibody prevalence of the remaining diseases tested for was virtually absent and indicates a general lack of disease exposure among Haines-Skagway area mountain goats; yet, it is important to recognize that such conditions likewise suggest a high level of vulnerability should such diseases become prevalent in the future (i.e., due to a lack of a previous immune response). The general lack of positive antibody responses for the suite of diseases examined was also typical of the other southeastern Alaska populations tested.

Trace Mineral Testing.—In 2010-2012, whole blood and serum samples were analyzed to determine trace mineral concentration of 38 mountain goats in order to examine whether mineral deficiencies were prevalent in our study population (Appendix 4a). Unfortunately, baseline mineral concentration values for healthy mountain goats are limited and constrain our ability to compare observed values in our study population to established standards. Nonetheless, Selenium (Se) and Copper (Cu) deficiencies have been studied in northern ungulates (Fielder 1986, O'Hara et al. 2001) and the mountain goats sampled did not appear to have concentrations below reported deficiency thresholds for both of these minerals (i.e., Se > 0.05, Cu >0.8). In comparison to other southeastern Alaska populations, mountain goats in the Haines-Skagway area appear to have comparable values for the minerals tested, suggesting that equivalent levels of mineral resources were available for animals in the Haines-Skagway population, relative to elsewhere. However, some evidence of local variation in Selenium concentration was evident in our study area (Appendix 4b).

Genetic Analyses.—Tissue samples from all mountain goats captured (and a majority of animals harvested via ADFG registration hunts) have been sent to Aaron Shafer (University of Alberta) for inclusion in a broad-scale mountain goat population genetics analysis. Previous results from Shafer et al. (2010) indicate that substantial genetic structuring exists among mountain goats in southeastern Alaska; however, broad-scale analyses suggest that animals within the Haines-Skagway study area are likely from the same genetic sub-population. In the future, additional analyses involving larger samples sizes may provide the opportunity to examine whether further structuring is evident within the study area.

Climate and Snow Monitoring

In order to validate the accuracy and precision of ibutton-based snow depth measuring devices, we collected field data at the Eaglecrest Ski Area; a site where daily snow depth measurements are collected manually by a trained NWS observer. The "raw" ibutton temperature data were analyzed to assign snow depth based on daily variation in temperature for ibuttons positioned at different heights. For example, if daily temperature readings did not deviate from zero, we assumed a given ibutton was buried by snow. We then adjusted predicted ibutton snow depths to account for temperature penetration into the snow pack (i.e. y-intercept of the regression between actual and predicted snow depth). The predicted daily snow depth measurements were then smoothed using a 5-day moving average algorithm. The resulting relationship between actual and predicted snow depth we strongly correlated (Figure 6) and indicated that the technique is capable of providing reasonably accurate estimates of daily snow depth and the seasonal snow depth profile (Figure 7).

In addition, five snow depth monitoring devices were collected from field sites in the Chilkat Valley in August-October 2013. The devices we originally deployed in 2011 and collected data over the course of two winter seasons. These data will be analyzed in 2014 in order to characterize local-scale geographic differences in snow depth in the Chilkat Valley.

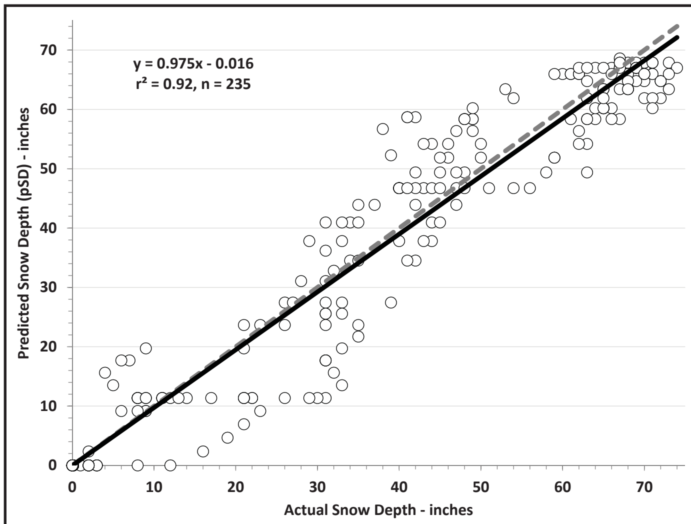

Figure 6: Relationship between actual and predicted daily snow depth during 2012-2013 at the Eaglecrest Ski Area, Juneau, AK. Predicted snow depth was derived using ibutton snow depth measuring technique.

