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Kodiak Island Mountain Goat Behavior, Diet, and Feeding Site Selection Patterns

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Kodiak National Wildlife Refuge
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ABSTRACT

In response to an irrupting population of non-native mountain goats (*Oreamnus americanus*), Kodiak National Wildlife Refuge developed a research plan to better understand the relationship among mountain goat population dynamics, resource selection patterns, and hunting regulations. For the first stage of this project, we conducted a pilot study aimed at quantifying mountain goat behavior, diet, and feeding site selection patterns across three study sites on Kodiak Island that had different mountain goat population densities and histories of occupancies. The results from scan sampling mountain goat group behaviors revealed that mountain goat spend the majority of their time during the summer days feeding or bedded, although the proportions of these behaviors varied among mountain goat populations. Microhistological analyses of mountain goat pellets indicated that sedges, forbs, and fern rhizomes were important summer forage (June-August). Fern rhizomes were largely consumed in early summer (June), before and during vegetative green-up. As the summer progressed, fern rhizomes consumption declined in favor of sedges and forbs. To quantify feeding site selection, we compared the diversity, and percentage frequency, and cover of habitat types between mountain goat feeding sites and available alpine sites. Our results indicated that mountain goats selected summer feeding sites with abundant long-awned sedge (*Carex macrochaeta*) and in close proximity to escape terrain. Feeding site selection varied little among Kodiak's mountain goat populations. Overall, our results are some of the first on Kodiak mountain goat diets, feeding site selection and behaviors, and will help guide management and future research of the population.

INTRODUCTION

The mountain goat (*Oreamnus americanus*) population on Kodiak Island, Alaska has increased dramatically in number and range since its introduction in 1952. Kodiak Island has since firmly established itself as mountain goat hunter's dream. More mountain goats were harvested from Kodiak in 2010 than any other management area in Alaska, and mountain goat meat now serves as an important food source for local communities. Hunting is also a popular and potentially effective means of regulating ungulate abundances, but the impact of mountain goat harvests on

annual changes in population abundance on Kodiak have been unclear. If the Kodiak mountain goat population exceeds its carrying capacity, ecological theory predicts that the population will over utilize its resources and crash to a new lower carrying capacity. This would result in reduced hunter harvest opportunities. In addition, as a non-native species, a high density population of mountain goats has the potential to adversely impact Kodiak's natural resources.

The long-term management goal of the Kodiak National Wildlife Refuge and the Alaska Department of Fish and Game (ADF&G) is to maintain mountain goat abundances at levels that satisfy hunter harvest expectations while avoiding irreversible resource damage. Introduced ungulates can cause detrimental landscape-level effects by altering vegetation structure and composition, soil system functioning, and chemical processes (Hobbs 1996, Spear and Chown 2009). Impacts can be especially severe on island and alpine ecosystems that are less resilient to disturbance (Courchamp et al. 2003). Studies on the effects of introduced mountain goats have generally found evidence for impacts on native ecosystems. Houston et al. (1994) concluded that mountain goats modified native plant communities and affected several rare and endemic plants in Olympic National Park, Washington. Mountain goats introduced to the Greater Yellowstone Area of Montana and Wyoming expanded in range and size (Lemke 2004), and ridge top vegetation cover is lower and barren areas along alpine ridges are more prevalent in areas with higher densities of mountain goats (Aho and Weaver 2003). To understand potential impacts of mountain goats on Kodiak's flora, managers need to understand the relationships between Kodiak mountain goats and their habitat. Quantifying these relationships requires detailed empirical data on mountain goat resource selection patterns.

Managing mountain goats and their habitats on Kodiak is a high priority to federal and state agencies. The importance of this goal has been well documented, and is supported by agency policies and plans. Managing Kodiak's mountain goats was recognized as a primary concern during an interagency meeting on Kodiak Island's nonnative species (Clough 2000). The ADF&G has identified 4 explicit goals related to mountain goats on Kodiak: developing low cost methods to index annual population trends, gaining a better understanding of movements and habitat selection, developing a harvest plan to provides ample hunter opportunities while maintaining habitat conditions, and gaining a better understanding of mountain goat impacts on habitats (Van Daele and Crye 2008). Managing mountain goats is an essential ungulate management goal for the Refuge, as highlighted in the Refuge's Comprehensive Conservation Plan (CCP). Specifically, the CCP stresses the importance of evaluating and reporting habitat use and preferences of mountain goats and improving the understanding of goat influence on habitat conditions (U.S. Fish and Wildlife Service 2006). Research on Kodiak mountain goats directly addresses other Refuge objectives; including increasing knowledge of fish and wildlife populations, their habitats, and their interrelationships (CCP Goal 1); managing nonnative species to minimize impacts on native resources, while continuing to provide opportunities for harvest (CCP Goal 3); and maintaining native plant populations, communities, and habitats (CCP Goal 6) These goals, objectives, and concerns are additionally supported by the Fish and Wildlife Service's overarching Biological Integrity, Diversity and Environmental Health Policy (USFWS 2001).

In addition to the applied goal of guiding management decisions, data collected on resource selection patterns of mountain goats are key elements to a more complete understanding of the

species' basic ecology and have a wide range of potential applications to other regions and species. Optimal foraging and ideal free distribution theories predicts that mountain goats on Kodiak should distribute themselves relative to resource availability to maximize their energy intake per unit time, but this theory has not been empirically tested on mountain goats to any extent. If forage resources are unevenly allocated, as likely the case for alpine regions of Kodiak, then we would predict that mountain goats' diet would be reflected in their feeding site selection patterns. In other words, mountain goat should feed in areas that contain a greater proportion and abundance of preferred forage. However, mountain goats rely on escape terrain to minimize predation risk, and areas with high forage value are not necessarily adjacent to escape terrain. Therefore, we expect that mountain goat feeding site selection patterns will reflect a balancing act between forage needed and predation aversion. Techniques to estimate ungulate diets, such as microhistological analyses of fecal pellets (Hinnant and Kothmann 1988, Smith and Fox 1988, Alipayo et al. 1992, Shrestha and Wegge 2006), are well established, but have rarely been used to assess mountain goat diets.

Refuge and ADF&G biologists have developed a research and monitoring plan aimed at better understanding mountain goat resource selection and population dynamics on Kodiak, in light of harvest management (Cobb 2011). A primary goal study plan of the plan is to determine mountain goat habitat selection patterns. This goal was further composed of individual objectives, two of which were to: 1) quantify mountain goat diets and 2) quantify feeding site selection and compare feeding site selection results among regions of Kodiak with different population densities and history of mountain goat occupancy. To achieve these objectives, the Refuge completed a pilot season of field work during the summer of 2011.

STUDY AREA

We conducted field work at 3 study sites on Kodiak Island, Alaska (Figure 1). We selected study site locations based on our understanding of historical mountain goat occupancy from annual aerial surveys (unpublished data). The first study site was on the Hepburn Peninsula, a 62 km^2 region on southeastern Kodiak Island, between Deadman and Sulua Bays ("Hepburn"). Survey records indicated that mountain goats colonized this area in the mid-1990s and were at low densities in 2011 (0.75/km^2, 47 goats). Hepburn was composed of a central valley bordered by 2 steep, southwest to northeast-running ridgelines. Elevations ranged from sea-level to 700 m. The second study site was centrally-located on Kodiak Island, between Uyak Bay and Zachar River ("Uyak"). Survey records indicated that mountain goats colonized this area in the 1970s, and that they were at high densities in 2011 (2.54/km^2, 122 goats). The Uyak study site (48 km^2) was composed of 2 regions: mountains surrounding Lake 629 ("Lake 629" region, 37 km^2), and mountains surrounding an unnamed valley on the northeast side of Amook Bay, which we termed "Brosis Valley" (11 km^2). Elevations in the Uyak study area ranged from sea-level to 1,320 m. The third study site was in northeastern Kodiak Island, between Hidden Basin and Terror Lakes, termed the "Hidden Terror" study area (76 km^2). This study site encompassed the site of the initial mountain goat introduction on the north side of Hidden Basin. The Hidden Terror study area was also divided into 2 regions: a 22 km^2 ridge north of Hidden Basin ("Hidden Basin") and a 54 km^2 region surrounding Terror Lake ("Terror Lake"). The mountain goat population at the Hidden Terror study site peaked in density in the 1985 (2.09/km^2) and had

since declined to 1.21/km^2 in 2011. Elevations in the Hidden Terror study site ranged from sea-level to 1,130 m.

Habitat diversity was similar among study site, although habitat distributions and relative abundances varied. Lower elevations (sea-level to 300 m) generally consisted of a matrix of mixed forb meadow, open alder with forb meadow, and dense alder habitat types (Fleming and Spencer 2007). The mixed forb meadow habitat consisted of lupine (*Lupinus nootkatensis*), fireweed *(Epilobium angustifolium)*, goldenrod (*Solidago lepida*), Jacob's ladder (*Polemonium acutiflorum*), paintbrush (*Caltilleja unalaschcensis*), and burnett (*Sanguisorba stipulate*). The open alder with forb meadow habitat type consisted of patches of dense alder (*Alnus crispa*), often mixed with salmonberry (*Rubus spectabilis*) and elderberry (*Sambucus racemosa*), and patches of forbs such as fireweed, lupine, and cow parsnip (*Heraculem lanatum*). In general, lower elevations in the Hepburn and Hidden Terror study sites were composed of more forbs and less alder, but the opposite was true for the Uyak study site. Higher elevations were dominated by alpine tundra, alpine forb meadow, alpine heath, prostrate shrub tundra, exposed bedrock, talus slopes, and snow-covered habitat types (Fleming and Spencer 2007). Common plants included long-awned sedge (*Carex macrochaeta*), mosses, lichens, partridgefoot (*Luetkea pectinata*), and black crowberry (*Empetrum nigrum*). The Hepburn study site consisted of less exposed bedrock and inaccessible cliffs than the other study sites. Snow was dominant at the Hidden Terror study site during the early summer, common at the Uyak study site, and almost absent from the Hepburn study site.

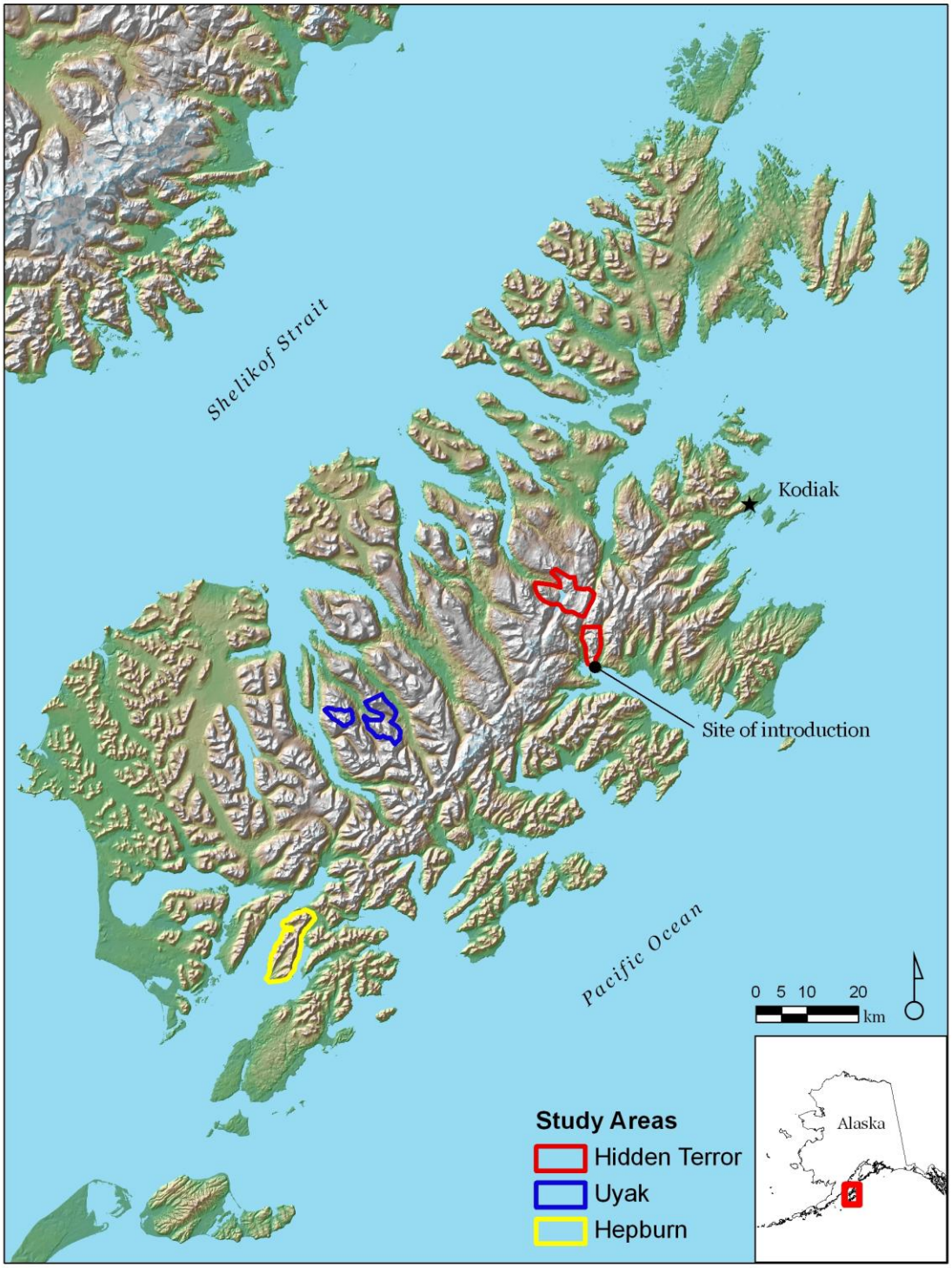


Figure 1. Mountain goat field research study sites, summer 2011, Kodiak Island, Alaska.

METHODS

We attempted to visit each study site twice: once in the early summer (June – early July) and once in the late summer (late July – August). During visits, our goals were to: conduct behavioral observations on mountain goats, collect fresh mountain goat fecal pellets, and to conduct vegetation surveys at mountain goat feeding sites and random alpine locations. To do this, we first located mountain goat groups by hiking to known mountain goat group locations (determined by aerial surveys), scanning for mountain goats with binoculars, and traversing the study areas looking for goats.

Diet

We quantified mountain goat diets at each study site using microhistological analyses of fecal pellets (Hinnant and Kothmann 1988). To collect fecal pellet samples, we observed a mountain goat group until we saw a goat defecate. We then slowly approached the center of the group's location, and searched for fresh fecal pellet samples. We classified pellets as fresh if they were moist, soft, had a slimy shin, and were free of mold and insects. We collected approximately 25-mg (15 pellets) of fresh pellets from individual piles into a Nasco WhirlPaks using a toothpick. We did not collect pellets if there was any doubt that they were fresh. We kept fecal pellet samples in a cool dry location while we were in the field, and then we froze samples upon returning to Refuge headquarters. We submitted a random subsample from each study area to the Wildlife Habitat Nutrition Lab at Washington State University (Pullman, WA) at the conclusion of the field season (September).

Behavior

We attempted to quantify mountain goats behaviors when we first observed a mountain goat group. To do this, we classified the behaviors (feeding, bedded, standing, walking, or running) of all individuals in a group at 5-minute intervals, for 30 minutes, or until the group moved out of view of the observers. In addition to classifying behaviors, we recorded the group's size and classified individuals into age/sex classes (adults, billies, nannies, and kids). We noted the weather (sun, partly cloudy, cloudy, rain, snow, sleet, or fog). We recorded wind speed and direction using a handheld weather station (Kestrel 2500, Birmingham, MI). We documented whether any goats in the group were aware of our presence. If the group was aware of us, we recorded the time that they first reacted, the distance between the closest mountain goat and us, and the majority of the group's behavioral response to our presence. We compared behaviors and group classifications among study sites with Kruskall-Wallis chi-square tests (Zar 2009).

Feeding Site Selection

We defined feeding sites as the centroid location of a mountain goat group that was observed feeding. To quantify feeding site selection, we compared habitats at feeding sites against random sites. We defined the extent of available habitat as typical mountain goat summer range; which including low willow, alpine tundra, heath, forb-graminoid meadows, snow/ice, and fragmented rock habitat types (Hjeljord 1970, Von Elsner-Schack 1986, Fox et al. 1989, Poole and Heard 2003). We used the Kodiak Archipelago Land Cover Classification (KLCC) GIS layer to delineate these regions within study sites (Fleming and Spencer 2007). Additionally, we limited available habitats to areas over 152 m (500 ft) above sea level because lowland regions were unlikely to include typical mountain goat summer range (Hjeljord 1973), and because including

these generally alder and willow-dominated habitats would require a survey effort beyond the scope of this project. We designated random sites by creating 100 unique random waypoints in available habitat, in each study site and for each visit, using Spatial Analyst in ArcGIS 9.3 (ESRI 2012). We included an inhibition distance (minimum allowable distance between random waypoints) of 100-m, to eliminate potential overlap between transects and to insure a more even distribution across the study site. We uploaded random waypoints into GPS units, which we used to locate random waypoints in the field.

