Wildlife Research Annual Progress Report

Mountain Goat Population Monitoring and Survey Technique Development

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December 2013

Alaska Department of Fish and Game Division of Wildlife Conservation

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Cover Photo: Photograph of an adult male mountain goat (KG-41) near Goat Hollow, Takshanuk Ridge, August 2013 ©2013 ADF&G/photo by Kevin White.

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INTRODUCTION

This annual progress report was prepared to meet the reporting requirements for United States Forest Service (USFS). In 2009, the USFS provided funding to support mountain goat aerial survey technique development and population monitoring field activities. Between 2005-2013, Alaska Department of Fish and Game (ADFG) and collaborators have conducted research on this and other topics as part of an independent studies funded by ADFG, Alaska Department of Transportation and Public Facilities (ADOT/PF), Bureau of Land Management (BLM) and Coeur Alaska, and the City of Sitka (see White et al. 2010, White et al. 2012a, White et al. 2012b, White et al. 2012c). This report summarizes activities associated with the USFS contract that have been completed by December 31, 2013 (but also includes relevant survey technique development research conducted since 2005).

Background

Monitoring the abundance and productivity of mountain goat populations is critical for evaluating the effects of forest management practices, including timber harvest, helicopter tourism, and mining activities. Mountain goats are designated a management indicator species under USFS policy yet actual monitoring has, historically, been very limited. Aside from routine surveys conducted by ADFG in high-use hunting areas, long-term, consistent monitoring data is absent; especially in areas where intensive helicopter tourism is prevalent. Compounding this problem are complexities associated with estimating actual population size from raw survey data. A common approach for calculating actual population size involves developing mark-resight or logistic regression based "sightability" models. Such models can then be used to calculate actual population size by statistically accounting for sources of environmental and survey bias recorded in routine surveys. Unfortunately, such models have not been developed for mountain goats in southeastern Alaska and, as a result, the ability to accurately monitor mountain goat populations is limited. This study aims to develop mountain goat "sightability" models to address this important limitation of monitoring efforts.

STUDY OBJECTIVES

This research is designed to investigate sources of mountain goat aerial survey bias (ie. behavioral, environmental and climatic) in order to develop statistical and field techniques needed to accurately estimate mountain goat population size during routine monitoring surveys. The specific objectives are as follows:

1) estimate individual mountain goat sighting probabilities under a range of different conditions (i.e., to determine which habitat conditions/circumstances result in the highest/lowest chance of seeing goats), and

2) estimate population sightability estimates for a given survey under a given set of conditions (i.e., proportion of animals seen during a survey).

STUDY AREA AND METHODS

Study Design Overview

Beginning in 2005, the Alaska Department of Fish and Game (with funding from ADOT/PF and Coeur Alaska) initiated a broad-based mountain goat ecology study in the Lynn Canal area (White et al. 2012b). Later, in 2009, ADFG initiated a small-scale research project on the lower Cleveland Peninsula, north of Ketchikan (White et al. 2010). And, in 2010, ADFG initiated additional research projects in the Haines/Skagway area (funded by ADFG and BLM; White et al. 2012a) and on central Baranof island (funded by ADFG and City of Sitka; White et al. 2012c). A key aspect of each of these projects has involved deployment of radio-collars on mountain goats to address various study objectives (i.e., habitat selection, movement patterns, vital rates, population estimation). Deployment of radio-collars on mountain goats in these areas has provided an additional opportunity to conduct research relating to mountain goat aerial survey technique development. As such, the focus of this specific project (jointly funded by the USFS) has been to gather field data to develop statistical models and field protocols that can be used in a man-