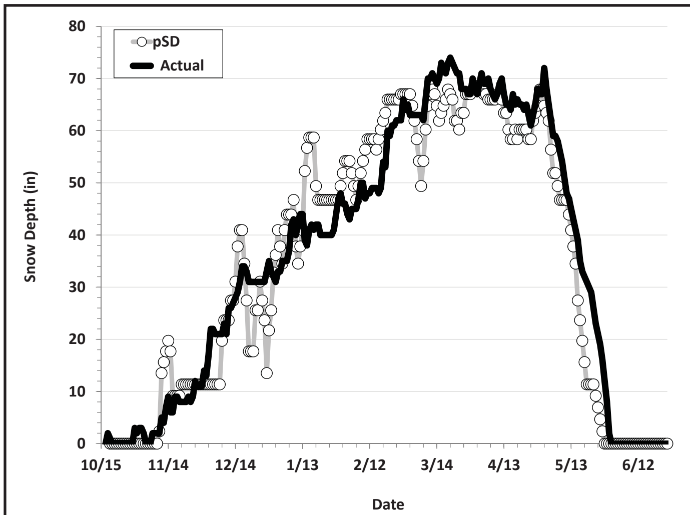

Figure 7: Relationship between actual and predicted daily snow depth during 2012-2013 at the Eaglecrest Ski Area, Juneau, AK. Predicted snow depth was derived using ibutton snow depth measuring technique.

Movement Patterns

GPS location data—We downloaded GPS location data from 37 mountain goats between August 2010-November 2012. Most data was derived from a sub-set of animals that were deployed with remotely downloadable collars. Thus, the existing data does not incorporate location data from all animals captured.

Activity and movement patterns—Preliminary analyses concerning seasonal patterns of mountain goat movement, activity, altitudinal distribution and overwintering strategies were previously described (White et al. 2011). Briefly, GPS-marked mountain goats in the Haines-Skagway area exhibited decreased movement and activity rates during

Table 1: Proportion of radio-marked adult female mountain goats seen with a kid at heel in the Haines-Skagway study area and, for comparison, the Baranof Island and Lynn Canal areas, 2005-2013.

Area	Year	Kids	AdF	Prop	SE
Baranof					
	2010	4	4	1.00	0.00
	2011	5	6	0.83	0.15
	2012	3	5	0.60	0.22
	2013	5	10	0.50	0.16
	Total	17	25	0.68	0.09
Haines-Skagway					
	2010	5	10	0.50	0.16
	2011	8	10	0.80	0.13
	2012	8	11	0.73	0.13
	2013	10	12	0.83	0.11
	Total	31	43	0.72	0.07
Lynn Canal					
	2005	8	12	0.67	0.14
	2006	16	25	0.64	0.10
	2007	20	32	0.63	0.09
	2008	19	33	0.58	0.09
	2009	15	25	0.60	0.10
	2010	18	26	0.69	0.09
	2011	18	27	0.67	0.09
	2012	9	15	0.60	0.13
	2013	8	12	0.67	0.14
	Total	131	207	0.63	0.03

winter relative to summer. However, altitudinal distribution varied not only seasonally but also geographically such that animals nearer the coast tended to winter in lower elevation habitats than animals further inland; presumably in response to local variation in climate (White et al. 2011). Overall, complete analyses of mountain goat spatial use patterns and resource selection will not be conducted until GPS data collection efforts are complete.

Reproduction and Survival

Reproduction—In order to estimate reproductive productivity, we monitored radio-marked adult females to determine whether they had kids at heel. In 2010, our estimates were based on surveys beginning in August and thus likely represent an underestimate of kid production. However, in 2011-2013, surveys were conducted during the parturition period and are expected to closely approximate actual parturition rates. We determined that 72% of marked females had kids at heel during 2010-2012 (Table 1). This preliminary baseline estimate appears to be higher than the longer-term estimates calculated for the nearby Lynn Canal study area (Table 1).

Survival—We estimated survival of 40 mountain goats monitored between August 2010-May 2012 (Table 2). Our estimates did not include fates of animals during June-July 2010 (prior to initial captures) and thus do not span an entire biological year. Nonetheless, since mortality rates are typically low during these months (White et al. 2011) our estimates for 2010 are expected to be similar to actual annual survival. Overall, we determined that 83±4% of animals survived annually during 2010-2013; overall estimates for male and female survival were not statistically different (Table 3). When considering mountain goat survival irrespective of sex, our data suggest that overall survival was higher in 2011 and 2012 than in 2010, however sample sizes are small and results should be interpreted with caution.

All mortalities occurred during winter (Dec-April). Eight of the 13 animals that died were found in avalanche debris, while the remainder died of unknown causes. While avalanche-related mortality is not an uncommon cause of death for mountain goats, the proportion of animals that have died via avalanche during the winter of 2010-2013 is uncharacteristically high, relative to findings from companion studies in Lynn Canal (2005-2013; White et al. 2012) and Baranof Island (2010-2013; White et al. 2012). Overall, estimated survival in the Haines-Skagway area was relatively low, overall, but higher than the declining population in the Lynn Canal study area (White et al. 2012). Nonetheless, it is important to recognize that our sample size for the Haines-Skagway area is small for the purposes of estimating survival, and chance events (such as avalanches) may result in our estimates not being representative of the local populations as a whole. Additional monitoring of an increased sample of marked mountain goats over multiple years will increase our ability to accurately characterize baseline survival rates for this population.