We surveyed vegetation at feeding sites and random sites. At feeding sites, we slowly approached the centroid of a mountain goat group's location. We recorded a GPS waypoint at that location using a portable GPS unit (Garmin 60CSx), and we inserted an aluminum tent stake (Coghlan's, Winnipeg, Manitoba) into the ground. Our methods for conducting vegetation surveys were the same at feeding sites and random waypoints. We selected a random compass bearing, using a random number table, and extended a tape measure from the tent stake along the random bearing for 16-m in both directions. Starting from the tent stake, we placed a 50 x 20-cm PVC plot to right side of the tape measure at 2-m intervals (Daubenmire 1959) (Figure 2). At each interval, we first attempted to record all vascular plant species, or habitat classes (bare ground, bare rock, litter, snow, water, and cliff) present at the point. We also recorded nonvascular plants (mosses, fungus, and lichens), but we did not attempt to classify them by species. We then recorded plants and habitat classes within each plot and classified percent canopy cover. Percent canopy cover was defined the percent of the plot that encompasses the sum of all imaginary polygons drawn on leaf tips of undisturbed canopies (ignoring inflorescences), and projected onto the ground (Kent 2012) (Figure 3). We classified canopy cover into 12 classes following a modified Domin cover scale (Currall 1987) and based on the relative percentage canopy cover within the plot (Figure 4). We quantified canopy cover by observing the plot from directly above and estimating percentage canopy cover for each plant species as a single unit. For vascular plants that we could not classify to the species level, we made attempts to classify to the genus level. Standing over the center waypoint, we took an oblique photo of the transect line in both directions. During the second half of the field season, we noted whether any mountain goat feces were observed within plots and whether plants in plots had been grazed.

To summarize habitat types, we quantified the habitat biodiversity, percent frequency, and percent cover at feeding and random sites. Biodiversity of a transect was defined as the sum of all plant species and habitat classes within all plots along a single transect. The habitat percent frequency of a transect was defined as the number of occurrences of a particular plant species or habitat type (the number of plots in which it was observed within a transect), divided by the total number of plots sampled along the transect (17), and then multiplied by 100. Habitat percent cover for each transect was defined as the summed percent canopy cover of each plant species within all plots on a particular transect divided by the total canopy cover of all plant species and habitats within all plots on a that transect.

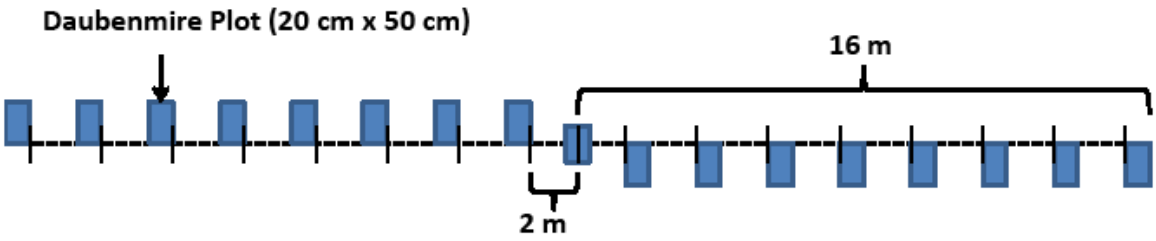


Figure 2. Vegetation survey transects and locations of Daubenmire plots used to quantify the plant diversity and canopy cover at mountain goat feeding sites and random sites, Kodiak Island, Alaska.

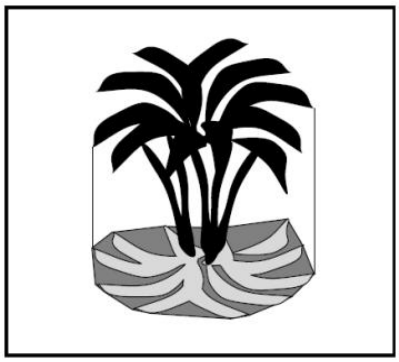
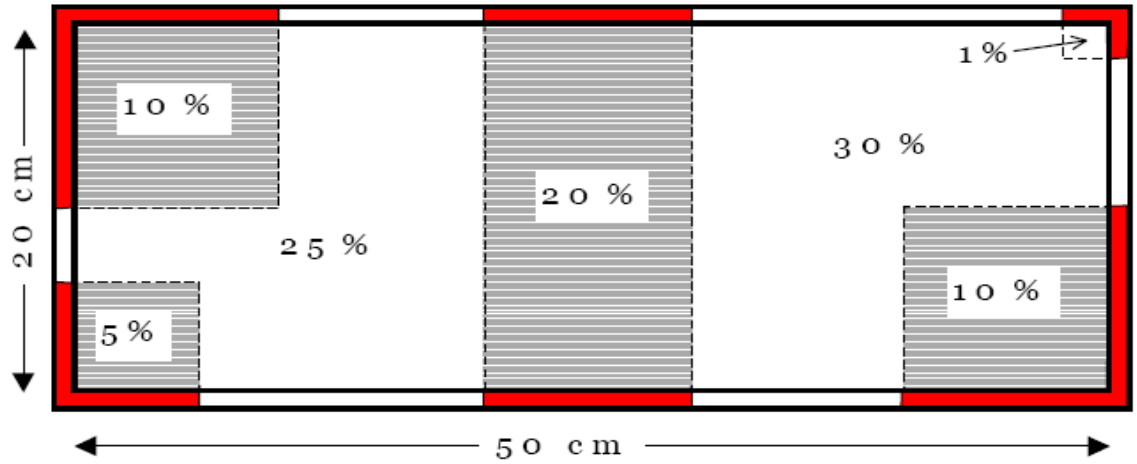


Figure 3. Canopy cover for an individual plant, as defined for mountain goat feeding site selection.

a.



b.

% Cover Classes					
Code	Range	Mid	Code	Range	Mid
T	0-1%	0.50%	**5**	45-55%	50%
0	1-5%	3%	**6**	55-65%	60%
1	5-15%	10%	**7**	65-75%	70%
2	15-25%	20%	**8**	75-85%	80%
3	25-35%	30%	**9**	85-95%	90%
4	35-45%	40%	**X**	95-100%	97.5%

Figure 4. Daubenmire plot with a guide for quantifying percentage vegetation canopy cover (a) and canopy cover classes with associated range of percent canopy covers (b) used to quantify vegetation cover at mountain goat feeding sites and random available locations.

Since mountain goats are associated with steep terrain that they use to escape from predators, we included a measure of escape terrain as a predictor of feeding site selection. Escape terrain has been described as steep rocky slopes, ranging from $>25^0$ to $>33^0$ (Adams and Bailey 1982, Gross et al. 2002). To be conservative, we defined escape terrain as slopes $>33^o$. We quantified the spatial distribution of escape terrain within study sites using a 30-m pixel Digital Elevation Model (DEM) (ESRI 2012). We entered waypoints into a GIS and used ArcMap's NEAR function to calculate the distance from the center of each transect to the closest patch of escape terrain.

Habitat selection of northern ungulates, such as mountain goats, is affected by forage availability and thermodynamics, which is in turn influenced by relative solar radiation (Keating et al. 2007). To determine if mountain goat feeding site selection at Kodiak was influence by solar radiation, we first estimated hypothetical solar illumination (1 July, 12:00pm) across Kodiak using the hillshade function applied to a DEM in ArcGIS (ESRI 2012). We then standardized hillshade values for Kodiak between 0 and 1 by converting raw hillshade raster cell values to *z*-score

values (Zar 2009). Finally, we overlaid feeding and random site waypoints onto the standardized hillshade raster layer to determine a relative hillshade at each waypoint.

We considered transects as the sampling unit for statistical analyses. Because the large number of plant species and habitats that we classified would have produced too many predictors in our candidate models, we first selected the 10 most commonly observed habitat types, and the 3 additional computed habitat predictors (habitat diversity, distance to escape terrain, and hillshade), to include in candidate feeding site selection models. The top-10 habitats accounted for approximately 33% of all observations. To avoid issues associated with correlation among habitat percent frequency and percent cover, we ran separate pools of candidate logistic regression models for each. Both pools of candidate models included diversity, distance to escape terrain, and hillshade. For each pool of candidate predictors, we computed a Pearson product-moment correlation matrix to assess relative correlation among predictors. For paired of predictors that were highly correlated (>.30) (Zar 2009), we retained the predictor that was most ecologically relevant. To evaluate competing candidate models, we examined differences in Akaike Information Criterion values corrected for small samples sizes (ΔAIC_c) using a backwards, step-wise approach (Burnham and Anderson 2002). Models with ΔAIC_c greater than 2 were considered to have better predictive ability. Finally, we calculated AIC_c weights (*w*) to determine relative support for each of the top models.

RESULTS

We visited each study area twice, between 2 June and 19 August, 2011 (Table 1). Each visit averaged 8 days in duration (range = 4-10 days). Four researchers visited each study site, but to maximize efficiency, we split into 2 groups each day to survey separate regions within the study site.

Table 1. Dates and durations (in days) of study site visits for mountain goat research, summer 2011, Kodiak, Alaska.

	Trip 1		Trip 2	
Study Area	Dates	Duration (days)	Dates	Duration (days)
Hepburn	6/2-6/8	7	7/13-7/21	9
Uyak	6/14-6/17	4	7/29-8/7*	10
Hidden Terror	6/22-7/1**	10	8/12-8/21**	10

*includes Lake 629 and Brosis Valley subregions
**includes Terror Lake and Hidden Basin subregions

Diet

We collected 200 mountain goat pellet samples (Table 2). From these, we sub-sampled 59 pellet samples to be microscopically analyzed for plant composition. We submitted 10 pellet samples per study area per visit, except for the first Hepburn visit for which we were only able to collect 9 samples because of foul weather (*n* = 59). Microhistological lab results will be available March 2012.

Table 2. Number of fecal pellet samples collected in each study site and subregion during summer 2011 mountain goat field season, Kodiak Island, Alaska.

Study Area	Subregion	Visit 1	Visit 2	Total
Hepburn	*n/a*	11	27	38
Uyak	629	9	34	43
Uyak	Brosis Valley	0	22	22
Terror/Hidden	Terror Lake	13	39	52
Terror/Hidden	Hidden Basin	15	30	45
TOTAL		48	152	200

Behavior

We conducted behavioral observations on 28 mountain goat groups. Mountain goats became aware of the observers during 9 (32%) attempts at an average distance of 527. 63 m (SE = 61.07). We were able to complete 16 (57%) full 30-minute behavioral observations (3 at Hepburn, 6 at Uyak, and 7 at Hidden Terror), without mountain goat groups moving out of view. Group sizes averaged 9 mountain goats (SE = 1.76), of which 8 (SE = 1.38) were adults and 1 (SE = 0.31) was a kid (Figure 5). We were unable to classify 13 (48%) groups by sex because of far distance between the groups and the observers, and because inclement weather (fog, low clouds, or heavy rain). Groups that we were able to classify by sex were on average composed of 69% nannies, 23% kids, and 8% billies. Group sizes did not differ among study sites (KW x^2 = 0.19, p = 0.91).

Figure 5. Box plot of mountain goat group sizes classified during behavioral observations, Kodiak Island, Alaska, summer 2011. Bold lines indicate medians, and boxes extend to the 1st and 3rd quartiles, and the circle indicates an outlier.

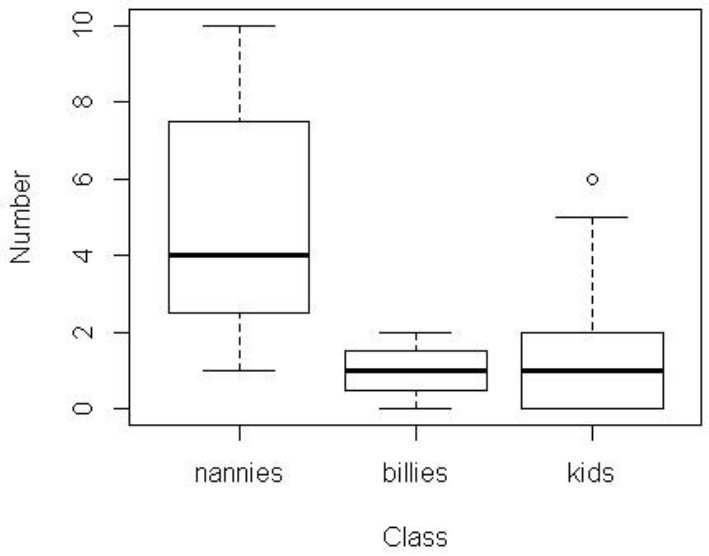


Figure 6. Average mountain goat behaviors by group, for observation that lasted the entire 30-minute period, Kodiak, Alaska, summer 2011. Groups are ordered chronologically from left to right within each study site.

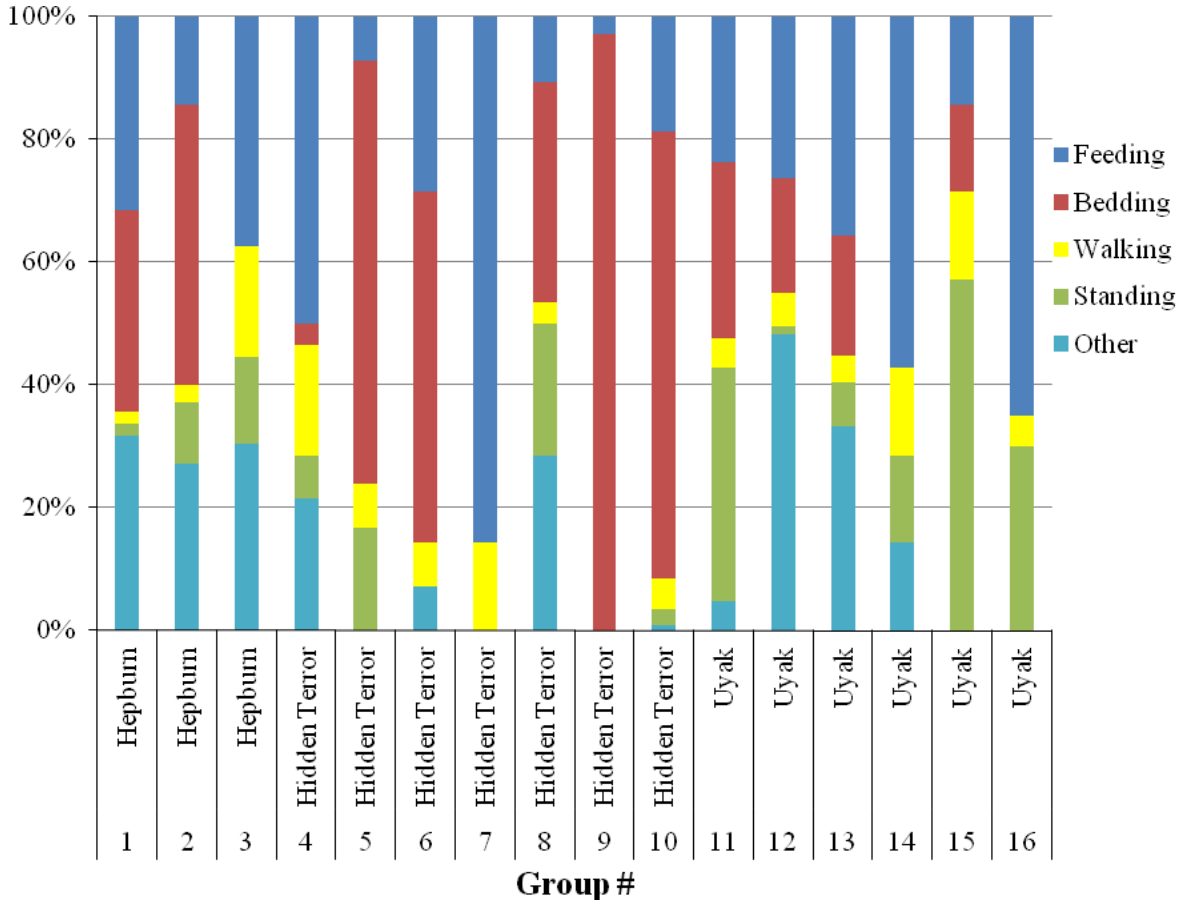
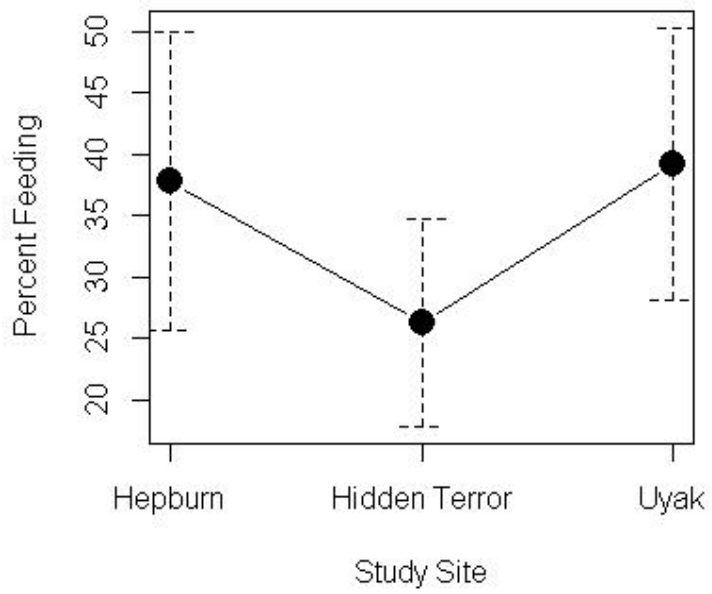


Figure 7. Average percentage of feeding behavior, by study site, observed during 30-minute behavioral observations (5-minute interval scan sampling) of mountain goats, Kodiak Island, Alaska, summer 2011. Dashed lines indicate 95% confidence intervals.