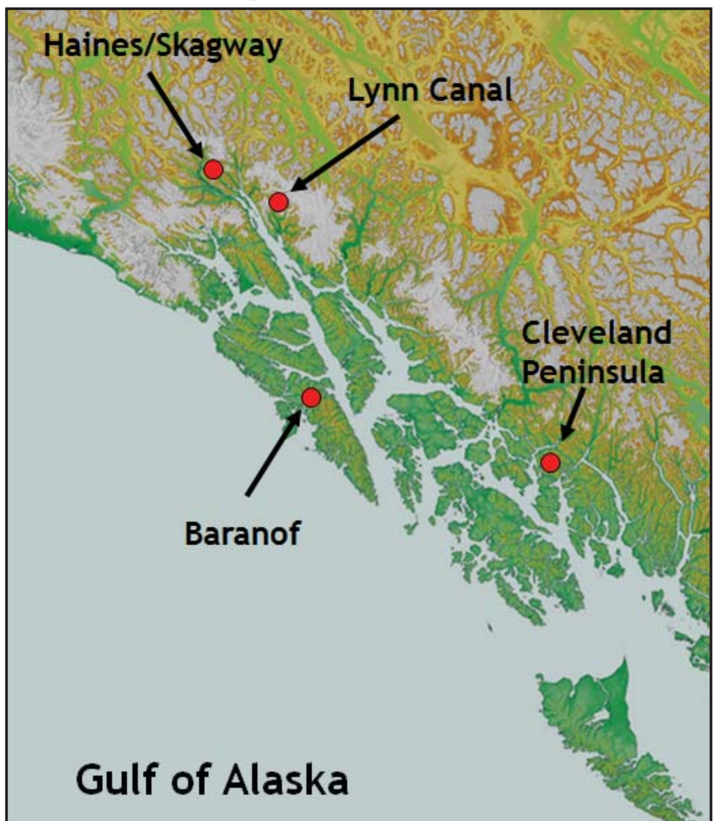

Figure 1: Location of radio-marked mountain goats (n = 89) in southeastern Alaska, as of September 2013 (Lynn Canal: n = 24, Haines/Skagway: n = 32, Baranof: n = 26, Cleveland Peninsula: n = 7).

agement context to monitor mountain goat populations in the future throughout southeastern Alaska. The basis of these efforts involves conducting routine aerial surveys in areas inhabited by radio-marked mountain goats and, subsequently, gathering site-specific information about factors that influence the probability of sighting mountain goats on a given survey and/or under certain circumstances. While funding for this project specifically involves gathering data from radio-marked animals collected during aerial surveys, information is also provided about activities associated with deployment of radio-collars (that was funded from other sources, as described).

Study Area

Mountain goats were studied in 4 separate study areas in southeastern Alaska (Figure 1), as described above. In general, the overall area has a maritime climate that is characterized by cool, wet summers and relatively warm snowy winters. Annual precipitation at sea-level averages 55-155 inches and winter temperatures are rarely less than 5º F and average 30-35º F. Elevations at 2600' can receive ca. 250 inches of snowfall, annually (Eaglecrest Ski Area, Juneau, AK, unpublished data). Predominant vegetative communities occurring at low-moderate elevations (<1500') include Sitka spruce (*Picea sitchensis*)-western hemlock (*Tsuga heterophylla*) coniferous forest, mixed-conifer muskeg and deciduous riparian forests. Mountain hemlock (*Tsuga mertensiana*) dominated 'krummholtz" forest comprises a subalpine, timberline band occupying elevations between 1500-2500 feet. Alpine plant communities are composed of a mosaic of relatively dry ericaceous heathlands, moist meadows dominated by grasses and forbs and wet fens. Avalanche chutes are common in the study area, bisect all plant community types and often terminate at sea-level.

Mountain Goat Capture

Mountain goats were captured using standard helicopter darting techniques and immobilized by injecting 3.0 - 2.4mg of carfentanil citrate, depending on sex and time of year (Taylor 2000, White and Barten 2009), via projectile syringe fired from a Palmer dart gun (Cap-Chur, Douglasville, GA). During handling, all animals were carefully examined and monitored following standard veterinary procedures (Taylor 2000) and routine biological samples and morphological data collected. All animals were equipped with red or orange-colored GPS (Telonics TGW-3590) and/or VHF radio-collars (Telonics MOD-500, MOD-410; Figure 2). Following handling procedures, the effects of the immobilizing agent was reversed with 100mg of naltrexone hydrochloride per 1mg of carfentanil citrate (Taylor 2000). All capture procedures were approved by the State of Alaska Animal Care and Use Committee.

Figure 2: Photograph of a radio-marked adult male mountain goat (LG-162) near Lions Head Mountain in the Lynn Canal study area, illustrating the types of habitat and ruggedness of the terrain inhabited by mountain goats in this area, August 2013.