Population Abundance and Composition Estimation

Aerial surveys were conducted in 12 distinct survey areas during 3 days in September 2010 (n = 7 areas), 4 days in September 2011 (n = 10 areas), 3 days in September/October 2012 (n = 9 areas) and 4 days in September 2013 (n = 9 areas; Appendix 5). During each survey, mark-resight protocols were followed in order to estimate sighting probability and population size. In general, sighting probabilities observed during aerial surveys in the Haines-Skagway area tended to be similar to sighting probabilities estimated

Table 2: Mountain goat survival estimates, and associated winter climate data, for radio-marked mountain goats in the Haines-Skagway study area and, for comparison, Baranof Island, Cleveland Peninsula, and Lynn Canal areas. Sample sizes in the Baranof Island, Cleveland Peninsula and Haines-Skagway area are small and estimates should be interpreted with caution.

	Males				Females				Total			
	At Risk	Died	Ŝ	SE	At Risk	Died	Ŝ	SE	At Risk	Died	Ŝ	SE
Baranof Island												
2010/2011	6.0	1	0.88	0.11	3.0	0	1.00	0.00	9.0	1	0.92	0.08
2011/2012	10.8	0	1.00	0.00	5.5	0	1.00	0.00	16.3	0	1.00	0.00
2012/2013	15.0	3	0.82	0.09	6.0	0	1.00	0.00	21.0	3	0.87	0.07
All years	31.8	4	0.89	0.05	14.5	0	1.00	0.00	46.3	4	0.92	0.04
Cleveland Pen.												
2009/2010	5.0	0	1.00	0.00	2.0	0	1.00	0.00	7.0	0	1.00	0.00
2010/2011	5.8	2	0.67	0.16	5.0	0	1.00	0.00	10.8	2	0.83	0.10
2011/2012	4.0	2	0.50	0.18	6.0	0	1.00	0.00	10.0	2	0.80	0.11
2012/2013	1.6	1	0.50	0.35	6.0	0	1.00	0.00	7.6	1	0.88	0.12
All years	15.1	5	0.71	0.10	18.5	0	1.00	0.00	33.6	5	0.86	0.05
Haines-Skagway												
2010/2011	11.6	4	0.69	0.13	9.2	3	0.70	0.14	20.8	7	0.70	0.10
2011/2012	13.2	2	0.87	0.09	9.0	1	0.90	0.09	22.2	3	0.88	0.06
2012/2013	16.3	2	0.89	0.07	10.3	1	0.91	0.08	26.6	3	0.90	0.06
All years	39.1	8	0.83	0.06	27.0	5	0.84	0.06	66.1	13	0.83	0.04
Lynn Canal												
2005/2006	9.6	2	0.79	0.13	10.0	1	0.90	0.09	19.6	3	0.85	0.08
2006/2007	25.4	11	0.57	0.10	22.1	4	0.82	0.08	47.5	15	0.68	0.07
2007/2008	26.5	6	0.79	0.07	20.8	3	0.88	0.07	47.3	9	0.83	0.05
2008/2009	24.2	10	0.66	0.09	21.4	6	0.73	0.09	45.6	16	0.69	0.06
2009/2010	25.1	4	0.86	0.07	22.3	4	0.85	0.07	47.4	8	0.85	0.05
2010/2011	24.3	3	0.88	0.06	23.2	2	0.91	0.06	47.5	5	0.90	0.04
2011/2012	17.9	6	0.72	0.10	15.3	3	0.85	0.08	33.2	9	0.77	0.07
2012/2013	16.8	8	0.59	0.10	13.6	7	0.60	0.11	30.4	15	0.59	0.07
All years	167.5	51	0.73	0.03	146.1	31	0.81	0.03	313.6	82	0.77	0.02

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

Table 3: Summary of sighting probabilities detected during mountain goat aerial surveys conducted in 4 seperate study areas during 2010-2013 in southeastern Alaska.

Area	Seen	Total	Prop. seen	SE
Baranof				
2010	--	--	--	--
2011	12	18	0.67	0.11
2012	11	21	0.52	0.11
2013	16	22	0.73	0.09
Total	39	61	0.64	0.06
Cleveland Pen				
2010	--	--	--	--
2011	--	--	--	--
2012	3	16	0.19	0.10
2013	10	21	0.48	0.11
Total	13	37	0.35	0.08
Haines-Skagway				
2010	14	20	0.70	0.10
2011	20	32	0.63	0.09
2012	8	18	0.44	0.12
2013	24	31	0.77	0.08
Total	66	101	0.65	0.05
Lynn Canal				
2010	39	73	0.53	0.06
2011	19	28	0.68	0.09
2012	21	32	0.66	0.08
2013	13	22	0.59	0.10
Total	92	155	0.59	0.04
Overall total	210	354	0.59	0.03

during simultaneous studies conducted in Lynn Canal and Baranof Island (Table 3). Overall, we estimated that, on average, 65% of mountain goats were seen during surveys in the Haines-Skagway area in 2010-2013. However, sighting probabilities in 2012 were lower than other years. This was likely due to a survey conducted on October 1, 2012 when sighting conditions were poor due to fresh snowfall above 3500-4500 ft. The marginal conditions on this one survey lowered the overall average for 2012; sighting probabilities observed during the other days were comparable to previous surveys and years. Ultimately, variation in survey conditions will be accounted for using survey-specific sighting probabilities and covariate information in a statistical modeling framework to derive actual population estimates (sensu White and Pendleton 2013).