Feeding Site Selection

We surveyed vegetation diversity and canopy cover at 298 locations (226 random and 72 feeding sites) for a total of 5,066 Daubenmire plots (Table 3, Figures 8 – 10). We observed 161 unique plant species and habitat types (Table 4). Moss and litter were the most commonly observed habitat; found in approximately 10% of all plots surveyed. The most common plant species was long-awned sedge (*Carex macrochaeta*), which occurred in over 4% (223) of plots. Other common plants included patridgefoot (*Luetkea pectinata*), arctic daisy (*Arctanthemum arcticum*), black crowberry (*Empetrum nigrum*), and variegated sedge (*Carex stylosa*). In the early summer, we were unable to identify some ferns, grasses, willows, and sedges to the species level because they were in early growth stages. Snow was common in plots during the early summer at the Hidden Terror study site. We estimated that more than two-thirds of the Hidden Terror study site was still covered in snow during the first visit (22 June – 1 July).

Table 3. Number of vegetation transects and Daubenmire plots per survey area during summer 2011 mountain goat field activities, Kodiak Island, Alaska.

Survey Area	Vegetation Transects	Daubenmire Plots
Hepburn	59	1,110
Hidden Terror	156	2,166
Uyak	83	1,918
TOTAL	298	5,194

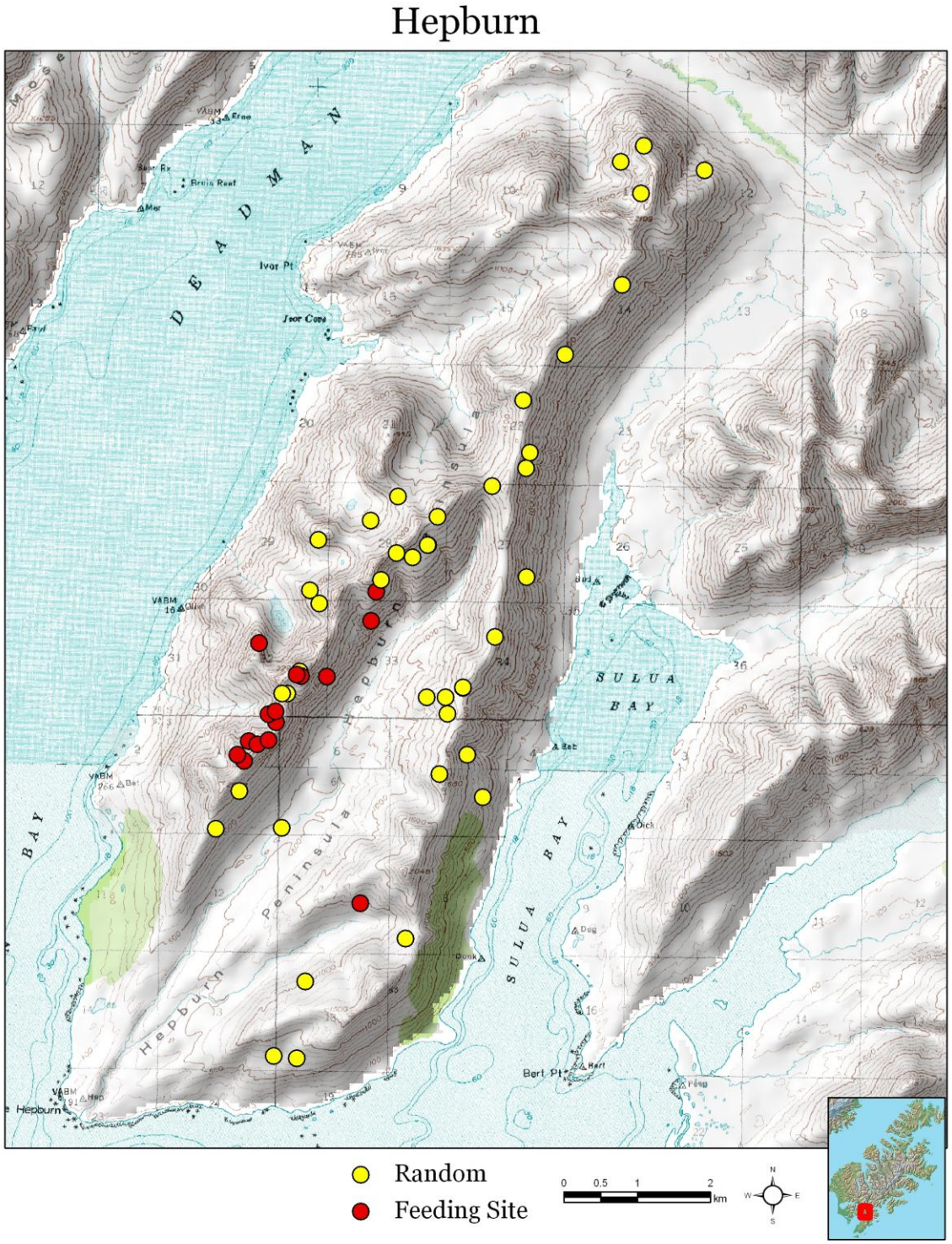


Figure 8. Locations of vegetation surveys at the Hepburn study site, summer 2011, Kodiak Island, Alaska.

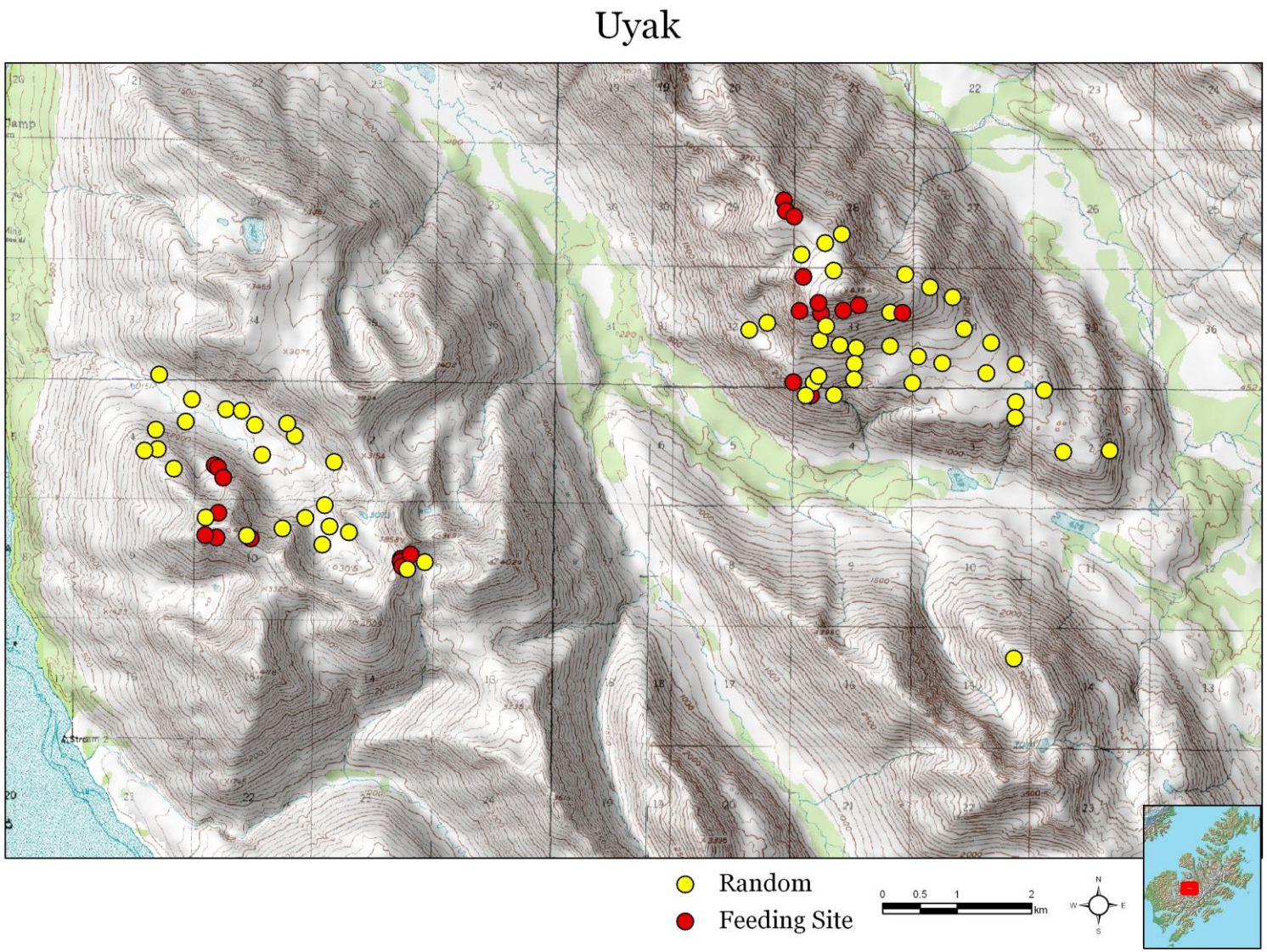


Figure 9. Locations of vegetation surveys at the Uyak study site, summer 2011, Kodiak Island, Alaska.

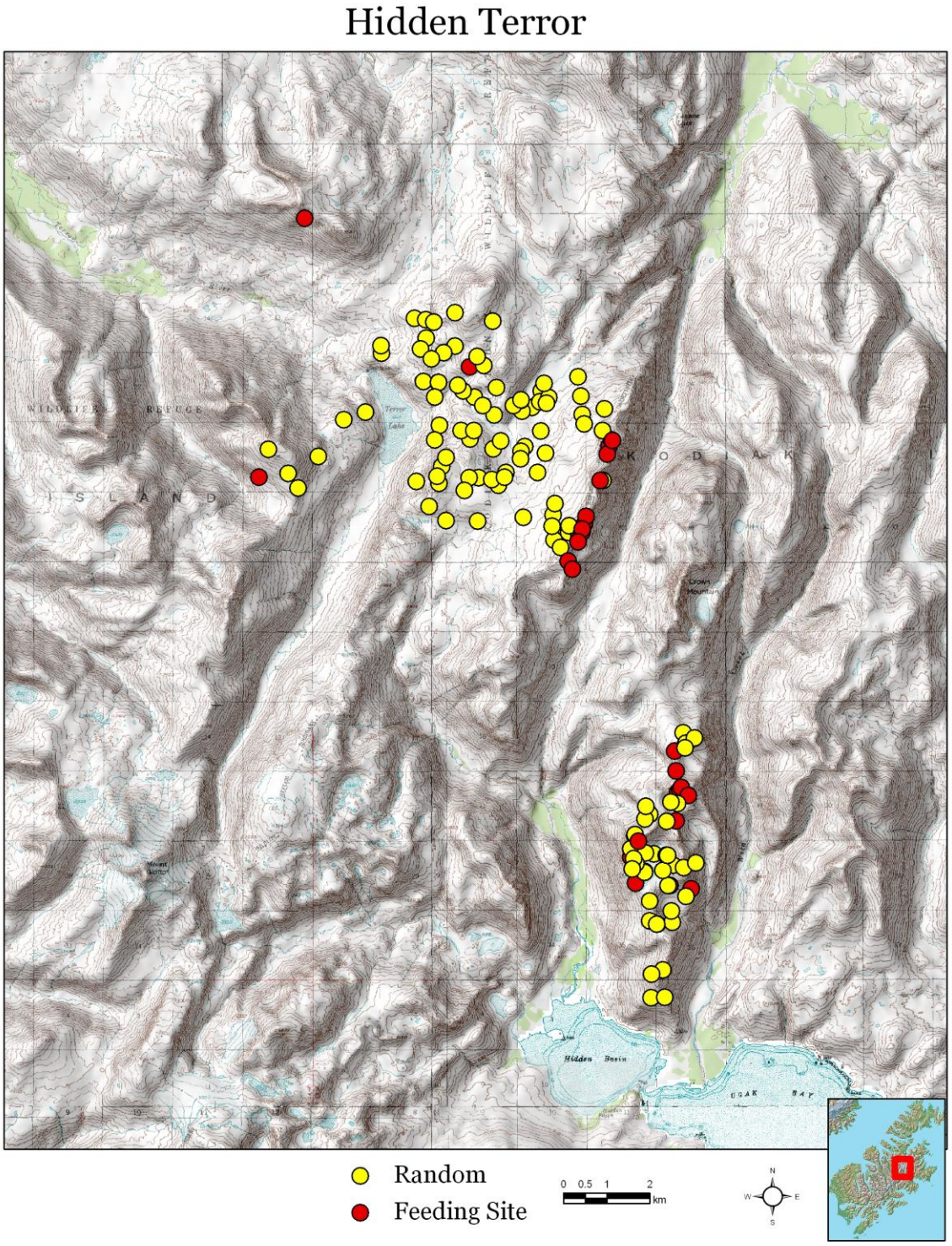


Figure 10. Locations of vegetation surveys at the Hidden Terror study site, summer 2011, Kodiak Island, Alaska.

The average slope at transects was 31.6^{o} (SE = 1.09). Slopes did not statistically differ between random (31.5^{o}) and feeding sites (31.9^{o}) (KW x^2 = 21.10, p < 0.01). The average distance to the nearest rock outcropping at transects was 263 m (SE = 18.84), and distances to the nearest rock outcropping were significantly less at feeding sites (59.3 m, SE = 8.24) than random locations (345.9 m, SE = 23.33) (KW x^2 = 634.2, p < 0.01).

Overall, feeding sites were characterized by approximately 7% more long-awned sedge cover than random sites (KW x^2 = 47.68, p < 0.01), although this difference between feeding and random sites showed variation among study sites (Figure 11). Additionally, feeding sites were found to be an average of 242 m closer to escape terrain (72 m versus 314 m) than random locations (KW x^2 = 49.73, p < 0.01). This finding was true across all study sites, although the difference was not statistically significant at the Hepburn study site (Figure 12).

The top-10 most common habitat types that were included in candidate logistic regression models were: moss, long-awned sedge, lichen, grass, partridgefoot, arctic daisy, willow, black crowberry, unknown sedge *spp*., and variegated sedge. Although bare rock, bare soil, and snow were within the top-10, we excluded these habitats from feeding site selection modeling because they are not potential forage. Additional candidate predictors included hillshade, habitat diversity, and distance to escape terrain.

The most parsimonious model using habitat percent cover predictors included the following predictors: percent cover of long-awned sedge, willow, lichen, and grass; distance to escape terrain, and study area (Table 5). Model results indicated that the probability that a location was a feeding site increased when it had more long-awned sedge cover, was closer to escape terrain, and had less willow cover, more lichen cover, and less grass cover. The model identified different levels of feeding site selection among study sites; however this result was likely due to difference in the proportions of feeding sites and random locations sampled in each study site. Based on ΔAIC_c values, the strongest predictors of feeding site selection in the final model was long-awned sedge percent cover followed by the distance to escape terrain. The weakest predictors in the final model were grass average cover and study area (Table 6).

