Wildlife Research Annual Progress Report

Mountain Goat Population Monitoring and Survey Technique Development

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Alaska Department of Fish and Game
Division of Wildlife Conservation

December 2011

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

ACKNOWLEDGEMENTS

This project was funded by the State of Alaska Department of Transportation and Public Facilities, Alaska Department of Fish and Game, United States Forest Service, Bureau of Land Management, City of Sitka and Coeur Alaska. Reuben Yost (SOA, DOT/PF), Carl Schrader (SOA/DNR), Dean Orbison (Sitka), Carol Seitz-Warmuth (USFS), Brian Logan (USFS) Bruce Seppi (BLM), Rod FLynn (ADFG) and David Thomsen (ADFG) coordinated project funding. Neil Barten, Lem Butler, John Crouse, Anthony Crupi, Rod Flynn, Jeff Jemison, Doug Larsen, Steve Lewis, Karin McCoy, Phil Mooney, Jeff Nichols, Boyd Porter, Dale Rabe, Chad Rice and Ryan Scott, Bruce Seppi, assisted in field and/or office work. Fixed-wing survey flights were conducted by Lynn Bennett, Doug Larsen, Mark Morris, Mark Pakila and Pat Valkenburg. Helicopter support was provided by Rey Madrid, Mitch Horton, Andy Hermansky and Eric Maine (Temsco Helicopters).

Cover photo: Photograph of a radio-marked adult male mountain goat in the Katlian watershed, Baranof Island, AK (Photo by Phil Mooney).

Contents

INTRODUCTION

This annual progress report was prepared to meet the reporting requirements for United States Forest Service. In 2009, the USFS provided funding to support mountain goat aerial survey technique development and population monitoring field activities. Between 2005-2011, ADFG and collaborators have conducted research on this and other topics as part of an independent studies funded by ADFG, ADOT/PF, BLM and Coeur Alaska and the City of Sitka (see White and Barten 2010, White et al. 2011a, White et al. 2011b). This report summarizes activities associated with the USFS contract that have been completed by December 31, 2011 (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 Forest Service 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 southeast 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 (ie. 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 (ie. 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 and Barten 2010). 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. 2011) and on central Baranof island (funded by ADFG and City of Sitka; White et al. 2010). A key aspect of each of these projects has involved deployment radio-collars on mountain goats to address various study objectives (i.e. habitat selection, movement patterns, vital rates, population estimation). The deployment of radio-collars on mountain goats in these areas 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 management context to monitor mountain goat populations in

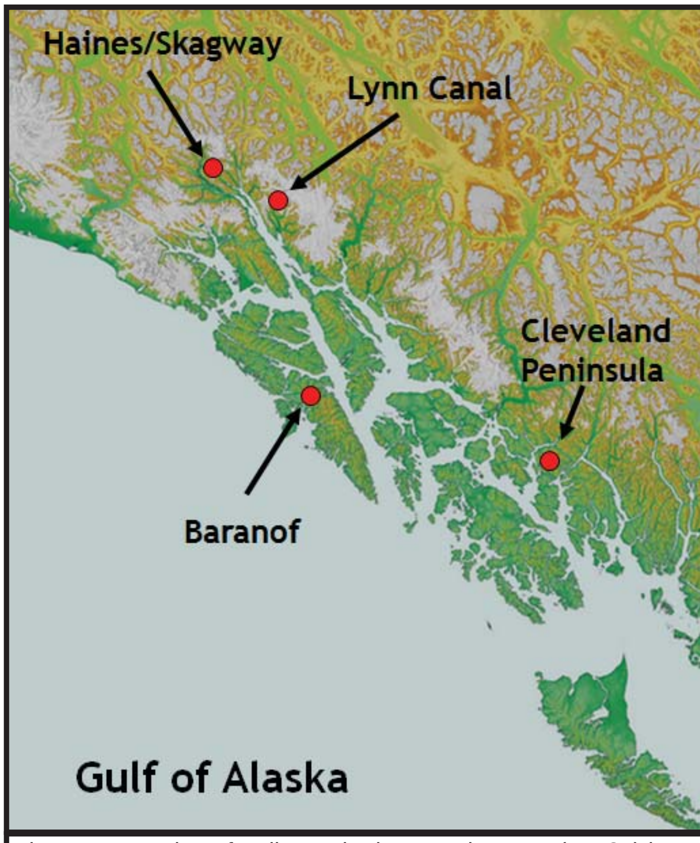

Figure 1: Location of radio-marked mountain goats (n = 87) in southeast Alaska, as of September 2011 (Lynn Canal: n = 33, Haines/Skagway: n = 26, Baranof: n = 18, Cleveland Peninsula: n = 10).

the future throughout southeast 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 above).