Preliminary analysis of environmental factors influencing the sighting probability of individual mountain goats during aerial surveys were summarized in White and Pendleton (2013).

Examination of preliminary population composition data (i.e., % kids in the surveyed population) indicate that most survey areas have moderate-high levels of kid productivity (i.e., 13-25% kids), relative to other areas surveyed in southeastern Alaska. However, the area between the Ferebee and Nourse glaciers (Halutu, Yeatman and Nourse-West survey areas) were characterized by very low proportions of kids (Appendix 5). During 2011, only 4.1% of the 96 animals seen were classified as kids. In 2012, the proportion of kids was higher (16.6%) but the number of animals seen was less (n = 50 total animals) and the number of kids was only slightly more (n = 10 kids). It is currently unclear whether such findings are representative of longer-term patterns for this area. Continued monitoring of this area, in addition to compilation and analyses of historical survey data, will be important for determining whether this area is typically characterized by low productivity.

Future Work/Recommendations:

Radio-marked mountain goats will continue to be monitored to determine survival and reproductive status during regularly scheduled aerial surveys. In the event radio-marked animals die, mortalities will be investigated as soon a practicable. In addition, for the subset of animals marked with TGW-3590/4590 collars, GPS location data will be downloaded during aerial surveys at 2-4 month intervals; acquired data will be integrated into the existing GPS location database. Funding permitting, during August/September 2014, 6 additional GPS radio-collars will be deployed via helicopter capture methods. Annual fall aerial population estimation and composition surveys will be conducted in September/October 2014. An annual project progress report will be prepared and submitted by December 31, 2014.

Longer-term goals of the project (i.e., to be accomplished once GPS radio-collar deployments are completed) will involve using GPS location data from radio-marked mountain goats combined with remote sensing GIS data layers to develop resource selection function (RSF) models for the summer and winter periods. Such models will represent data-based tools for predicting areas most important for mountain goats across the study area. Ultimately, mountain goat RSF models can be integrated with spatially explicit helicopter tourism activity information to quantitatively examine if or where areas of conservation concern occur (see Figure 1 in White et al. 2011). The best mechanism for accurately characterizing helicopter activity involves standardized collection of GPS locations during helicopter flights (i.e., via handheld GPS units) to develop remote-sensing models comparable to mountain goat RSF models. The Haines Borough has recently implemented a program focused on gathering GPS location data from helicopter skiing operators. Continued collection of such data will play a critical role in the ability to implement an objective, data-based framework for examining putative conservation concerns related to helicopter tourism and local mountain goat populations. However, the availability of such data for analytical purposes is uncertain and data sharing commitments have changed since the inception of the study. In the event such data are made available, the completion of this project objective will be possible and represent the single-most important product of research activities thereby providing resource managers and stakeholders with a much needed tool for making defensible and appropriate policy decisions.

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Project Publications:

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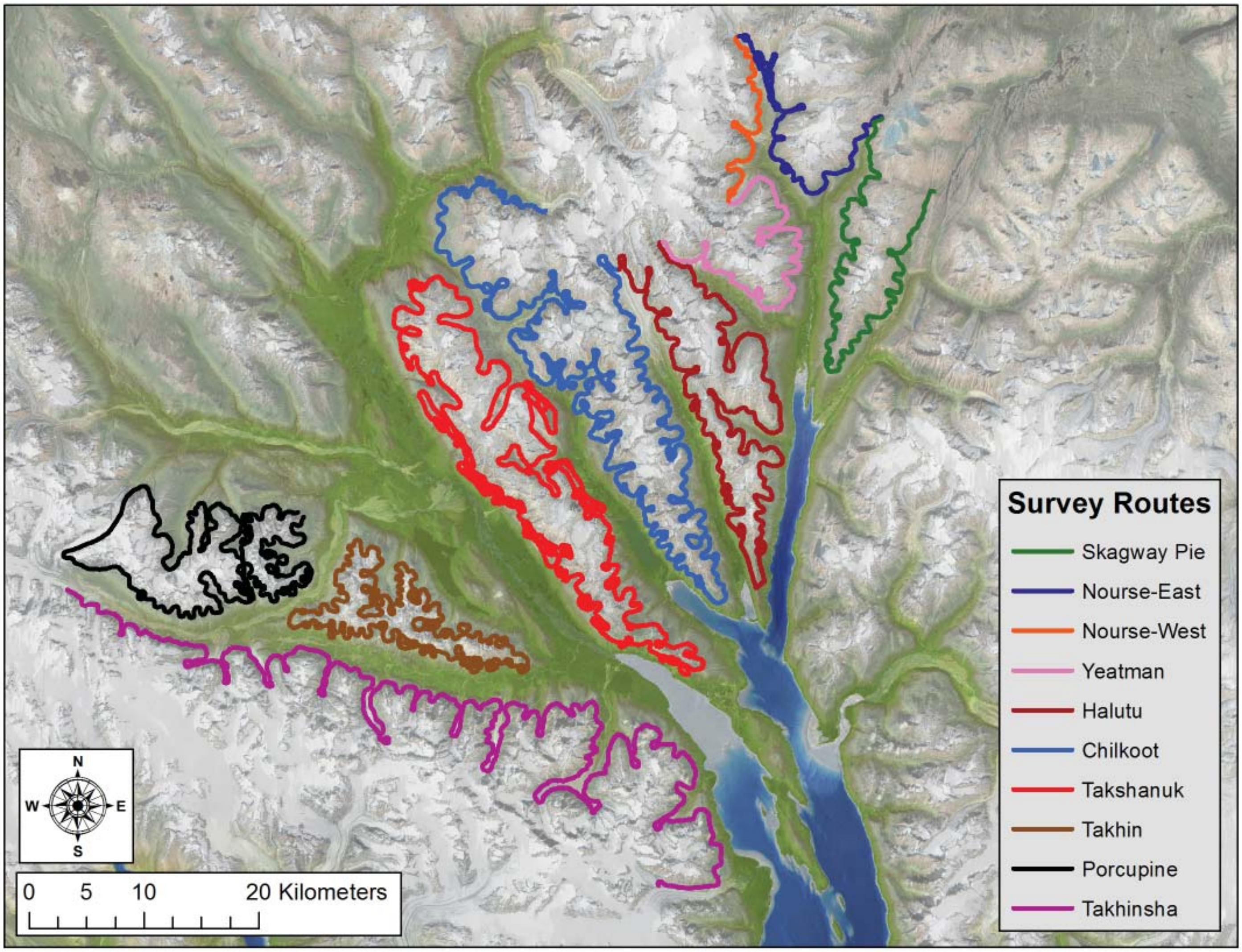
Appendix 1. Map depicting mountain goat aerial survey routes in the Haines-Skagway study area, 2010-2013; survey results are reported in Appendix 5.