The most parsimonious model using habitat percent frequency included the following predictors: the percent frequencies of long-awned sedge, arctic daisy, unknown sedge *spp*., grass, lichen, and willow; distance to escape terrain, hillshade, and habitat diversity (Table 7). Model results indicated that the probability that a location was a feeding site increased when it had higher percent frequencies of long-awned sedge, sedge spp., arctic daisy, and lichen; lower percent frequencies of grass and willow; was closer to escape terrain, had lower habitat diversity, and was more exposed to sunlight. Based on ΔAIC_c values, the strongest predictors of feeding site selection in the model was long-awned sedge percent frequency followed by the distance to escape terrain. The weakest predictors were the percent frequencies of grass and lichen (Table 8).

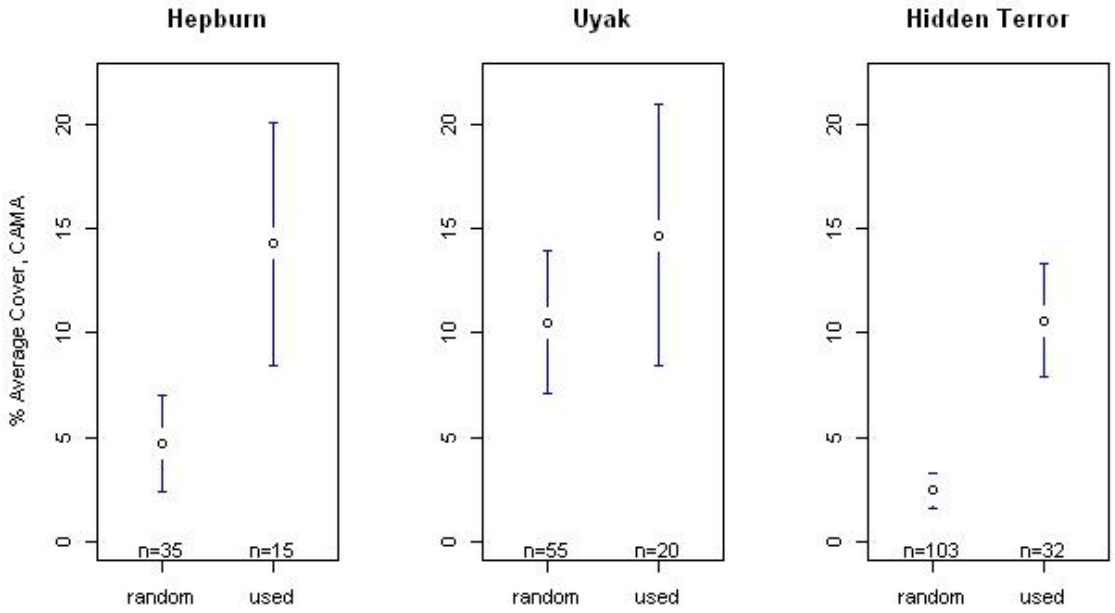


Figure 11. Percent average cover of long-awned sedge (*Carex macrochaeta*) at random and used (feeding) sites, by study sites, Kodiak Island, Alaska, summer 2011. Circles indicate averages and bars extend to 95% confidence intervals.

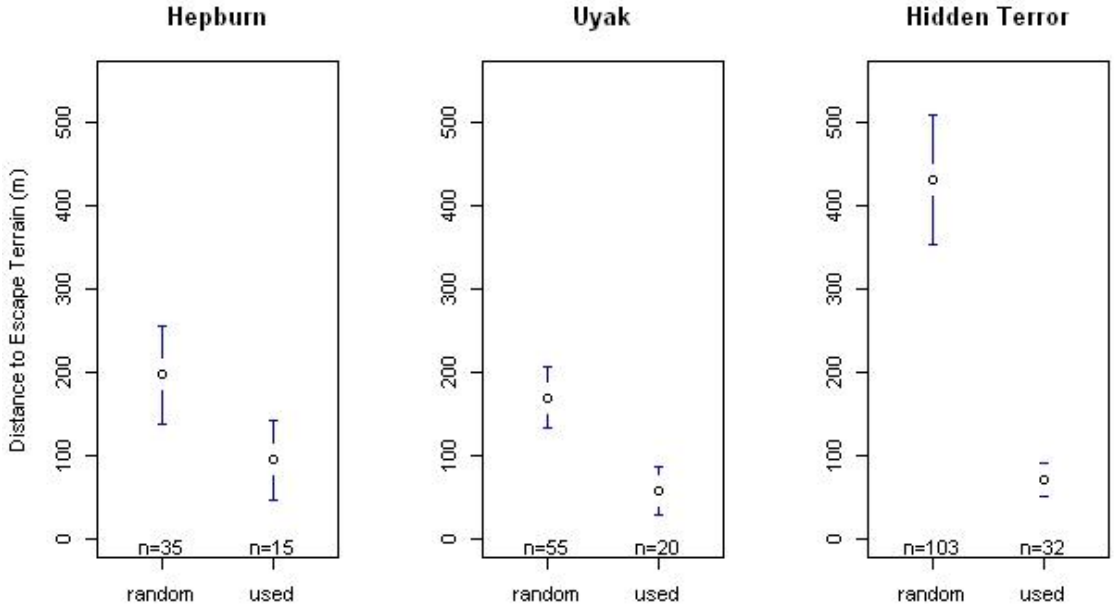


Figure 12. Average distance to escape terrain (m) at random and used (feeding) sites, by study sites, Kodiak Island, Alaska, summer 2011. Circles indicate averages and bars extend to 95% confidence intervals.

Table 4. List of plants and habitats recorded during mountain goat vegetation surveys (feeding sites and random locations), in order by the number of plots in which they were found during summer 2011 fieldwork, Kodiak Island, Alaska.

Rank	Common Name	Scientific Name	Count
1	moss spp.		258
2	litter		253
3	long-awned sedge	*Carex macrochaeta*	223
4	bare rock		194
5	bare ground		184
6	lichen spp.		177
7	grass spp.		164
8	partridgefoot	*Luetkea pectinata*	151
9	arctic daisy	*Arctanthemum arcticum*	142
10	willow spp.		129
11	sedge spp.		125
12	black crowberry	*Empetrum nigrum*	121
13	variegated sedge	*Carex stylosa*	112
14	mountain harebell	*Campanula lasiocarpa*	108
15	Nootka lupine	*Lupinus nootkatensis*	106
16	alpine bistort	*Bistorta vivipara*	101
17	yellow anemone	*Anemone narcissiflora*	97
18	seacoast angelica	*Angelica lucida*	81
19	alpine clubmoss	*Diphasiastrum alpinum*	81
20	woolly geranium	*Geranium erianthum*	79
21	snow		74
22	creeping sibbaldia	*Sibbaldia procumbens*	73
23	lingonberry	*Vaccinium vitis-idaea*	72
24	Canadian burnet	*Sanguisorba stipulata*	70
25	Alaska Indian paintbrush	*Castilleja unalaschcensis*	70
26	Lousewort spp.	*Pedicularis spp.*	70
27	woolly hawkweed	*Hieracium triste*	67
28	rush spp.		63
29	subalpine fleabane	*Erigeron peregrinus*	61
30	bog blueberry	*Vaccinium uliginosum*	56
31	fireweed	*Epilobium angustifolium*	55
32	lance-leaf arnica	*Arnica lanceolata*	51
33	ledge stone crop	*Sedum rosea*	49
34	boreal yarrow	*Achillea borealis*	45
35	arctic alpine fleabane	*Erigeron humilis*	45
36	alpine pussytoes	*Antennaria alpina*	44
37	false hellebore	*Veratrum viride*	43
38	stiff clubmoss	*Lycopodium annotinum*	42
39	Hornemann's willowherb	*Epilobium hornemannii*	42
40	least willow	*Salix rotundifolia*	42
41	calthaleaf avens	*Geum calthifolium*	41
42	nodding arnica	*Arnica lessingii*	40
43	netleaf willow	*Salix reticulata*	38
44	arrowleaf groundsel	*Senecio triangularis*	37
45	alpine azalea	*Loiseleuria procumbens*	36
46	Aleutian mountain heather	*Phyllodoce aleutica*	34
47	fern spp.		34
48	violet spp.		34
49	redstem saxifrage	*Saxifraga lyallii*	33
50	Kamchatka rhododendron	*Rhododendron camtschaticum*	32

Table 4. (cont.)

Rank	Common Name	Scientific Name	Count
51	arctic sweet coltsfoot	*Petasites frigidus*	31
52	Lapland corneal	*Cornus suecica*	31
53	larkspurleaf monkshood	*Aconitum delphinifolium*	31
54	arctic starflower	*Trientalis europaea*	29
55	veronica spp.		28
56	alpine shinleaf	*Pyrola asarifolia*	27
57	salmonberry	*Rubus spectabilis*	27
58	pale gentian	*Gentiana glauca*	23
59	Sitka alder	*Alnus crispa*	22
60	common cow parsnip	*Heracleum lanatum*	21
61	western rattlesnakeroot	*Prenanthes alata*	21
62	sprouting leaf willow	*Salix stolonifera*	21
63	stream violet	*Viola glabella*	21
64	water		20
65	alpine pea	*Oxytropis nigrescens*	19
66	arctic willow	*Salix arctica*	18
67	heartleaf twayblade	*Listera cordata*	17
68	tealeaf willow	*Salix pulchra*	17
69	cliff		17
70	common lady fern	*Athyrium filix-femina*	16
71	horsetail spp.		15
72	yellow thimbleweed	*Anemone richardsonii*	14
73	cloudberry	*Rubus chamaemorus*	13
74	alpine forget-me-not	*Myosotis alpestris*	12
75	Siberean spring beauty	*Claytonia sibirica*	12
76	wedgeleaf primrose	*Primula cuneifolia*	12
77	northern dandelion	*Taraxacum alaskanum*	11
78	alpine bearberry	*Arctous alpina*	11
79	arctic dock	*Rumex arcticus*	11
80	bract saxifrage	*Saxifraga bracteata*	11
81	reddish groundsel	*Senecio resedifolius*	11
82	alpine bittercress	*Cardamine bellidifolia*	10
83	boreal starwort	*Stellaria borealis*	9
84	American alpine speedwell	*Veronica wormskjoldii*	9
85	bearberry	*Arctostaphylos uva-ursi*	8
86	broadpetal gentian	*Gentiana platypetala*	8
87	northern Jacob's-ladder	*Polemonium boreale*	8
88	Aleutian violet	*Viola langsdorfii*	8
89	lakeshore sedge	*Carex lenticularis*	7
90	Kamchatka fritillary	*Fritillaria camschatcensis*	7
91	Pacific serviceberry	*Dryas incisa*	7
92	long-bract frog orchid	*Coeloglossum viride*	6
93	Eschscholtz's buttercup	*Ranunculus eschscholtzii*	6
94	red elderberry	*Sambucus racemosa*	5
95	marsh Labrador tea	*Ledum palustre*	5
96	pretty Jacob's ladder	*Polemonium pulcherrimum*	5
97	villous cinquefoil	*Potentilla villosa*	5
98	Canada goldenrod	*Solidago lepida*	4
99	longpod stitchwort	*Minuartia macrocarpa*	4
100	dwarf fireweed	*Epilobium latifolium*	4

Table 4. (cont.)

Rank	Common Name	Scientific Name	Count
100	dwarf fireweed	*Epilobium latifolium*	4
101	fireleaf leptarrhena	*Leptarrhena pyrolifolia*	4
102	glandular willow herb	*Epilobium halleanum*	4
103	fungus spp.		4
104	Chamisso arnica	*Arnica chamissonis*	3
105	bog birch	*Betula nana*	3
106	umbel bittercress	*Cardamine umbellata*	3
107	pincushion plant	*Diapensia lapponica*	3
108	northern bedstraw	*Galium boreale*	3
109	three-petal bedstraw	*Galium trifidum*	3
110	Lyre-leaf rock cress	*arabis lyrata*	3
111	hairy rockcress	*Arabis hirsuta*	3
112	devils club	*Echinopanax horridus*	2
113	boreal draba	*Draba borealis*	2
114	blunt-leaf grove sandwort	*Moehringia lateriflora*	2
115	cushion-pink, moss campion	*Silene acaulis*	2
116	silver sedge	*Carex canescens*	2
117	tufted bulrush	*Trichophorum cespitosum*	2
118	field horsetail	*Equisetum arvense*	2
119	alpine milkvetch	*Astragalus alpinus*	2
120	alpine bog swertia	*Swertia perennis*	2
121	common clubmoss	*Lycopodium clavatum*	2
122	alpine brook saxifrage	*Saxifraga rivularis*	2
123	capitate lousewort	*Pedicularis capitata*	2
124	Steller Speedwell	*Veronica stelleri*	2
125	Ross' avens	*Geum rossii*	2
126	kneeling angelica	*Angelica genuflexa*	1
127	pygmy pussytoes	*Antennaria monocephala*	1
128	disc mayweed	*Matricaria discoidea*	1
129	common scurvygrass	*Cochlearia officinalis*	1
130	highbush cranberry	*Viburnum edule*	1
131	Northwest Territory sedge	*Eriophorum angustifolium*	1
132	oval-leaf blueberry	*Vaccinium ovalifolium*	1
133	field locoweed	*Oxytropis campestris*	1
134	chestnut rush	*Juncus castaneus*	1
135	common selfheal	*Prunella vulgaris*	1
136	keyflower	*Dactylorhiza aristata*	1
137	Huron green orchid	*Platanthera huronensis*	1
138	northern groundcone	*Boschniakia rossica*	1
139	goose tongue	*Plantago maritima*	1
140	tall Jacob's-ladder	*Polemonium acutiflorum*	1
141	alpine mountain sorrel	*Oxyria digyna*	1
142	large-leaf avens	*Geum macrophyllum*	1
143	Nootka rose	*Rosa nutkana*	1
144	feltleaf willow	*Salix alaxensis*	1
145	alpine heuchera	*Heuchera glabra*	1
146	fivestamen miterwort	*Mitella pentandra*	1
147	whiplash saxifrage	*Saxifraga flagellaris*	1
148	purple mountain saxifrage	*Saxifraga oppositifolia*	1
149	subalpine eyebright	*Euphrasia mollis*	1
150	weaselsnout	*Lagotis glauca*	1

Table 4. (cont.)

Rank	Common Name	Scientific Name	Count
151	Oeder's lousewort	*Pedicularis oederi*	1
152	whorled lousewort	*Pedicularis verticillata*	1
153	little yellow-rattle	*Rhinanthus minor*	1
154	dwarf marsh violet	*Viola epipsila*	1
155	Sitka spruce	*Picea sitchensis*	1
156	mountain wood fern	*Dryopteris campyloptera*	1
157	Alaska spirea	*Spiraea beayverdiana*	1
158	long-stalked starwort	*Stellaria longipes*	1
159	poison water hemlock	*Conium maculatum*	1
160	stinging nettle	*Urtica doica*	1
161	wooly lousewort	*Pedicularis kanei*	1

Table 5. Logistic regression model output for the top candidate model evaluating mountain goat feeding site selection using percent habitat cover, Kodiak Island, Alaska, summer 2011.

Predictor	Estimate	SE	*p*-value
(Intercept)	-0.54	0.49	0.27
Long-awned Sedge Average Cover	0.11	0.02	<0.01
Distance to Escape Terrain	-0.01	0.00	<0.01
Grass Average Cover	-0.11	0.06	0.06
Lichen Average Cover	0.07	0.03	0.01
Willow Average Cover	-0.23	0.09	0.01
Hidden Terror Study Site	0.44	0.47	0.34
Uyak Study Site	-0.90	0.55	0.10

Table 6. Top 7 candidate models for feeding site selection using habitat percent cover. The final model included all 6 predictors that were removed for model comparison.

Model	AICc	ΔAICc	*w*
Final Model	195.84	0	0.66
(- Grass Average Cover)	198.59	2.75	0.17
(- Study Area)	198.83	2.99	0.15
(- Lichen Average Cover)	202.65	6.81	0.02
(- Salix Average Cover)	204.52	8.68	0.01
(- Distance to Escape Terrain)	226.28	30.44	0.00
(- Long-awned Sedge Average Cover)	231.47	35.63	0.00

Table 7. Logistic regression model output for the top candidate model evaluating mountain goat feeding site selection using habitat percent frequency, Kodiak Island, Alaska, summer 2011.