Aerial Survey Technique Development Data Collection

Aerial Surveys.—Population abundance and composition surveys were conducted using fixed-wing aircraft (Helio-courier and PA-18 "Super Cub") and helicopter (Hughes 500) during August-October 2006-2010. Aerial surveys were typically conducted when conditions met the following requirements: 1) flight ceiling above 5000 feet ASL, 2) wind speed less than 20 knots, 3) sea-level temperature less than 65 degrees F. Surveys were typically flown along established flight paths between 2500-3500 feet ASL and followed geographic contours. Flight speeds varied between 60-70 knots. During surveys, pilots and experienced observers enumerated and classified all mountain goats seen as either adults (includes adults and sub-adults) or kids. In addition, each mountain goat group observed was checked (via 14X image stabilizing binoculars) to determine whether radio-collared animals were present.

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

RESULTS AND DISCUSSION

Mountain Goat Capture and Handling

Capture Activities.—Mountain goats were captured during August-October in 2005-2013. Overall, 269 animals (116 females and 153 males) were captured using standard helicopter darting methods. Due to programmed GPS-collar self-release or natural mortality, by the fall 2013 aerial survey season 89 animals were deployed with radio-collars in 4 separate study areas (Figure 1).

Aerial Survey Technique Development Data Collection

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

Aerial Surveys.—Overall, 19 aerial surveys were conducted during September-October 2013 (Table 1). During nearly all of these surveys (n = 19), data were collected for purposes of developing individual-based and population-

Table 1. Categorical covariate summary, including proportion of animals seen under each sub-category, for mountain goat sightability trials (n = 511) conducted in southeastern Alaska, 2007-2013.

Variable	Category	Seen	Missed	Total	Prop Seen	SE
Group Size						
	1	126	65	191	0.66	0.03
	2-3	97	49	146	0.66	0.04
	4-5	38	13	51	0.75	0.06
	6-10	33	1	34	0.97	0.03
	11-15	8	0	8	1.00	0.00
	16-20	3	0	3	1.00	0.00
	21-40	4	0	4	1.00	0.00
Behavior						
	Running	6	0	6	1.00	0.00
	Bedded	139	38	177	0.79	0.03
	Feeding	36	15	51	0.71	0.06
	Walking	57	27	84	0.68	0.05
	Standing	68	42	110	0.62	0.05
Landform						
	Mid-Slope	201	89	290	0.69	0.03
	Ridge	52	25	77	0.68	0.05
	Ravine	51	67	118	0.43	0.05
Slope						
	Flat	3	1	4	0.75	0.22
	Gentle	20	8	28	0.71	0.09
	Moderate	114	46	160	0.71	0.04
	Steep	125	59	184	0.68	0.03
	Very Steep	41	66	107	0.38	0.05
Terrain						
	Smooth	84	10	94	0.89	0.03
	Broken	183	108	291	0.63	0.03
	Very Broken	38	63	101	0.38	0.05
Habitat						
	Meadow	141	16	157	0.90	0.02
	Rocky	117	70	187	0.63	0.04
	Subalpine Fst.	27	32	59	0.46	0.06
	Thicket	14	29	43	0.33	0.07
	Snow	4	27	31	0.13	0.06
	Mature Fst.	0	13	13	0.00	0.00
Lighting						
	Overcast	189	108	297	0.64	0.03
	Sun	80	50	130	0.62	0.04
	Shade	36	31	67	0.54	0.06
% Canopy Cover						
	0	207	96	303	0.68	0.03
	1-5	1	1	2	0.50	0.35
	6-25	13	7	20	0.65	0.11
	26-50	11	5	16	0.69	0.12
	51-75	9	13	22	0.41	0.10
	76-95	0	10	10	0.00	0.00
	96-100	0	27	27	0.00	0.00
Dist to Terrain Obs (m)						
	0	7	10	17	0.41	0.12
	1-10	111	80	191	0.58	0.04
	11-25	64	13	77	0.83	0.04
	26-50	26	11	37	0.70	0.08
	51-100	22	3	25	0.88	0.06
	101-200	7	2	9	0.78	0.14

level sighting probability models. Aerial surveys were conducted in all four study areas.

Individual-based Sightability Data Collection.-During 2012, habitat and behavioral covariate data were collected for 96 marked mountain goat observations during aerial surveys. These data were paired with records of whether animals were seen or not seen during routine surveys in order to compile a database suitable for determining factors related to mountain goat survey sighting probability. Overall, data has been collected during 511 "sightability trials" involving marked mountain goats between 2007-2013.

Survey-level Sightability Data Collection.-During 2013, nineteen aerial surveys were conducted that provided adequate data for estimating survey-level sightability (Appendix 1). Survey-level sighting probability estimates ranged between 0.00-1.00; however, sample sizes were generally too small for meaningful comparisons between individual surveys.