Appendix 2. Characteristics of mountain goats (n = 48) captured and deployed with GPS radio-collars in the Haines-Skagway area, 2010-2013. "Status" denotes fate as of December 6, 2013.

as of 12/6/13

ID	Capture Date	Area	Sex	Age	Kid	Mass (lbs.)	Horn Length (in.)[1]	Horn Circ. (in.)[1]	Status
KG001	8/4/10	Takshanuk	F	8	1	184	9 9/16	4 3/16	Alive
KG002	8/4/10	Takshanuk	M	6	--	385	9 14/16	5 7/16	Died
KG003	8/4/10	Takshanuk	F	6	0	211	9 13/16	4 6/16	Alive
KG004	8/4/10	Takshanuk	M	5	--	284	9 11/16	5 14/16	Alive
KG005	8/4/10	Takshanuk	F	13	1	187	9 10/16	4 4/16*	Died
KG006	8/4/10	Takshanuk	F	14	0	147	8 15/16	3 12/16	Died
KG007	8/4/10	Four Winds	F	6	1	135	8 5/16	4 1/16	Alive
KG008	8/4/10	Takhin	M	5	--	345	8 5/16*	5 12/16	Alive
KG009	8/13/10	Ferebee	M	11	--	305	8 1/16*	5 2/16	Died
KG010	8/13/10	Ferebee	M	5	--	283	8 11/16	5 9/16	Alive
KG011	8/13/10	Nourse	M	6	--	255	9 10/16	5 8/16	Alive
KG012	8/13/10	Nourse	M	12	--	289	8 9/16	5 8/16	Alive
KG013	8/13/10	Ferebee	M	9	--	289	9 7/16	5 10/16	Died
KG014	8/13/10	Chilkoot	M	11	--	306	9 14/16	5 6/16	Died
KG015	8/13/10	Chilkoot	F	6	0	204	8 6/16	4 4/16	Alive
KG016	8/13/10	Chilkoot	F	6	1	180	8 4/16	4 4/16	Alive
KG017	8/14/10	Takhin	M	7	--	370	9 14/16	5 9/16	Alive
KG018	8/14/10	Takhin	M	6	--	325	8 8/16	5 14/16	Died
KG019	8/14/10	Takhin	M	4	--	--	--	--	Alive
KG020	8/14/10	Porcupine	M	6	--	336	8 13/16	5 4/16	Alive
KG021	8/14/10	Porcupine	F	3	0	177	8 6/16	4 9/16	Alive
KG022	8/14/10	Porcupine	F	4	0	194	9	4 10/16	Died
KG023	8/14/10	Four Winds	F	11	1	185	9 12/16	4 1/16	Died
KG024	9/8/11	Haska Ck	F	5	0	164	8 14/16	3 14/16	Alive
KG025	9/8/11	Haska Ck	M	5	--	284	8 8/16	5 5/16	Alive
KG026	9/8/11	Takhin	M	4	--	251	9	5 6/16	Alive
KG027	9/8/11	Takhin	M	6	--	357	9 2/16	5 6/16	Alive
KG028	9/8/11	Takhin	M	7	--	341	9 4/16	5 3/16	Alive
KG029	9/8/11	Takhin	F	1	0	115	5 8/16	3 12/16	Alive
KG030	9/8/11	Porcupine	M	4	--	304	9 4/16	5 12/16	Alive
KG031	10/2/11	Takshanuk	M	4	--	281	8 6/16	5 5/16	Alive
KG032	10/2/11	Porcupine	M	6	--	346	9	5 5/16	Alive
KG033	10/2/11	Porcupine	F	8	1	256	10 5/16	4 5/16	Died
KG034	8/15/12	Kicking Horse	M	6	--	263	8 14/16	5 8/16	Alive
KG035	8/15/12	Takshanuk	M	6	--	292	9 1/16	5 2/16	Died
KG036	8/15/12	Takshanuk	M	4	--	257	9 2/16	5 3/16	Alive
KG037	8/15/12	Ferebee	M	5	--	216	8 8/16	5	Alive
KG038	8/15/12	Ferebee	M	11	--	346	9 14/16	5 4/16	Died
KG039	10/10/12	Haska Ck	F	10	1	--	9 1/16	3 14/16	Alive
KG040	10/10/12	Takshanuk	F	7	1	203	9 7/16	4 4/16	Alive
KG041	8/29/13	Takshanuk	M	9	--	--	8 8/16	5 7/16	Alive
KG042	8/29/13	Takshanuk	M	6	--	312	8 6/16	5 4/16	Alive
KG043	8/29/13	Takshanuk	M	7	--	326	9 6/16	5 11/16	Alive
KG044	8/29/13	Hiteshitak	F	1	0	137	6 2/16	4	Alive
KG045	8/29/13	Hiteshitak	M	3	--	196	8 9/16	5 4/16	Alive
KG046	8/29/13	Hiteshitak	M	6	--	294	9 2/16	6	Alive
KG047	8/29/13	Four Winds	M	7	--	329	8 11/16	5 10/16	Alive
KG048	8/29/13	Four Winds	F	4	1	179	9 5/16	4 4/16	Alive