Predictor	Estimate	SE	*p*-value
(Intercept)	-1.33	0.71	0.06
Artic Daisy	0.03	0.01	0.01
Long-awned Sedge	0.04	0.01	0.00
Sedge spp.	0.03	0.01	0.01
Distance to Escape Terrain	-0.01	0.00	0.00
Diversity	-14.75	6.54	0.02
Grass	-0.02	0.01	0.11
Hillshade	-0.18	0.09	0.05
Lichen	0.01	0.01	0.09
Willow	-0.03	0.01	0.03

Table 8. Top 7 candidate models for feeding site selection using habitat percent frequency. The final model included all 8 predictors that were removed for model comparison.

Model	AICc	ΔAICc	*w*
Final	186.97	0	0.34
(- Grass Average Freq.)	187.7	0.73	0.23
(- Lichen Average Freq.)	187.93	0.96	0.21
(- Hillshade)	189.09	2.12	0.12
(- Diversity)	190.38	3.41	0.06
(- Arctic Daisy Average Freq.)	192.06	5.09	0.03
(- Sedge spp. Average Freq.)	193.09	6.12	0.02
(- Distance to Escape Terrain)	205.31	18.34	0.00
(- Long-awned Sedge Percent Freq.)	206.59	19.62	0.00

DISCUSSION

Our behavioral observation data suggest that mountain goats on Kodiak spent most days feeding or bedded within feeding sites, as expected. We rarely observed mountain goat groups moving among feeding sites. Observations in the field showed that mountain goats generally walked short distances (a few meters) to new foraging patches within a feeding site, but this walking behavior was likely under-represented in the data using our scan-sampling method because the behavior was erratic, and each bout was short in duration. Although little information is available on mountain goat behavior (but see Festa-Bianchet and Cote 2008), studies of other northern ungulate behaviors have revealed results similar to ours (Frair et al. 2005). Large herbivore spatial behavior has been characterized by short and localized movements within a feeding site, separated by longer and more linear forays to new feeding sites (Forester et al. 2007). Our observations anecdotally support this pattern for mountain goats on Kodiak, although more data is needed to statistically confirm it. Mountain goat behaviors on Kodiak are likely adapted for conserving energy within a heterogeneous environment, while avoiding predation. If preferred forage resources are unequally distributed and selected, as our feeding site selection results suggest, mountain goats would benefit energetically by remaining at a feeding site until the available forage reaches a critically low threshold and triggers a movement to a new feeding site, or a threat immerges. When we inadvertently caused mountain goat groups to flee feeding sites, we commonly observed what appeared to be the same individuals (similar group sizes and classifications) reoccupy the same area shortly thereafter (i.e. the next day).

Although we were unable to classify a large portion of mountain goat groups by sex, groups that we could classify were generally composed of a large proportion of adult females, some kids, and few adult males. Sexual segregation during the post-partuation to pre-rut season (typically June to September) is common for mountain goats ("nursery bands") (Festa-Bianchet and Cote 2008), and other northern herding ungulates such as bighorn sheep (Woolf et al. 1970), elk (Weckerly 1998), and caribou (Jakimchuk et al. 1987). It is likely that the few adult males that we observed were yearlings subsequently left the nursery bands to join other males following the rut. Billies are typically solitary, or form small groups during the summer (Festa-Bianchet and Cote 2008). Therefore, they might have been less likely to have been observed in this study and underrepresented in our results.

Feeding site selection model results indicated that the percent cover and frequency of long-awned sedge (*Carex macrochaeta*) were important predictors of summer feeding site selection by mountain goats on Kodiak. Like many ungulates, mountain goats are considered selective generalist feeders and display preferences for specific forage (Festa-Bianchet and Cote 2008). This selective feeding behavior generally manifests itself in differential selection of available habitats, which is likely what we observed on Kodiak. Mountain goat foraging sites have been generally described as alpine meadows near cliffs (Von Elsner-Schack 1986). Confirming our findings, mountain goats in the Hidden Basin region of Kodiak in the 1970s were found to select sedge meadows and slopes as feeding sites during the summer, where their preferred forage was also long-awned sedge (Hjeljord 1971). Microhistological results of mountain goat pellets collected at feeding sites will confirm whether long-awned sedge is currently an important diet item.

In addition to long-awned sedge's importance to mountain goats on Kodiak, long-awned sedge has also been found to be heavily used by Kodiak bears in the spring (Atwell et al. 1980). Given overlapping dietary preferences, the potential exists for forage competition between bears and mountain goats. Bears have been observed congregating at high densities (0.85 / km^2) on localized patches of long-awned sedge, and Atwell et al. proposed that bears focus on this plant because it is fast growing, nutritious, and one of the first to emerge following snowmelt but before salmon spawning (Atwell et al. 1980). Although the potential for competition exists, we did not directly observe interactions between bears and mountain goats to support this hypothesis.

Our model results indicate that escape terrain proximity is a critical element of mountain goat feeding site selection. The importance of escape terrain to mountain goat habitat selection has been well-documented (Gross et al. 2002, Poole and Heard 2003, Hamel and Cote 2007). Our results are not surprising because capturing nutrients and avoiding predation are two of the most fundamental elements to an animal's behavior. Unlike other mountain goat populations that are preyed upon by wolves (Fox and Streveler 1986), the only large predators capable of killing an adult mountain goat on Kodiak are bear and humans (Cote and Beaudoin 1997, Demarchi et al. 2000). The level of bear predation on mountain goats on Kodiak is unknown, but bears are known to predate mountain goats and their kids (Cote and Beaudoin 1997).

Field work on Kodiak's mountain goats presented substantial logistic difficulties. Foul weather often delayed flights transporting field crews, prevented aerial surveys, and made camping and traveling in the field challenging. Researchers experienced high winds (40-50 mph) and rain while camped on the eastern ridge of the Hepburn study area during the first night of field work that damaged tents and nearly threw a food tent off the mountain. After this experience, we camped in lower elevation valleys that were more protected from the winds and slept more comfortably. Although we slept better, camping lower in elevation required longer and steeper hikes (ascends exceeding 2000+ft daily), and long days (often 10-14 hours) to complete the field work. When snows melted in the mountains and the weather was more amiable (mid-July to August), the field crew was able to comfortably camp in the high country, and conserve time and energy.

Our ability to locate and approach mountain goat groups depended on the study site, time of year, and weather conditions. Goats at the Hepburn study site were easiest to locate and approach because were relatively close to camp, not on inaccessible terrain (Hepburn is the lowest elevation study site), and were found in the only 2 areas. Alternatively, locating and approaching mountain goats in the Uyak and Terror Lake study sites presented more of a challenge because they were further from our camps, on steeper or inaccessible terrain (steep snow field and cliffs). In general, mountain goats were easier to locate and approach as the summer progressed. This was mainly because they were generally found on ridges rather than steeper mid-elevation slopes, and getting to their locations was easier because we were often camped higher in elevation, and we were not required to post-hole over snow. Finally, mountain goats were difficult-to-impossible to locate when weather conditions deteriorated. Low cloud cover prevented us from be able to spot mountain goats from any distance, and we experienced winds on ridges that made even standing and walking difficult. We found that mountain goats

were especially vigilant during high winds, which compounded the challenges associated with approaching them. Taken together, these observations should have implications for future work. Unless there is a direct need, researchers may want to consider delaying field work until mid-late June when conditions are more hospitable and extending field work into September. We ended field work before hunting season began (end of August) in response to concerns that our work may impact hunters' experience. Future field work might require trips longer than 10-day to achieve study goals. Longer trip would allow for rest days and would buffer for potential weather.

Understanding the diets, feeding site selection patterns and behaviors of the irrupting Kodiak mountain goat population is a critical first step to empirically-driven harvest management. Although just a pilot study, our results indicate that mountain goats select feeding sites that have a greater proportion and abundance of sedge species, specifically long-awned sedge, and sites that are close to escape terrain. This finding was universal, regardless of goat population densities or history of occupancy. Pending fecal microhistological results will provide additional information on their diets. If Kodiak's mountain goat population exceeds their carrying capacity on Refuge lands, which will occur unless the current population growth rate is limited by hunting or other means, goats will likely cause a reduction in their preferred forage species, which could in turn affect other species, such as bears, that also rely on these species. Future work is needed to further understand the relationship between goats and Kodiak's mountain goat resource selection patterns, population dynamics, and harvest management options.

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APPENDIX 1

Mountain Goat Behavioral Observation Datasheet
Summer 2011, Kodiak, Alaska

Datasheet ID:_____ (YYYYMMDD##)

Mountain Goat Behavioral Observations

Date:_____ **Study Site**: Hepburn Uyak Crown **Observer initials**:_____

Weather: Sun P/C Cloud Rain Snow Sleet Fog **Wind**: Speed_____ Direction (°) _____

Observer UTM: E: _____ N: _____ **+/-Error** _____

Group Size: _____ **Adults**:_____ **Nannies**: _____ **Billies**:_____ **Kids**: _____

Observer Aware: Y N **1st Reaction Time**:_____ **Distance**:_____ **Response**: Alert Stand Walk Run

Location Description: _____

_____

_____

Group Behavior

Time	# Feeding	# Bedded	# Standing	# Walking	# Running	# Other

Fecal Samples

ID:_____ UTM E:_____ N:_____

ID:_____ UTM E:_____ N:_____

ID:_____ UTM E:_____ N:_____

ID:_____ UTM E:_____ N:_____

ID:_____ UTM E:_____ N:_____

ID:_____ UTM E:_____ N:_____

ID:_____ UTM E:_____ N:_____

Mountain goat vegetation survey datasheet, summer 2011, Kodiak Island, Alaska.

Mountain Goat Habitat Site Description

Study Area: *Hepburn Uyak Terror/Hidden* **Site:** *Random Used* **Site ID:**_____ *(eg. YYYYMMDDPlot##)*

Date: _____ **Observer** *(initials)*:_____ **Permanent?** *Y N*

UTM E: _____ N:_____ **+/-Error** *(m)*:_____

Aspect *(°)*:_____ **Slope** *(°)*:_____

Initial bearing:_____ **KLCC class:**_____ **Distance to Rock Outcrop** *(m)*:_____ **Feces in plots?** *Goat Deer Unknown*

Site Description:_____

Species	0		2		4		6		8		10		12		14		16		18		20		22		24		26		28		30		32	
	T	*P*	*T*	*P*	*T*	*P*	*T*	*P*	*T*	*P*	*T*	*P*	*T*	*P*	*T*	*P*	*T*	*P*	*T*	*P*	*T*	*P*	*T*	*P*	*T*	*P*	*T*	*P*	*T*	*P*	*T*	*P*	*T*	*P*

**** shade the lower right corner of the box if species are grazed.*

APPENDIX 2

2011 Mountain Goat Field Summary
Heidi Helling, Biological Science Technician

Overview
The 2011 summer field season began June 2, 2011 and ended on August 19, 2011. Mountain goats were sampled from 3 study sites as part of a pilot study to determine methodologies, logistics, and the feasibility of each site. The principal investigator, McCrea Cobb was present in the field with a field crew for the first half of the summer season. One field tech (Heidi Helling) and 2 volunteers (Ross Dorendorf, Adia Stovie) were present throughout the entire summer field season. The third volunteer (Aarin Sengsirirak) joined the field crew for the second half of the summer field season.

Hepburn Study Site
Trip 1
June 2-9, 2011

Route of travel / Camp sites
McCrea Cobb, 2 volunteers, and I were dropped off at the tip of Hepburn Peninsula by Refuge pilot, Kevin Van Hatten. We proceeded to hike up the eastern ridgeline of the peninsula and set up camp night 1 just south of peak 2048 by about 1 km. We experienced extremely strong wind speeds that night (~50mph), causing our cook tent to almost blow off the mountain and damaging tent poles, so the following morning we hiked down in elevation into Hepburn Valley to camp (UTM N444145, E6317596). The crew worked from this camp for 3 nights, and then unfortunately moved camp during a second extreme wind/rain storm (X-tuffs, thermos and pack covers were blown off our packs). That day, we hiked out from camp heading north intending on reaching a cash of food located on the shore near the northern end of the peninsula. We traveled along the eastern ridgeline, but to avoid the strong winds, dropped down into a bowl where the western and eastern ridgelines merge. We camped in a lovely (not really) fern salmonberry side-hill meadow at approx. UTM N446043, E6323161. The weather continued to be horrendous into the following day, which we stayed in tents to try to stay warm and dry, then hiked down the valley the following day to Ivor Cove where Refuge pilot Kevin Van Hatten picked us up. No points could be accomplished the last three days, because of the weather conditions. Note: vegetation on the western Deadman side of Hepburn is extremely thick in vegetation and populated by Devil's Club.

Work Accomplished
Being the first stint of a pilot season and with the adverse weather conditions in early June, efficiency was not necessarily high. Potential goat populations and random location were not accessed north of the midsection of the peninsula (which is where the western and eastern ridges merge). Sampling methods were tested on 4 used sites and 17 random locations (Total: 21). Four behavioral observations were conducted and 11 fecal samples were collected. See data for specific points sampled. We revised our initial vegetative sampling from four 16 meter transects (forming an "X") to two 16 meter transect (a straight line) due to time needed to allocate towards

a T4 transect (~2hrs during a plant dormancy phase). Random locations were primarily reached on the eastern and western ridgeline. Techs reported the western ridgeline is accessible during this time of year, but to be cautious of steep drop-offs along jagged ridgeline. Snow was still present down to ~1200 ft in elevation.

Mountain goat locations / on the ground herd populations estimates

Goats were primarily at lower elevations which may represent late winter / spring ranges. A total of 39 individuals were counted throughout the study area visited, which was south of where the west and east ridgeline merge. A group of 7 adults with 5 kids were located on a south facing slope in the bowl near our first campsite (UTM: N445250 E6316004). The goats were using a steep eroded drainage for escape cover and feeding on a ~30^0 slope adjacent to the drainage, which was predominantly salmonberry/fern meadow and at ~ 1,000 ft in elevation. Reproductive rates appeared to be high. The remaining 27 goats (17 adults and 10 kids) were mid-slope at ~1000-1200ft in elevation. (Generally at UTM N444276 E6318845). Goats were on the western ridgeline feeding along SE facing slopes. However, I did notice a trend with goat movements and cloud cover. The goats seemed to graze along the cloud ceiling line and moved up or down in elevation depending on changing weather conditions. On June 5, we had calm skies with a 10,000 ft ceiling. On this day, goats on the western ridgeline (which were visible to me since I was on the eastern ridge) moved along the SE face and up to the highest peak on the ridge (peak 2290). Obvious escape terrain exists on the western face of this mountain. No additional goats were spotted though binocular observations further north where the east and west ridgelines merge.

Future Considerations for early June research in Hepburn

Weather at Hepburn Peninsula during the early summer months (May and June) is inclement. Geographically, the peninsula seems to frequently receive extreme conditions, since it is exposed to westerly and SE winds coming off the gulf. This study site has the highest probability for high winds, and campsites should remain low at this site. Camping in Hepburn valley is a great option for future research and also allows for field crews to begin days at 600 ft in elevation. Early on, the vegetation is not too difficult to navigate through and ridges/goats are easily accessible.

Hepburn Study Site
Trip 2
July 13-21, 2011

Route of travel / Camp sites

Three volunteers (Ross, Adia, Aarin) and Heidi returned to Hepburn on July 13. A first attempt to fly in was made on July 9, but winds were too strong to land. Initially, the logistics were mapped out to camp near the southern tip of the peninsula (south of a private cabin) with a food cache (bear box), and leave another cache on the northern end of Sulua Bay. We were going to work from the first cache for roughly 5 days then backpack (with Trango / Hilleberg tents) and then work from the Sulua Bay cache for another 5 days. When we flew in with Refuge pilot Isaac Bedingfield on the July 13th, he indicated that winds were forecasted to be high for 4 days

and scheduled to reach 38 mph. The southern end of the peninsula is the most exposed to weather, so I decided to start field work based from the Sulua Bay camp. We arrived at Sulua Bay and set up camp behind an alder stand for added cover (UTM N447932 E6320084). Camp worked well in this area although at night we still had strong winds for ~3 days. On day 5 we moved camp down the beach at low tide to the southern tip of the peninsula and made it to lake 65, which was about a 9 mile hike. The main reason for moving camp was Ross and I worked a 14 hr day (which meant getting back to camp at 12:15am) to reach goat populations on the western ridgeline from Sulua Bay. This work was manageable, but not sustainable or efficient. We were attempting to climb up into Hepburn Valley where we camped during the first visit, but at this time of year all vegetation is leafed out, and from the southern tip of the peninsula, the hike was another 4 miles through deceivingly diverse topography and head high vegetation. Although this route looks easy to traverse on paper, I would not suggest this route for future research. Camping at lake 65 was okay. We had water, but it was questionable since it seemed so stagnant. One tech later contracted giardia, although the source was unknown. Bugs were bad. But, the sunsets were beautiful. The day after we moved camp, McCrea and Isaac visited us while conducting aerial goat surveys. Ross and I met the plane (Aviat Husky) on the beach near the cabin, and Isaac shuttled us in the plane to lake 1035 located due west of peak 2290. Here, goats were easily accessible and an ideal future camping spot was discovered. (Side Note: When we camped at lake 65, two techs hiked to the western ridgeline towards goat populations when Ross and I were being flown to lake 1035. They were quite successful in data collection, and reported minimal bush-whacking. However, their work day was still 12 hrs.) On day 8, we hiked east and north along beaches at low tide towards Sulua Bay to be in a more accessible spot for airplane pick-up. Kevin was able to get us later that evening from Sulua Bay.