Comparison of sighting probabilities between study areas and years revealed substantial variation (Table 2). In particular, sighting probabilities at the Cleveland Peninsula site were markedly lower than elsewhere; however, samples sizes are low. Mountain goats on the Cleveland Peninsula tend to utilize forested habitats more frequently than in other areas and such behavior likely accounts for low sighting probabilities in that area. In addition, inter-annual variation in sighting probabilities were also evident within specific study areas. Such variation is likely due to differences in survey conditions between years.

Statistical Analyses.-Preliminary analyses of individual- and survey-level data were described in White and Pendleton (2011). Briefly, logistic models were fit using Bayesian procedures (Program OpenBUGS) to predict sighting probability as a function of individual and survey-level covariates. Preliminary results of individual-level sighting probability models have been used to simplify field data collection (i.e., collecting data on only the most important variables). Preliminary population-level models have been used to derive relatively precise population estimates for the Lynn Canal study area (White et al. 2012). Nonetheless, additional refinements of models incorporating data collected in 2013 are expected to further improve model performance.

Table 2: Summary of sighting probabilities detected during mountain goat aerial surveys conducted in 4 seperate study areas, 2010-2013, southeastern Alaska.

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

FUTURE WORK/RECOMMENDATIONS

Individual- and population-level sightability data sets are not yet adequate for complete statistical analyses and additional data collection efforts are needed. Currently, 89 mountain goats are deployed with radio-collars in four study areas throughout southeastern Alaska. Additional radio-collar deployment efforts are planned for late-summer 2014 and will occur in the Lynn Canal and, possibly, the Baranof and Haines-Skagway study areas. A significant opportunity exists to continue mountain goat aerial survey technique data collection efforts in multiple areas throughout southeast Alaska. Currently, funding is available to maintain the current level of survey effort during 2014. In addition, during 2014, efforts will continue to further develop and refine statistical methods for analyzing mountain goat aerial survey data.

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Pendleton, G. W., and K. S. White. 2010. Covariate-based detectability models for repeated aerial surveys. Abstract. Wildlife Society Conference, Snowmass, UT.

White, K. S. and G. Pendleton. 2009. Mountain goat population monitoring and survey technique development. Research Progress Report. Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

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White, K. S., B. Porter and S. Bethune. 2010. Cleveland Peninsula mountain goat population monitoring. Research Progress Report. Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

Appendix 1: Summary of mountain goat aerial surveys conducted in 2013 in order to gather data needed to develop sighting probability models. Preliminary sighting probability estimates are provided for each survey in addition to sample size of marked animals and survey conditions.

Study Area	Date	Temp	Weather	Wind	Collars Seen	Total Collars	Sighting Prob
Lynn Canal							
B-L Ridge	9/23/13	37	Clear	0-5	2	2	1.00
Lions Head	9/23/13	37	Partly Cloudy	0-10S	7	11	0.64
Sinclair Mtn.	9/23/13	37	High Overcast	0-10S	2	5	0.40
Mt. Villard	9/23/13	39-40	High Overcast	10-25S	0	2	0.00
East Berners	9/25/13	37	High Overcast	0-15	1	3	0.33
Grandchild Pks	9/28/13	43	High Overcast	15-20S	1	1	1.00
Haines-Skagway							
Porcupine	9/25/13	37	High Overcast	5-15	3	3	1.00
Takhin	9/25/13	37	High Overcast	5-15	6	7	0.86
Hiteshitak-US	9/25/13	32	High Overcast	15-20S	2	3	0.67
Takhinsha	9/28/13	40-42	High Overcast	5-15	2	4	0.50
Takshanuk	9/28/13	39	High Overcast	10-20	7	9	0.78
Chilkoot	9/29/13	38	High Overcast	5-20N	2	2	1.00
Four Winds	9/29/13	36	High Overcast	10N	2	3	0.67
Baranof							
Blue Lake	9/24/13	36-40	Partly Cloudy	0-15	6	9	0.67
Katlian	9/24/13	40	High Overcast	0-15	6	8	0.75
Nakwasina	9/24/13	40	High Overcast	0-15	4	5	0.80
Cleveland Pen							
Cleveland	10/2/13	40	Partly Cloudy	0-5	3	7	0.43
Cleveland	10/8/13	45	Partly Cloudy	0-5	4	7	0.57
Cleveland	10/17/13	40	Clear	5-10NW	3	7	0.43
Total					63	98	0.64