[1]Horn dimensions reflect maximum length or basal diameter for the largest horn. Asterisk denotes the horn tip was broomed.

Appendix 3. Incidence of disease prevalence of mountain goats in the Haines-Skagway study area, 2010-2011. Results are also provided for three other populations in southeastern Alaska, 2005-2012, for comparison.

	Baranof			Cleveland			Haines			Berners			Kakuhan			Villard			Total		
Disease	n	Pos.	Prop	n	Pos.	Prop	n	Pos.	Prop	n	Pos.	Prop	n	Pos.	Prop	n	Pos.	Prop	n	Pos.	Prop
Contagious Ecthyma	23	1	0.04	10	1	0.10	26	3	0.12	20	1	0.05	49	3	0.06	24	0	0.00	152	9	0.06
Chlamydia	11	1	0.09	12	1	0.08	22	0	0.00	27	2	0.07	29	1	0.03	30	0	0.00	131	5	0.04
Q Fever	19	0	0.00	11	0	0.00	32	0	0.00	29	0	0.00	50	3	0.06	32	1	0.03	173	4	0.02
Bluetongue	17	0	0.00	10	0	0.00	20	0	0.00	20	0	0.00	17	0	0.00	18	0	0.00	102	0	0.00
Bovine respiratory synctial virus (BRSV)	17	0	0.00	10	0	0.00	20	0	0.00	21	0	0.00	17	0	0.00	16	0	0.00	101	0	0.00
Infectious bovine rhinotrachetis (IBR)	17	0	0.00	10	0	0.00	20	0	0.00	21	0	0.00	17	0	0.00	17	0	0.00	102	0	0.00
Parainfluenza-3 (PI-3)	17	0	0.00	10	0	0.00	20	0	0.00	21	0	0.00	17	0	0.00	17	0	0.00	102	0	0.00
Epizootic hemorrhagic disease (EHD)	17	0	0.00	9	0	0.00	20	0	0.00	21	0	0.00	17	0	0.00	17	0	0.00	101	0	0.00
Caprinae arthritis encephalitis (CAE)	17	0	0.00	9	0	0.00	20	0	0.00	21	0	0.00	17	0	0.00	16	0	0.00	100	0	0.00
Malignant cataharral fever-ovine (MCF)	17	0	0.00	9	0	0.00	20	0	0.00	21	0	0.00	17	0	0.00	16	0	0.00	100	0	0.00
Leptospirosis cannicola	17	0	0.00	9	0	0.00	20	0	0.00	21	0	0.00	17	0	0.00	17	0	0.00	101	0	0.00
Leptospirosis grippo	17	0	0.00	9	0	0.00	20	1	0.05	21	0	0.00	17	1	0.06	17	1	0.06	101	3	0.03
Leptospirosis hardjo	17	0	0.00	9	0	0.00	20	0	0.00	21	0	0.00	17	0	0.00	17	0	0.00	101	0	0.00
Leptospirosis ictero	17	0	0.00	9	0	0.00	20	3	0.15	21	2	0.10	17	3	0.18	17	3	0.18	101	11	0.11
Leptospirosis pomona	17	0	0.00	9	0	0.00	20	0	0.00	21	0	0.00	17	0	0.00	17	0	0.00	101	0	0.00

Positive titers: PI3>1:120, IBR> 1:64, BRSV >1:32, Leptospirosis sp.>1:100

Appendix 4a. Trace mineral concentration (ppm) documented for mountain goats in the Haines-Skagway study area, 2010-2012. Results are also provided for three other populations in southeastern Alaska, 2010-2012, for comparison.