Work Accomplished

Despite the lack of a perfectly positioned campsite to work from, we still managed to get a ton of work done. Camping far from goats meant 10-13 hr days, with one work day topping out at 14 hrs (no exaggeration, and these long days were also filled with mountain climbing). We completed vegetation plots at 12 used sites and 26 random locations (total 38). We conducted 4 behavioral observations and collected 31 fecal samples. See data for specific points sampled. The entire peninsula was successfully traversed to reach random locations, and we were able to reached northern southern ends. Additionally, all ridges were accessed and data was reasonable to collect from these areas.

Mountain goat locations / on the ground herd populations estimates

Observations indicated that goats on Hepburn Peninsula showed a strong site fidelity to the western ridgeline south of the ridgeline merge. Goats moved throughout this region, but tend to concentrate around peak 2290. Significant escape cover is characteristic of the western aspect of this peak. A few lone goats were observed on the eastern ridge and at lower elevations (most likely billies) during the aerial survey, but we did not spot these goat from the ground. Goat sign was observed at the northern end of the peninsula, but it was minimal and likely represents only a few individuals. Escape cover is not a significant part of the topography in areas where goats were not observed. Herd estimates were difficult due to topography and timing of herd movements, but at one time a total of 29 individuals were counted with 8 kids. I believe that this estimate is low, and that numbers were similar to what we observed in early June (near 40 individuals). Compared to other study sites, reproduction does seem to be high in these areas.

My personal observation of this herd, in comparison to the Uyak or Terror/Hidden study sites, is that goats look visibly younger. I was unable to get a good count of horn annuli for multiple individuals to support this, but in general, the goats look quite young (thinner horns and smaller/younger looking bodies). Also, goats in this region were seemingly perplexed when approach by us and did not instantly run like in other areas. This difference in behavior might be due to limited human interactions. We were sometimes able to get quite close to herds (~20 m), so future behavioral observations are definitely feasible and our observed used sites are accurate. The goats have created a well-worn trail along the western ridgeline, south of where the eastern and western ridgelines merge, in the area that they seem to habitually use. They appear to be quite weary if you have come between them and their escape cover, to the extent that they will even approach an observer to reach escape cover. Primarily, goats appear to be selecting for Long-awned sedge (*Carex macrochaeta)* at feeding sites, however *Bistorta vivipara, Sedum rosea, Lupinus nootkatensis* (flowerheads), *Erigeron peregrinus*, other sedges species, *Salix pulchra,* and *Calamagrostis canadensis* were also grazed upon at used sites. Lichen did not appear to be grazed upon, but *Cladina* species where present in veg plots. This observation was consistent across all study sites. Evidence of digging and areas of bare ground were observed often at Hepburn, which was likely primarily to create bed sites. However, it appears this behavior might also be related to goats foraging on roots because of the shape and depth of the digs. Evidence of this behavior was even more prevalent at the Hidden Basin study area.

Future Considerations for July research in Hepburn

Overall, the trip was a success. Weather was sunny, clear, and a bit windy the first few days, but we did not experience severe weather like the earlier Hepburn trip. Hepburn is a feasible study site, but camp placement is a crucial determinant of work efficiency. I recommend two campsites: the first at Lake 1035 (this would be more of a mid-late summer site) and the second in Hepburn Valley near where we camped on our first trip. Goats could be easily accessed from these sites, and both sites are relatively protected from inclement conditions that frequent the region. Also, goats are typically in the southern end of the peninsula, so less time can be spent scouring the slopes on the northern end of the peninsula. To reach Hepburn Valley, I would recommend hiking from Sulua Bay (after July 1) or up from the tip of the peninsula (before July 1, and if a plane can get in there). Green up patterns dictate the choice of starting points. At Sulua Bay, there would be an enjoyable (not really) several hours of swimming uphill in dense salmonberry to reach the ridgeline, but this would be the most efficient approach. Since I know a path of least resistance up that slope, it may not be too terrible with heavy packs. I believe that the Deadman Bay side of Hepburn Peninsula is too densely populated with vegetation to easily traverse, unless one hikes up the valley to Lake 1035. Overall, it is important to reach a centrally-located campsite, even if doing that is arduous. Doing this significantly sheds hours of rough hiking to reach locations and goats daily, which could lead to additional complications (i.e. fatigue, knee injuries, hiking at night, and experiencing weather). Even from a spike camp, hiking to goats and some random locations is difficult and fatigue, injuries, and weather consistently come into play. After mid-season, there are no running streams in the highcountry, so crews need to carry ample amounts of water with them. Unfortunately at Hepburn, camping high on ridges is a recipe for getting your camp blown off the mountain, no matter what time of year. But, the area is manageable, gorgeous, and has many goats that can provide data representing selection patterns, since they seem to have tight site fidelity to a particular region

within the study area. It appears that they are heavily foraging at specific sites. Also the timing of colonization of goats to this specific region makes for an ideal study site.

Uyak Study Site (Lake 629 Subregion)
Trip 1
June 14-17, 2011

Route of travel / Camp sites
This was our second trip of the season, and in hindsight, I think we were personally scarred from the extreme weather conditions and arduous travel experienced at Hepburn. In that week at Hepburn, we all lost a significant amount of weight (~6-10 lbs each!). In response, we attempted to work from a basecamp at Lake 629 using two Bomb Shelter tents, camp chairs, a table, boot dryers, cots, tons of food (bear box), and with no intention of moving camp. Camp was comfortable and dry, but we were required to hike 12 hr a days to reach goats and random points. We worked from this base camp and approached both mountain ranges to the north and south of Lake 629 for several days. It should be noted that traversing up the southern mountain involves committing yourself to serious bushwhacking, although the northern mountain has a semi-established trail up the SE spine which we used to reach reasonable flat bench below the summit. On this bench, we found several half frozen lakes which would make (and did during the 2nd trip) great spike campsites.

Work Accomplished
At this juncture, the study site was still ambitiously large, and our time was primarily served as a reconnaissance mission for future research. We completed vegetation plots at 2 used sites and 6 random points (Total = 8), conducted 2 behavioral observations, and collected 12 fecal samples. The majority of the random plots were accessed on the northern mountain, while the southern mountain remained largely inaccessible during this time of year due to steep and icy terrain. Climbs from base camp required crews to hike up to 3000 ft or more. The north side mountain peaks at 4,300 ft, but the snow line was at 2,000-2,500 ft.

Mountain goat locations / on the ground herd populations estimates
One single billy goat was observed on the mountain south of Lake 629 (UTM N463575 E6362498) on June 14. Larger groups were located on the southern aspect of the northern mountain at about green up elevation (2,000-2,500 ft). Here, goats were foraging just above the salmonberry- alder line. We spotted a group of 18 goats (UTM N461776 E6366743), which were feeding east of some escape terrain. When approached, the group traveled upslope towards another group of 22 (UTM N461866 E6367249) that were also feeding adjacent to escape terrain (to the west). The combined group had 7 kids. Goats here were approachable, and we were able to get 80 m from the initial group of 18. We collected fecal samples from this group. The goats have made a well-worn trail along the spine of their feeding site and the adjacent escape terrain. As we approached our first used site, 3 goats were still below us and instead of giving us a wide birth and walking upslope and away from us, their behavior indicated there was a need to group up with the larger group. This was the first time I realized how “hard-wired” goats are in terms of their landscape use. The goats approached us along this trail (looking perhaps confused and/or worried), using the established trail to reach the other herd. One of the two used sites was

primarily composed of *Empetrum nigrum*, with *Carex macrochaeta*. I noticed (which may not entirely be true) what appeared to be a lack of moss species and seemingly dry soil at used sites. The other used site had a bit more alpine forbs present. We observed several beds dug into the slope, and a large amount of goat hair was caught among willow branches surrounding the site.

Future Considerations for June research at Uyak- Lake 629

More in-depth details discussing this study site are mentioned in the Trip 2 portion of this summary. Most importantly, a spike camp is necessary for this study site. There are several lakes located along the eastern side of the northern mountain which are not completely frozen at this time of year. The southern mountain has potential spike camps sites located at approximately UTM N466466 E6361171. The use of ice axes is necessary at this site during this time of year.

Uyak Study Site (Lake 629 Subregion)
Trip 2
July 29- August 7, 2011

First 5 days – Lake 629

An aerial survey was conducted prior to our second stint in this region. Results indicated that the vast majority of goats were located on the northern mountain, while several goats were located on the southern mountain. The study site was initially designed to have crews visit both the northern and southern mountain. Given the 5-day time constraint, I decided to concentrate efforts to one of the two mountains. The northern mountain was selected primarily due to the greater goat occupancy.

Route of travel / Camp sites

Kevin dropped us off on the eastern shore of Lake 629, and we approached the northern mountain. We hiked the same route traveled on our first visit (the SE spine where there is an overgrown established trail). We were carrying 65-70lb packs. We set up a spike camp near the largest lake on the bench (UTM N464837 E6366401), which took us about 3 hours to reach. The campsite was ideal and should be used for subsequent field seasons. The northern mountain peaks at 4,354 ft., however, reaching it from our spike camp was seemingly easy. This mountain is not especially steep, except for some parts of the northern aspect. We summited this peak on several occasions and the views were amazing. After the first round of study site visits, McCrea and I decided to limit the extent of study sites to regions more realistically covered over 5-day stints. Random locations occurred across the mountains bench, on all aspects, and NW along the ridgeline to approximately (UTM N462087 E6368650). Since we were based from a spike camp, traversing the extent of the study site was feasible and efficiency increased dramatically. We approached the peak by side-hilling the mountain, hiking up the SE spine, and hiking up the western face (bit steeper) and all was feasible. On day 5, we hiked down to Lake 629 (no data was collected on this day) in hopes to get picked up to get moved to the Brosis Valley site (the next study site). We followed the same route that we took on the initial ascent. The weather was poor; we hiked in rain, which only stopped for a few hours in the afternoon while we were waiting for Kevin at Lake629 and allowed some gear to dry. Conditions remained windy, preventing a pick-up that day. Conditions were still marginal until mid-afternoon the next day.

Kevin picked us up around 3pm and transferred us to the Brosis Valley site (the drop off site is at sea level). After shuttling the crew twice to get out of Lakae 629 and repacking gear, it was evening and weather conditions were again deteriorating (wind, rain, and fog). Therefore, we camped for the night at the drop off location.

Work Accomplished

We had a campsite that was ideally positioned and allowed high work efficiency. Crews averaged about 7 points per day, which helped with crew moral. On our first day after we hiked up to our spike camp, we were able to visit 5 random locations that were relatively (very) close to camp. We completed vegetation plots at 10 used sites and 30 random locations (Total = 40), conducted one behavioral observation, and collected 38 fecal samples. We would have liked to have conducted more than only one behavioral observation; however, I initially stressed the importance of collecting used site data as a higher priority to the behavioral observations.

Mountain goat locations / on the ground herd populations estimates

Aerial surveys indicated that the region east of Uyak Bay held some of the highest mountain goat densities on Kodiak. On Mt. 4354 (north of Lake 629), our largest group totaled 55 individuals, which included 11 kids. This group was located at approximately UTM N 461977 E 6368103. I believe that this particular group (which was observed after Tim and I found them around at a location ~500 m to the NW along the ridgeline) was a near census of goats on the mountain (with perhaps an additional ~10 uncounted). Billies at this time of year were generally spotted near nursery groups, bedded or feeding alone, or a bit further down slope (~50-150m). At other times they are with the larger group, such as the group of 55. During our visit, a group of ~20 goats were visible from Lake 629 (before we hiked up) near the summit on the SE aspect. In one day, they moved further back along the ridgeline and were located near the furthest extent of our study area (See UTMs above). The NE aspect of this ridgeline has (seemingly) ideal escape terrain for goats. Goats were observed feeding on ridgeline where terrain was relatively flat, but adjacent to cliff band. Goats primarily stayed in this region for the duration of our stay. Plant species grazed upon was once again primarily *Carex macrochaeta* with sign of grazing on *Bistorta vivipara*, *Sedum rosea*, *Lupinus nootkatensis* (flowerheads), *Erigeron peregrinus*, various other sedges, and *Calamagrostis canadensis*. I completed several used site plots (while working with Tim) at these locations, and observed an abundance of *Cladina* spp. lichen in plots and the surrounding area, but not much of *Carex macrochaeta* (which is usually dominant at used sites). When goats were approached, they appeared to be a bit spookier than Hepburn goats, although we were getting closer to the hunting season opener. Perhaps this influenced behavioral patterns. Even still, we were able to still get within ~40 m. Tim and I were on the cliff-band edge and approached to about 4 m from a nanny and kid who were using a steep trail just beneath us to move away from our tape measure. From this experience, I realized that it could be possible to run down a kid (and collar it). But, I am not so sure how the nanny would react. Overall, mountain goats in the region were generally accessible; plenty of them from which record used site data ad gather fecal samples. The goats were approachable.

Future Considerations for July-August research at Uyak-629 (Mountain 4354)

Well, I believe that this visit was a success, taking into account the 5-day time frame. Regardless of the advantages of the spike camp and the relatively easier terrain to navigate, we still worked 10-12 hr days to take advantage of the great weather and the seemingly endless opportunities to

approach goats. The long days felt less exhausted since more time was spent at plots (sitting) rather than hiking (the size of the study site was more reasonable). I would recommend conducting field logistics in this area similarly in the future. I would, however, recommend extending the duration of the trip to enable us to visit more used and random site locations.

Uyak (Brosis Valley Subregion)
Trip 2 (1st for Brosis Valley)
August 2 – 7, 2011

Route of travel / Camp sites
As mentioned above, we arrived at the base of a drainage which heads up the 1800ft hillside that leads into Brosis Valley late in the day and with worsening weather conditions. We camped at the drop-off location for one night, and then hiked up Brosis Valley to establish a spike camp the next day. The valley lies at the base of 3,700-4,000 ft mountains. Vegetation from sea level to approximately 1,800 ft was HEINOUS; thick and overgrown. It almost looks impassible, or passible with foresight of one becoming seriously irate towards the ridiculous overgrown plants that seem to be hopped up on fertilizer. It was the thickest vegetation that I have encountered in 3 summers on Kodiak. I personally committed myself to not speak to anyone during the hike up, or severe negativity might have spewed out. The south side of the drainage for some reason looked marginally manageable. In reality, there was a network of establish bear trails that we followed, making the experience manageable. The trail that we followed led to the south and then up hill. By no means is there a trail all the way up, but the bushwhacking in this region could have been much, much worse without this trail. So, the hike up is quite feasible. We establish a spike camp (UTM N 453843 E 6366463) on the south side of Brosis valley. The valley is large and largely populated with chest high willows, so I would suggest this campsite. The campsite worked quite well, it was near several streams and protected from high winds. Much of our work was based at the back end of the valley, over the ridge into the nest bowl (SE), and along the southern ridgeline.

Work Accomplished
Similar to the second Lake 629 trip, this trip was a success and the only limiting factor was time. We completed vegetation plots at 11 used sites and 24 random locations (Total = 35), conducted 5 behavioral observations, and collected 22 fecal samples. The terrain was a bit steeper than the Lake 629 site, but manageable. We typically worked 10hr days (which were incredibly rewarding) and were able to access most locations. Once again, more time in the field was spent conducting vegetation surveys, so physical fatigue wasn't too bad.