	Se			Fe			Cu			Zn			Mo			Mn		
Area	mean	SE	n	mean	SE	n	mean	SE	n	mean	SE	n	mean	SE	n	mean	SE	n
Baranof	0.32	0.01	24	1.78	0.09	24	1.08	0.03	24	0.82	0.03	24	0.05	0.00	24	0.01	0.00	24
Cleveland	0.26	0.01	5	1.71	0.09	5	0.81	0.03	5	0.70	0.04	5	0.05	0.00	5	0.01	0.00	5
Grandchild	0.27	0.08	2	2.86	0.03	2	1.07	0.05	2	0.77	0.06	2	0.05	0.00	2	0.01	0.00	2
Kakuhan	0.17	0.02	19	1.75	0.11	19	0.96	0.05	19	0.82	0.04	19	0.05	0.00	19	0.01	0.00	19
Haines	0.25	0.03	38	1.94	0.08	37	1.07	0.04	37	0.81	0.03	37	0.05	0.00	37	0.01	0.00	37
Average	0.25	0.01	88	1.86	0.05	87	1.04	0.02	87	0.81	0.02	87	0.05	0.00	87	0.01	0.00	87

Appendix 4b. Trace mineral concentration (ppm) of Selenium documented for mountain goats in the Haines-Skagway study area, 2010-2012. Results are also provided for three other populations in southeastern Alaska, 2010-2012, for comparison.

Area	mean	SE	n	Min	Max	# < 0.10	Prop < 0.10
Baranof	0.32	0.01	24	0.21	0.41	0	0.00
Cleveland	0.26	0.01	5	0.22	0.29	0	0.00
Kakuhan	0.17	0.02	19	0.05	0.33	5	0.26
Grandchild	0.27	0.08	2	0.19	0.35	0	0.00
Haines	0.25	0.03	38	0.03	0.73	8	0.21
Haska	0.04	0.01	3	0.03	0.05	3	1.00
Takshanuk	0.20	0.04	10	0.05	0.33	3	0.30
Ferebee	0.20	0.02	8	0.10	0.26	1	0.13
Takhin	0.21	0.04	7	0.08	0.33	1	0.14
Four Winds	0.23	0.05	2	0.18	0.27	0	0.00
Nourse	0.24	0.01	2	0.23	0.25	0	0.00
Porcupine	0.57	0.06	6	0.39	0.73	0	0.00
Average	0.25	0.01	88	0.03	0.73	13	0.15

Appendix 5. Summary of mountain goat aerial survey results for surveys conducted in the Haines-Skagway area, 2010-2013.

Study Area	Year	Date	Adults	Kids	Total	% Kids	Temp	Wind	Weather	Marked	Seen	Sighting Probability	Comments
Takhinsha	2010	--	--	--	--	--	--	--	--	--	--	--	
Takhinsha	2011	9/26/11	56	8	64	12.5%	27	10-15	Mostly Clear	2	1	0.50	
Takhinsha	2012	--	--	--	--	--	--	--	--	--	--	--	
Takhinsha	2013	9/28/13	72	14	86	16.3%	39-43	10-20	High Overcast	4	2	0.50	
Takhin Ridge	2010	9/10/10	94	29	123	23.6%	42-50	0-10	High Overcast	4	3	0.75	
Takhin Ridge	2011	9/12/11	54	14	64	21.9%	46	5-10	Mostly Clear	8	2	0.25	
Takhin Ridge	2011	9/26/11	92	27	119	22.7%	32	5-15	High Overcast	8	6	0.75	
Takhin Ridge	2012	10/1/12	79	22	101	21.8%	31	10-20	Mostly Clear	4	1	0.25	snow line: 3500 ft (N), 4000 ft (S)
Takhin Ridge	2013	9/25/13	89	22	111	19.8%	32-37	5-15	High Overcast	7	6	0.86	
Porcupine	2010	9/10/10	71	19	90	21.1%	43-45	0-10	High Overcast	3	1	0.33	
Porcupine	2011	9/12/11	68	31	99	31.3%	50	5	High Overcast	3	3	1.00	
Porcupine	2011	9/26/11	87	26	113	23.0%	36	10-15	High Overcast	3	1	0.33	
Porcupine	2012	10/1/12	70	23	93	24.7%	35	10-20	High Overcast	4	1	0.25	snow line: 3500 ft
Porcupine	2013	9/25/13	85	14	99	14.1%	32-37	5-15	High Overcast	3	3	1.00	
Takshanuk	2010	9/8/10	311	73	384	19.0%	50	5	High Overcast	6	5	0.83	
Takshanuk	2011	9/27/11	275	90	365	24.7%	35	0-10	High Overcast	4	3	0.75	
Takshanuk	2012	9/22/12, 10/1/12	225	50	275	18.2%				7	5	0.71	
Takshanuk-W (partial)	2012	9/22/12					49	0-15	Mostly Clear	6	5	0.83	
Takshanuk-E (partial)	2012	10/1/12					28-30	0-15	High Overcast	1	0	0.00	snow line: 4200-4500 ft
Takshanuk	2013	9/28/13	243	63	306	20.6%	39-43	10-20	High Overcast	9	7	0.78	
Four Winds	2010	--	--	--	--	--	--	--	--	--	--	--	
Four Winds	2011	--	--	--	--	--	--	--	--	--	--	--	
Four Winds	2012	--	--	--	--	--	--	--	--	--	--	--	
Four Winds	2013	9/29/13	55	13	68	19.1%	35-38	5-20	High Overcast	3	2	0.67	
Hiteshitak	2010	--	--	--	--	--	--	--	--	--	--	--	
Hiteshitak	2011	--	--	--	--	--	--	--	--	--	--	--	
Hiteshitak	2012	--	--	--	--	--	--	--	--	--	--	--	
Hiteshitak	2013	9/25/13, 9/29/2013	116	31	147	21.1%	35-38	5-20	High Overcast	3	2	0.67	
Chilkoot	2010	9/22/10	144	41	185	22.2%	35	5-15	High Overcast	5	3	0.60	
Chilkoot[1]	2011	9/25/11	172	34	206	16.5%	34-37	5-10	Mostly Clear	2	2	1.00	
Chilkoot	2012	9/21-22/12, 10/1/12	136	37	173	21.4%				3	1	0.33	
Chilkoot-S (partial)	2012	9/21/12					49-50	0-5	Mostly Clear	2	1	0.50	
Chilkoot-N (partial)	2012	9/22/12					54	10-30	Partly Cloudy	0	--	--	
Chilkoot-C (partial)	2012	10/1/12					32	0-15	High Overcast	1	0	0.00	snow line: 4500 ft
Chilkoot	2013	9/29/13	160	47	207	22.7%	35-38	5-20	High Overcast	2	2	1.00	
U Chilkat	2012	9/22/12	23	1	24	4.2%	54	10-30	Partly Cloudy	0	--	--	
Halutu Ridge[2]	2010	9/22/10	22	8	30	26.7%	35	5-15	High Overcast	1	1	1.00	
Halutu Ridge[2]	2011	9/25/11	50	2	52	3.8%	34-37	5-10	Mostly Clear	1	1	1.00	
Halutu Ridge[2]	2012	9/21/12	33	6	39	15.4%	49-50	0-5	Mostly Clear	1	1	1.00	
Halutu Ridge[2]	2013	9/29/13	42	12	54	22.2%	35-38	5-20	High Overcast	0	--	--	

[1]new area added north of Klukwah (19 adults, 3 kids in this new area)

[2]Ferebee Gl-Burro Ck

Appendix 5. Summary of mountain goat aerial survey results for surveys conducted in the Haines-Skagway area, 2010-2012.

Study Area	Year	Date	Adults	Kids	Total	% Kids	Temp	Wind	Weather	Marked	Seen	Sighting Probability	Comments
Face[3]	2010	--	--	--	--	--	--	--	--	--	--	--	
Face[3]	2011	9/25/11	9	1	10	10.0%	34-37	5-10	Mostly Clear	0	--	--	
Face[3]	2012	9/21/12	5	1	6	16.7%	49-50	0-5	High Overcast	0	--	--	
Face[3]	2013	--	--	--	--	--	--	--	--	--	--	--	
Yeatman	2010	--	--	--	--	--	--	--	--	--	--	--	
Yeatman	2011	9/25/11	14	0	14	0.0%	34-37	5-10	Mostly Clear	0	--	--	
Yeatman	2012	9/21/12	7	1	8	12.5%	49-50	0-5	High Overcast	0	--	--	
Yeatman	2013	--	--	--	--	--	--	--	--	--	--	--	
Nourse-West	2010	9/22/10	14	0	14	0.0%	39	5-15	High Overcast	0	--	--	
Nourse-West	2011	9/25/11	19	1	20	5.0%	34-37	5-10	Low Overcast	0	--	--	
Nourse-West	2012	9/21/12	5	2	7	28.6%	49-50	0-5	High Overcast	0	--	--	
Nourse-West	2013	--	--	--	--	--	--	--	--	--	--	--	
Nourse-East[4]	2010	9/22/10	13	3	16	18.8%	39	5-15	High Overcast	1	1	1.00	
Nourse-East	2011	9/25/11	32	5	37	13.5%	34-37	5-10	Low Overcast	1	1	1.00	
Nourse-East	2012	9/21/12	24	2	26	7.7%	49-50	0-5	High Overcast	0	--	--	
Nourse-East	2013	--	--	--	--	--	--	--	--	--	--	--	
Skagway Pie	2010	--	--	--	--	--	--	--	--	--	--	--	
Skagway Pie	2011	9/25/11	27	4	31	12.9%	34	5-10	Low Overcast	0	--	--	
Skagway Pie	2012	--	--	--	--	--	--	--	--	--	--	--	
Skagway Pie	2013	9/24/13	19	1	20	5.0%	39-40	8	Partly Cloudy	0	--	--	Cessna 185

[3]Burro Ck-West Ck

[4]did not survey Saussure Glacier (accounted for 5 adults, 0 kids in 2011)