Mountain goat locations / on the ground herd populations estimates
Goats occupied the ridgeline south of Brosis Valley. For our first night at the spike camp, three single billies were observed on the north face of this ridgeline. The following day, a group of 11 goats (no kids) were observed just below Peak 4064 on the NW aspect on a small linear patch of vegetation among scree. Adia and I hiked to this location and later found a group of 25, 12 and 7 on the southern aspect of peak 4064. The group of 7 were bedded further east along the ridgeline on a scree slope. The group of 25 goats were observed on the southern aspect (directly downslope) from peak 4064. Some goats (~12) were bedded on scree, approximately 45m from

the remaining goats who were feeding in a vegetated chute that ran down the mountain side. Another group of 12 were feeding on the SW aspect approximately 200m from the group of 25 (See data for specific used site UTM locations). The goats were approachable, and we were able to get ~50 m from the nearest individuals. A group of 6-7 goats were spotted east of Brosis Valley near the eastern edge of our study site (UTM N 456641 E 6364813, in a bowl). An aerial survey conducted less than 2 weeks prior observed the majority of the goats in this study site were at this location. I'm assuming the larger groups we saw were the same individuals located during this aerial survey.

Future Considerations for July-August research in Brosis Valley

This was my favorite site. A spike camp is essential for mountain goat work in this area. I would also recommend spike camping from the initial spike camp, perhaps with minimal gear (bivy), to enhance data collection opportunities. Data collection is feasible on all ridges and mountains. On marginal weather days, inclement conditions tend to sit at the far eastern end of the valley (something to consider when considering camp sites) and also the southern ridgeline (which could be due to the fact that it is significantly higher in elevation than the northern ridgeline). Work efficiency was high, with an average of 7 vegetation surveys per day, per team. Our only limitation was time, so I would suggest a longer site visit.

Hidden Study Site (Terror Lake Subregion)
Trip 1
June 21-26, 2011

Route of travel / Camp sites

We operated out of a base camp established on the road on the northeastern short of Terror Lake (UTM N 499844 E 6388815). We used two Bomb Shelter tents, camp chairs, and bear box for food storage.

We hiked to random locations along the southern mountain rising from Terror Lake, the large snow basin south of this mountain, and on Shotgun Ridge. McCrea, Ross, and Adia also visited the mountain range NW of Terror Lake, which was approached by an extremely long (3hr round trip) road walk and a climb to approximately 3,600 ft. To approach the snow basin and other areas south of Terror Lake, we walked the road. Snow was extremely prevalent. McCrea and I traveled throughout the snow basin and Shotgun Ridge, and managed to remain on snow for the entire work day. Skiing at this site (specifically south of Terror Lake) for the first trip would be the most effective way of travel, and should be implemented into subsequent field seasons. The western aspect of shotgun ridge remained largely inaccessible (cliffs) but possibly could be accessed via a bowl to the south. The mountain range to the north of Terror Lake was visited to access a used site, and the mountain to the NE of Terror Lake was accessed for random and used locations. Travel was relatively easy, bushwacking is minimal, and longer distances can be covered more efficiently at this site.

Work Accomplished

We completed vegetation plots at 3 used sites and 47 random locations (Total = 50), conducted 3 behavioral observations, and collected 15 fecal samples. A large portion of the random sites were snow.

Mountain goat locations / on the ground herd populations estimates
A group of 12 goats were observed at about 2,500 ft on the western aspect of Shotgun Ridge. This location was characteristic of the green up line at this time, and this aspect could be considered typical goat escape cover. Large cliffs dominated slopes with intermittent shallower bands of vegetation above more cliffs. Goats at this site were seen bedded/foraging along benches, which later moved further down slope and used areas adjacent to steep eroded drainages. Mid-slope eroded drainages are a consistent land feature of many mountains across Kodiak Island. Goats were also observed from camp on the NE slope of the mountain range west of Terror Lake. This included a single billy and a group of ~10 that were using a ridgeline or an area just below to feed. When crews visited this site, they observed a larger group further down the valley on the next mountain to the west that could not be accessed within a day trip. Another group of 3 goats (2 nannies and 1 kid) were observed from the road just NE from camp. goats are rarely seen on this mountain, but it appears to be used by goats for dispersal to adjacent ranges (tracks in the snow observed). No adequate escape terrain exists on this mountain range. The valley to the NW may be used as a corridor for goats to access the range north of Terror Lake. Goat hair was found in this valley among willow branches. The approach to the northern range took 8 hours and we recorded 2 used sites. Once again the goats were at roughly the same elevation as those on Shotgun Ridge (2,500 ft line and on the green-up transition line). This used site was similar to others (i.e. elevation, species present, aspect, distance to escape cover) except that we observed a significant bed excavated by goats. As we approached, two goats were both laying in the bed. The excavated site was 5 feet in length, 2 feet wide, and about 2 feet deep. All goats were approachable to close range. We approached this group to within 100 m.

Future Considerations for June Research at Terror Lake
My suggestions to increase efficiency at this site are listed below in the Trip 2 section. During the early season, I recommend using skis to reach locations within the region south of Terror Lake (and it would be fun).

Hidden Terror Study Site (Hidden Basin Subregion)
Trip 1
June 27-July 1, 2011

Route of travel / Camp sites
We camped using the same gear as we did for Terror Lake, and once again worked from a base camp. We set up our campsite at UTM N 505419 E 6374161. This site is characterized by a long north-south ridgeline running from Hidden Basin towards Crown Mountain, with high alpine bowls and steep slopes. There is an established trail up the SE spine of the ridge, so we did not have to navigate through thick vegetation. However, we were climbing a cumulative of ~3,500-4,000ft daily, and descending the same distance. The crew fatigued quickly. We were not able to access regions north of the second bowl (Twin Lakes), and I think this was a product of long days of hiking. There are steep and snow-covered regions that makes this site a bit more inaccessible this time of year for data collection. Some points were on $>50^0$ slopes, which were dangerous to traverse at this time of year without mountaineering gear.

Work Accomplished
We completed vegetation plots at 4 used sites and 13 random locations (Total 17), conducted 2 behavioral observations, and collected 15 fecal samples.

Mountain goat locations / on the ground herd populations estimates
We found two distinct groups of goats on south facing slopes near the "first" and "second" bowl. I'll refer to the second bowl as Twin Lakes since there are two lakes (creative). A group of 10 goats was observed on the NE spine of the first bowl and later moved up near the peak. This area was snow-free, being a southern aspect. Another group of 10-12 goats was observed on the NW spine of the Twin Lakes bowl in one of the few snow-free locations. No kids were observed in either group. At used site locations, it appears that the goats had dug up significant portions of the ground. Bare ground resulting from goat digging appeared more prevalent at this site than other study sites. It appeared that goat beds have been dug up over longer periods. We also saw evidence of goats pawing at the ground, possibly for roots or minerals. A well-defined trail runs along the spine of the areas where goats were observed, and along the ridge line to the two bowls. Therefore, it appears that goats use the entire ridgeline within the study area. Like at other sites, goats were approachable to close distances.

Future Considerations for June / July research at Hidden Basin
A spike camp was needed. During this period, the first bowl is relatively snow-free and would have been an ideal location for camping. Water was available. The Twin Lakes bowl was still completely frozen. Accessing goat locations from a basecamp at sea level was not efficient, and there is too much elevation change to maintain the crew. Contrary to other members of the crew, I believe the steep face on the north end of Twin Lakes ("The Wall") is climbable this time of year (did not attempt it this stint). The long approach from sea level tired the crew and made it look more arduous than it actually is. Even still, an unarrested fall down The Wall would send a person into a half frozen lake. Like for other sites, I suggest a longer trip that would allow for more data collection opportunities and give us a larger window for marginal weather conditions. I also recommend camping in the first bowl (with lots of warm clothes) and carrying ice axes. Some areas will take time navigate due to the terrain (steep and need good weather). With a longer trip, we could focus on data collection in difficult locations for selected days without feeling rushed. This actually speaks for all study sites!

Hidden Terror Study Site (Terror Lake Subregion)
Trip 2
August 11-15, 2011

Route of travel / Camp sites
We used the same campsite as the first trip. Unlike the first trip, the road was now snow-free and being used by KEA for maintenance. After speaking with them, we camped on the road shoulder to be out of the way. The campsite was great. Routes of travel were the same as the first trip and a bit easier since it was predominantly snow free. **Except** ….once I arrived to the site for the second trip I decided to focus efforts on the ridgeline west of crown mountain (Shotgun Ridge). At this point in the season, I found that when efforts were concentrated to a particular region more data was collected, especially used sites. I choose this ridge because it

was closest to the site of introduction (Crown Mountain) and closer to the Hidden Basin study site. The mountain range to the west of Terror Lake (where previously we saw groups of goats) required a spike camp to effectively collect data. This can be done, if more time is allotted.

Work Accomplished

We completed vegetation plots at 13 used sites and 37 random locations (Total = 50), conducted 2 behavioral observations, and collected 40 fecal samples.

Mountain goat locations / on the ground herd populations estimates

One billy was located on the mountain range west of Terror Lake and visible from camp. As stated earlier, we did not collect data from that region. For several days, we collected used site data from two groups who were occupying Shotgun Ridge and the adjacent steep cliffs that are characteristic of its western aspect. A group of 18 goats with 5 kids were located at approximately UTM N503439 E6386607 and another group of 6 with 0 kids further north (approximately UTM N 504178 E 6388658). I approached the group of 18 goats and noticed that as the group size increased, they became more comfortable with our presence. At one point, a younger billy slowly approached us to further investigate and came within 12 m. The goats were primarily located on Shotgun Ridge and appeared to be feeding on *Carex macrochaeta* among bedrock. The wide ridgeline was mostly free of vegetation except for a brim along the ridgeline. On Aug. 12, we saw a group of 12 goats on the ridge, and two groups of 4 and 6 goats below and at the same contour line where they were observed in June. The group of 6 goats further to the north was using sites near the ridgeline, similar to the group of 18 goats. At several used sites, I noticed excavated areas at which the goats appear to be digging to get roots. These regions are characterized by low hummocks and sparse vegetation intermixed with bedrock. Hummocks have been dug parallel to the ground surface (much like a burrow) leaving an overhang of vegetation and exposed roots. It appears that the goats may be selecting for roots and/or minerals. I took pictures of this site and additional "excavated" sites at the Hidden Basin study site. Surrounding the hummocks, I observed significant amounts of bare ground and wondered if this was evidence of goat impacts to the environment in an area for a significant time period. Bare ground is not found on ridges where goats were absent and bare rock was minimal in this area. Why is vegetation not growing within the matrix of bare ground?

Future Considerations for August research at Terror Lake

Unless more time is allocated to the site, data collection should be focused on the ridgeline adjacent to Crown Mountain (Shotgun Ridge) to attain vegetation composition data nearest to the site of introduction. The eastern aspect of the ridge is steep, leaving few routes that are feasible to descend. Down-slope of UTM N 503439 E 6388815, there is a safe route to reach a bench (I did a used site along this slope). I would advise not attempting any down climbing in clouds or rainy weather. Another route on/off the ridge is south where the cliffs shallow out into a bowl (Steve at Orion's has skied down this bowl). A third option is to camp at Crown Mountain and approach this slope from the bottom, which may be easier. However, camping on Crown would require a helicopter drop-off or another spike camp further back from Hidden Basin (this would be more feasible in late summer). The geology surrounding Terror Lake is granite (i.e. the mountains directly S and E of the lake), so this should be taken into consideration when comparing veg composition across study sites. Ice axes were not necessary this time of year.

Hidden Terror Study Site (Hidden Basin Subregion)
Trip 2
August 15-19, 2011

Route of travel / Camp sites

Kevin flew us directly from Terror Lake to Hidden Basin on the morning of the August 15. The sunny weather made the hike up to our spike camp enjoyable. It took about 4.5 hours to reach the area, and then another 2 hours to find perfect camp site. Similar to our first trip, we hiked the SE spine of the mountain, where there was still an established trail that was not too overgrown with vegetation. We then took the ridgeline north, and Adia and I dropped down into the first bowl to get water and to avoid a section of the ridgeline that cliffs-out and appeared somewhat unsafe to traverse with heavy packs on. We hiked out of the bowl and into the second bowl, which we named "Twin Lakes". Aarin and Ross managed to hike the ridgeline with heavy packs. This section is crossable, but handing off packs and the shotguns for two different sections is helpful….well, necessary. We camped on the north side of the lakes at UTM N 504780 E638245. The camp site was absolutely gorgeous and the western lake had a white sand beach. The weather was sunny and clear for the following 3 days, albeit a bit windy the first day. We were able to access areas north of "The Wall" which is the low point on the bowl's northern ridgeline, and areas north of this point continued to be high in elevation, but accessible. We were able to collect data from as far south as the first bowl to back north of a third bowl. The eastern face of the ridge east of Twin Lakes bowl is extremely steep. There is also a significant gorge which does not show up on topographic maps or the GPS. Impressively, goats definitely use this region as we saw evidence of their presence (beds, trails, hair, and feces). Aarin and I hiked down-slope as far as we could to reach a random location, but had to retreat to the ridgeline. Ross and Adia were able to hike the ridge NW of Twin Lakes bowl. This route can be traveled on future trips.

Near the end of our stint the weather deteriorated. The day before we were scheduled to fly out (August 19), we waited in a fog (visibility: trace, Rain: X) and the weather intermixed from mist to down-pouring rain. I thought that it would not be safe to hike the ridges in this condition, so we completed a few random locations (5) near the bowl in which we were camped. The weather continued to be poor the following day (fog and mist) but we hiked down to Hidden Basin the same way that we hiked in. We made it to sea level in about 4 hours. We all hiked down into the first bowl to avoid the cliffed-out region along the ridgeline. On the hike down, we did not experience too many troubles with slippery wet vegetation because we stayed on an established trail. Kevin was able to pick us up the evening of August 19, after the cloud ceiling lifted a bit, which was the day before the opening day of the mountain goat hunting season.

Work Accomplished

We completed vegetation plots at 12 used sites and 26 random locations (n = 39), conducted 4 behavioral observations, and collected 20 fecal samples.

Mountain goat locations / on the ground herd populations estimates

Four mountain goats were initially observed bedded on a snowfield (hot sunny day) on the ridgeline east of Twin Lakes bowl. Another 3 goats were also bedded on a small snow field on the eastern aspect near the ridgeline NW of Twin Lakes bowl. Observations during subsequent

days indicated that the goats had moved further back (north) near UTM N 505746 E 6380206 on existing ridgelines which were higher in elevation, had snow which they used to bed on, and adjacent steep cliffs. Areas where goats feed were easily accessed. The weather was blazing sun and quite warm (70s). It appeared the goats were trying to compensate for this by bedding in snowfields. By 10:00am they had moved onto a shaded NW facing slope. Like other area, goats in this region were approachable. My best approximation for the number of goats in this region is 46 adults (no kids). Adia and Ross indicated that they saw one kid, but they also verbalized the individual had horns, leaving me to believe that the individual was most likely a yearling. We took pictures of evidence of digging behavior on the ridgeline near the UTM listed above. My hypothesis for this behavior is indicated above (see Terror Lake Trip 2). Bare ground at this site was quite pronounced. At used sites, the goats appeared to be selecting for *Carex macrochaeta*, *Bistorta vivipara*, *Sedum rosea*, *Lupinus nootkatensis* (flowerheads), *Erigeron peregrinus*, and various other sedges. We did not observed lichen that was grazed upon, but the presence of *Cladina* species in vegetation plots was assumed to be foraged. Goats were generally bedded on NW facing slope (cooler temps) and foraging in areas largely dominated by bare rock. It was noted that vegetation species diversity was quite high at used sites, based on vegetation plot data, and appeared to be quite different than random sites.

Future Considerations for August research at Hidden Basin

Our visit managed to fall within a high pressure weather system, so clear sunny skies made data collection feasible. Like at other study sites, we were limited by time. I would suggest a longer trip in the future. Longer trips would also compensate for marginal weather days, when data collection is more difficult or impossible. Some random locations took a long time to access (steep) so a longer stint would allow crews to access more random points. The campsite location was ideal and should be reused in future seasons. It appeared that our presence camping in the Twin Lakes bowl did not disturb nearby goats. I would also recommend spike camping further north towards Crown Mountain if/when there is a weather "high" for a few days. This may give us access to Shotgun Ridge (see associated recommend in Terror Trip 2). Although we planned to, we were unable to collect data from permanent plots or random locations further south along the ridgeline due to the weather conditions on our second to last day. Overall, our trip was a success and the study site was quite manageable.

APPENDIX 3

2011 Mountain Goat Field Summary
Ross Dorendorf, Volunteer Field Assistant

Hepburn Study Site
Hepburn was somewhat difficult logistically. I think each stint could be different, in terms of where to camp, and where data collection is feasible. Our first trip to Hepburn was daunting, but we learned a great deal about what is possible.

The goats were much lower early in the season than late, and we located several areas where they concentrate early on in the season. They seemed to be very accessible from the valley in between the eastern and western ridges. A possibility for next season would be to get dropped off close to the southern end (weather permitting), and hike up to the second camping location (near the northwest part of the valley). Here the crew could work on the northern section of the valley. The western facing slope of the western ridge seemed to be a bit sketchy early on with the amount of snow cover and cliffed out locations. There were many goats that were easily accessible to us on the lower end of the eastern slope of the western ridge. After spending 5 days there, the crew could move camp to a location near the western facing slope of the eastern ridge, possibly near the bowl on the southern end where goats were earlier in the season. The second location may need a food drop, but that could be done on the initial flight in. The crew could work on the southern end for 5 days, after that they could hike back down to the southern end of the peninsula and walk the beach heading northeast towards Saloua Bay. Saloua Bay is a better location for pick up and drop off with the beaver, especially given Hepburn's reputation for crummy weather.

On the second trip to Hepburn, the goats concentrated on the western ridge. This might sway how much work you do on the eastern versus the western ridge. When Heidi and I got dropped off at Lake 1035, right away we knew that camping in that area would be a huge advantage. Getting flown to the lake would be great, hiking up to the lake would work, and both options come with the disadvantage of having to land the plane either in Deadman Bay or Lake 1035. If possible, this would be a very productive area for the second trip to Hepburn. If the eastern ridge were to be worked again, it may be possible to hike from Lake 1035 to the other ridge, though this would also require an airdrop of food somewhere up high. I would talk to Heidi about camping up there. I don't think there are many opportunity for used sites on the eastern ridge during the second stint. We did not find any goats, or fecal samples there this year. Nonetheless, it still provides comparative data for vegetation plots.

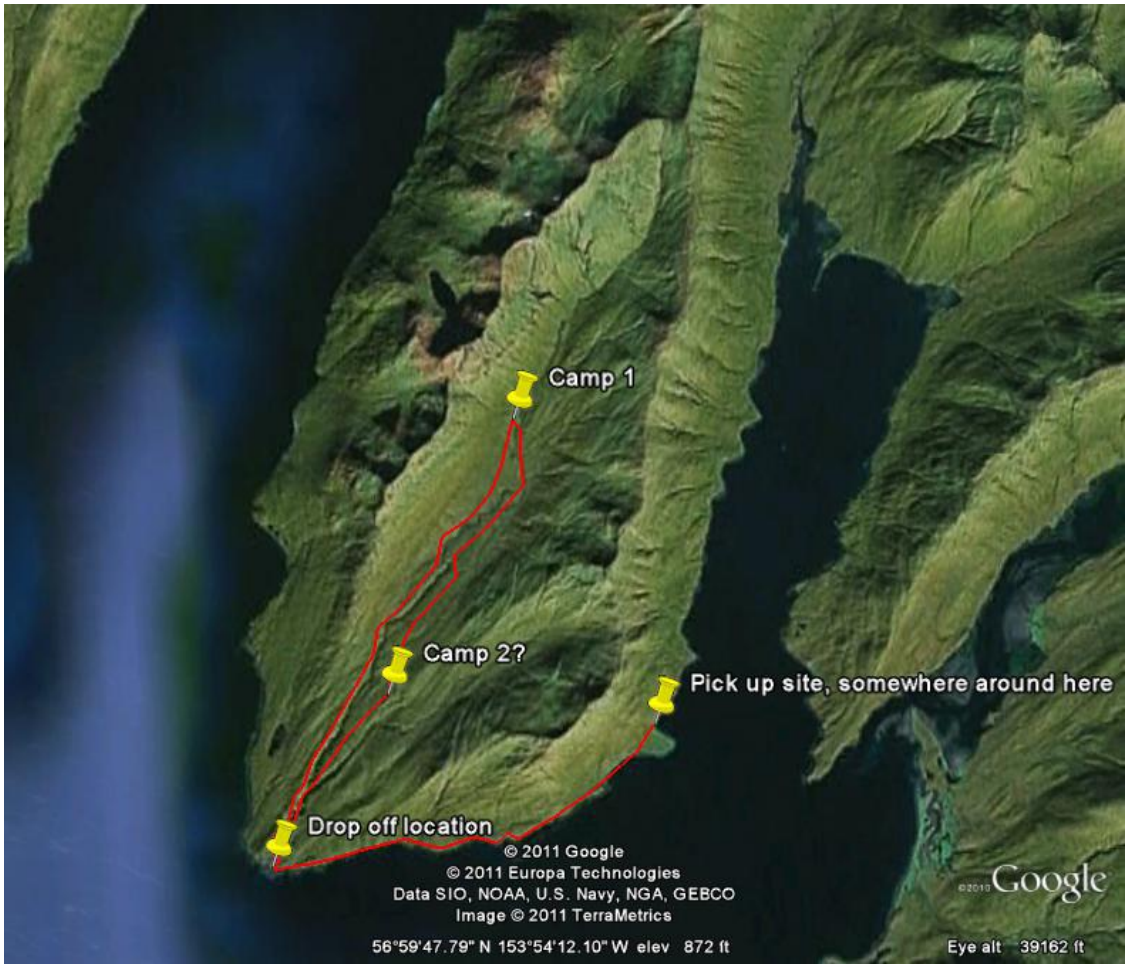

Figure 1. Locations of camps and drop off/pick up locations from the first trip to the Hepburn study site.

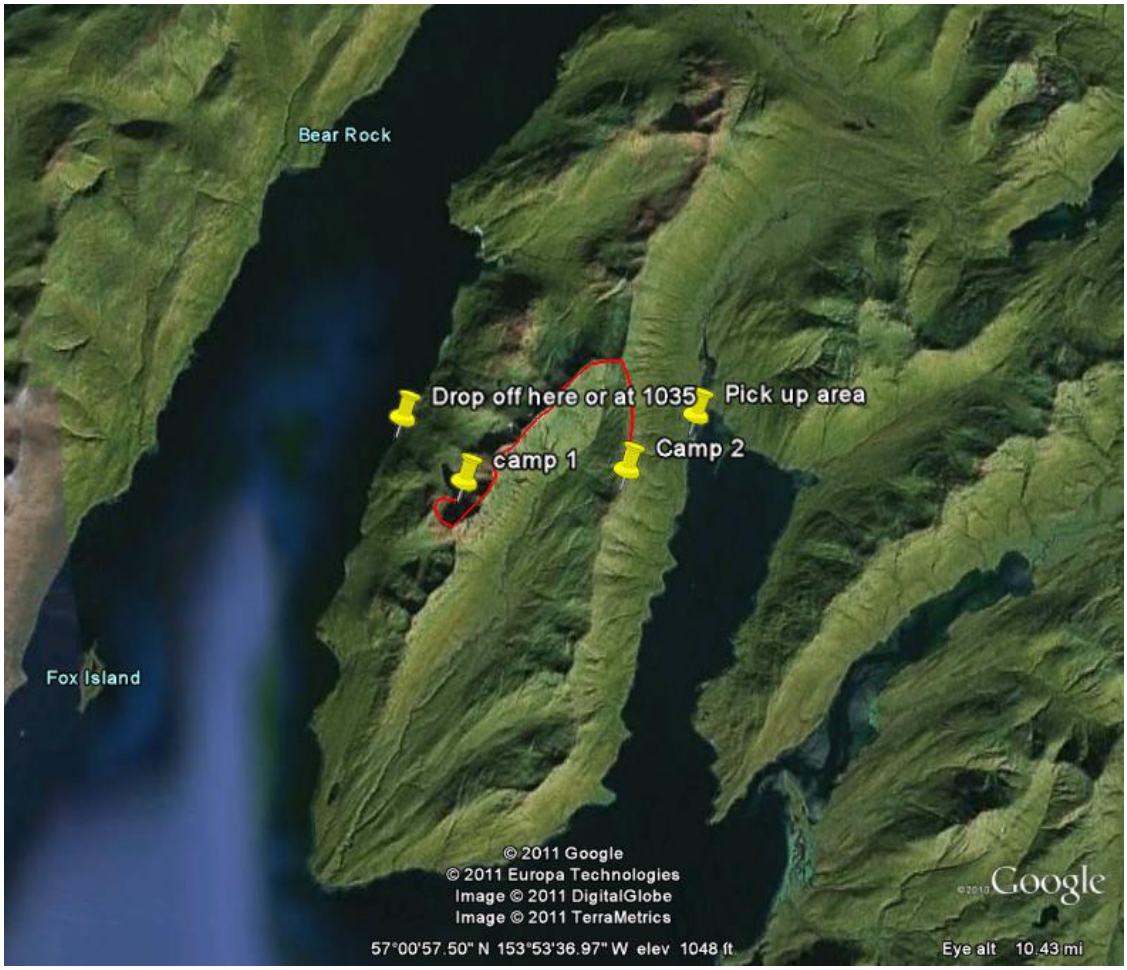

Figure 2. Proposed campsites and drop off/ pick up locations for future field seasons to the Hepburn study site.

Uyak Study Site
I guess I can't say too much about these locations other than don't let people drink unfiltered water, and don't let them break their knees. From what the rest of the crew said, it sounded like the 2 locations were very "doable" once they camped up high. I'm still upset that I missed out on these locations! Camping up high may yield different results early on in the season because of snow, but I think at least Lake 629 would be feasible. Maybe flying over Brosis Valley before the start of the field season would be valuable to see snow pack where the crew camped.

Hidden Study Site (Terror Lake Subregion)
This location was great minus the reservoir. Hiking all the way around on that road to get to the western mountains was quite a trip. The possibility of having MOCC training could greatly cut down on travel time and increase productivity. We could get up to the goats on the western mountains much quicker, and have a much more reasonable day. The eastern ridgeline was great for goats. I wasn't able to see what the ridgeline looked like on the first stint, but it seems that the only way to get at those goats early on is very carefully.
On the second stint, the camping location worked great. The people that worked on the dam mentioned that we could possibly use their housing and a vehicle if we talked with them ahead of time. This would be a great benefit, and make life at terror even easier! If that is possible.. Maybe you could look into that…. We camped in a slightly different location, just off the side of the road instead of directly on it. This was actually a comfy spot with fewer rocks in our backs. Again, with MOCC training, the entire section of mountain to the west would be accessible and could bring in more poo samples than ever before!

Hidden Terror Study Site (Hidden Basin Subregion)
Camping high here was key. On the first stint, camping low worked, but it also kicked our butts. I think it would be possible to camp high on the first stint. The camp locations may be tricky. On the first stint, it may be possible to camp in a bowl that is south of the Twin Lakes bowl. If it was not possible to camp high, a base camp would mean less production and fewer days working.

The last stint at this location proved that camping high is very beneficial. We essentially camped in the middle of the study area, giving us access to the northern end of the study area (previously unattainable). We were able to get many used sites, and fecal samples because of our proximity to the goats. The vast majority of goats we found were behind "China Wall" (see map) on the mountain directly north. I would also look into the possibility of flying the crew into the twin lakes. They appear to be large enough to get in and out of with a smaller plane (not sure about a beaver). While camping near twin lakes, we found lots of beer cans, a Coleman fuel tank, and other miscellaneous garbage. The weight of these items tells me that they were flown in. No one would backpack in a bunch of beer and fuel cans unless they were alcoholics that wanted to grill full sections of the goats they shot.

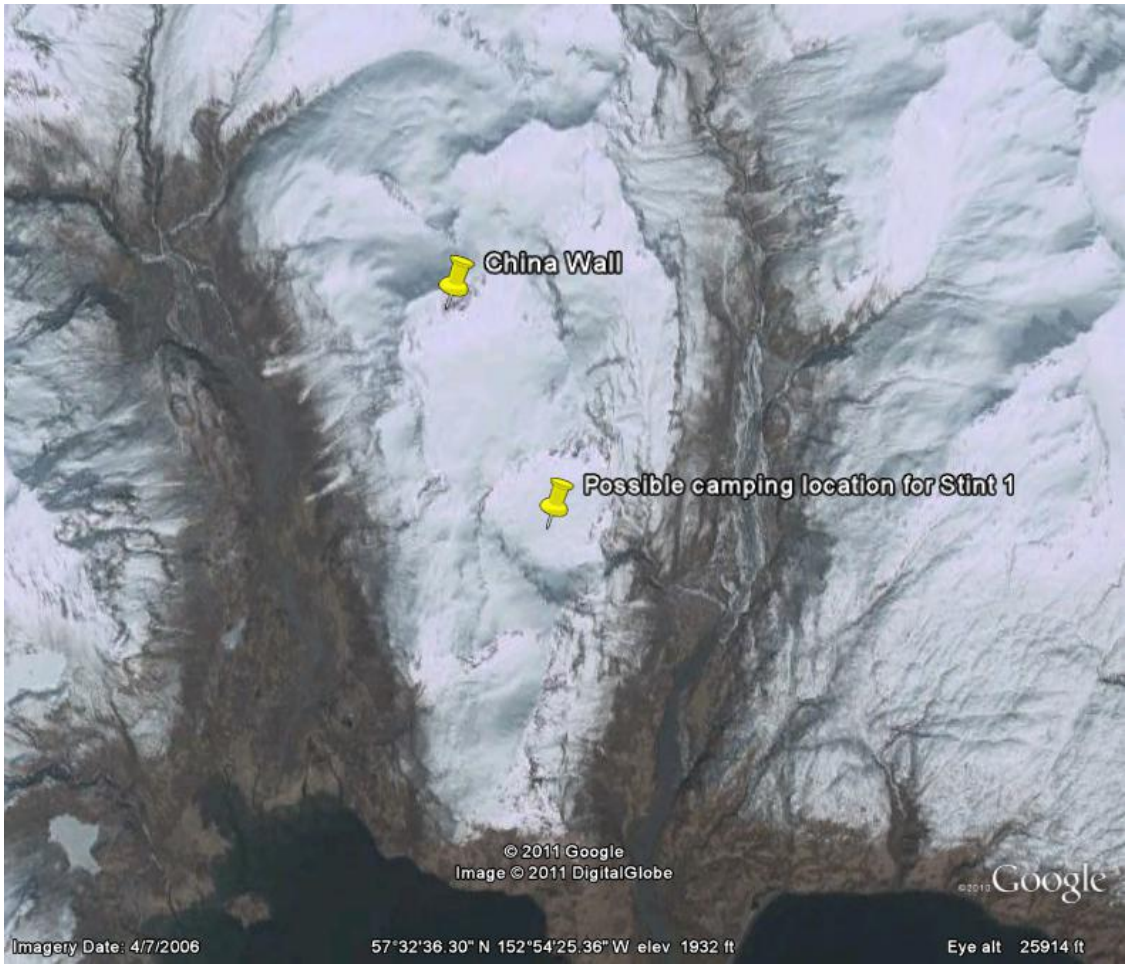

Figure 3. Map of potential camp site for the first trip in future field seasons to the Hidden Basin study site.

Additional Suggestions

In the future, 10 day trips may not work so well due to weather. We were extremely fortunate this summer with our blue bird days. Lengthening our trips may work to avoid working in crappy conditions. On the other side I thought that 10 days was effective. It was plenty of work on the body, and time to rest between stints was beneficial.

Only the data can tell us if we are getting the information we need or not, but shortening transects to 20 meters may work out. This is the length that I used while in Colorado, so I'm not sure if it is applicable to Kodiak.

It was very difficult to find permanent locations when revisiting sites. We also forgot to keep the original bearing with us, so on several occasions we had to pick a random bearing. I'm not so sure that will work well for data analysis. Maybe something could be attached to the stake to make it more visible. Or use a Trimble for those locations to get more accurate points.

At the beginning of the year it may be beneficial to do multiple trips with Stacy Studebaker, or more training in general for plant identification. When attempting to identify plants down to species, it is important to have a basic concept of plant anatomy and plant taxonomy. Also, a dichotomous key would be valuable in the field. I'm not sure if there are any field guide sizes available for Alaska's flora, but they are very beneficial when you only have a leaf to deal with.

I don't know if this is possible, but climbing gear may be beneficial to get to the points that were previously unattainable. This may reduce bias in the overall study. Again I'm not sure the USFWS would be ok with it, but it's an idea.

Food was a huge moral boost at the end of the day. Sitting down at the beginning of the year and creating a food list with a little of what everyone wants can make a huge difference to the overall season. A food list is important to have when packing food for the stints. Some crew members didn't see the value in taking time to do this, resulting in food being forgotten….(POP TARTS!).

Aside from all these picky comments, I just wanted to say how impressed I was with Heidi. Her prioritization of what to do on a day to day basis was superb. She was also very good at resolving tension in camp, and with problems that arose in town. Her positive attitude made this summer a blast!