Study Area

Mountain goats were studied 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.

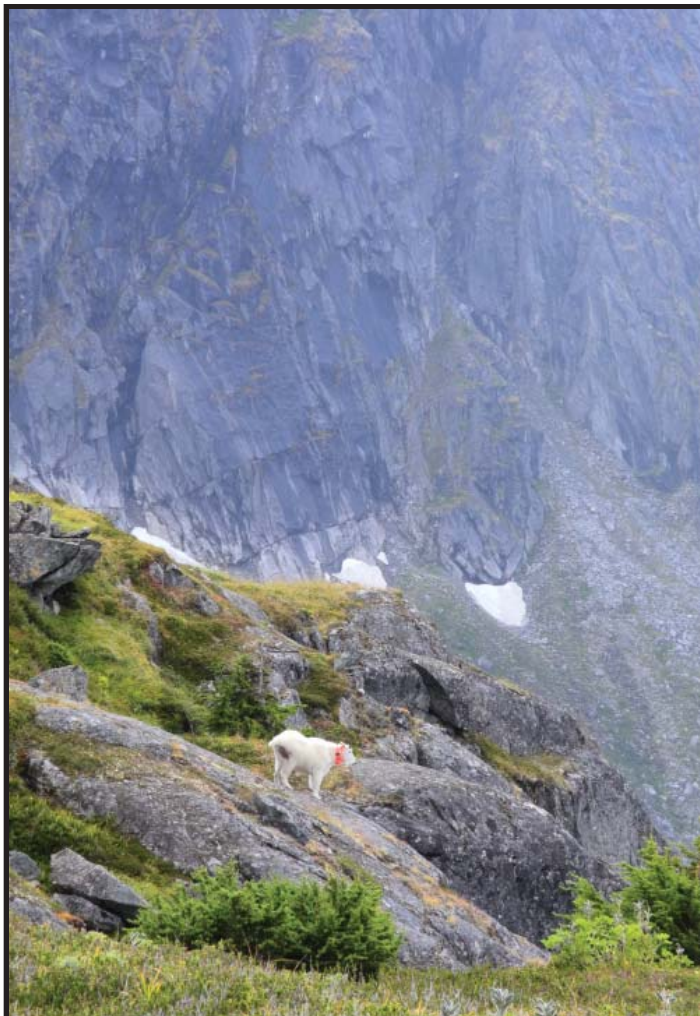

Figure 2: Photograph of a radio-marked adult female mountain goat in the Katzehin river watershed illustrating the types of habitat and ruggedness of the terrain inhabited by mountain goats in the study area, August 2011.

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, the pilot and experienced observers enumerated and classified all mountain goats seen as either adults (includes adults and sub-adults) or kids. In addition, each mountain group observed was checked (via 14X image stabilizing binoculars) to determine whether radio-collared animals were present.

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

RESULTS AND DISCUSSION

Mountain Goat Capture and Handling

Capture Activities.—Mountain goats were captured during August-October in 2005-2011. Overall, 226 animals (100 females and 126 males) were captured using standard helicopter darting methods. Due to programmed GPS-collar self-release or natural mortality, by the fall 2011 aerial survey season 87 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, 14 aerial surveys were conducted during September 2011 (Table 1). During nearly all of these surveys (n = 13), data were collected for purposes of developing individual-based and population-level sighting probability models. Aerial surveys were conducted in three of the four study areas; surveys were not conducted on the Cleveland Peninsula in 2011.

Table 1. Categorical covariate summary, including proportion of animals seen under each sub-category, for mountain goat sightability trials conducted in southeastern Alaska, 2007-2011.

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

Individual-based Sightability Data Collection.-During 2011, habitat and behavioral covariate data were collected for 83 marked mountain goat observations during aerial surveys. These data were paired with records of whether animals were either seen or not seen during routine surveys in order to compile a database suitable for determining factors related to mountain goat survey sighting probability.

Overall, data has been collected during 328 "sightability trials" involving marked mountain goats have been conducted between 2007-2011.

In order to further examine patterns in these data, we fit logistic models to predict sighting probability as a function of the individual covariates listed in Table 1; models were fit using Bayesian procedures with the program OpenBUGS using data through 2011. Data for all of the covariates were not collected for each marked goat (i.e., some covariates were included only in later surveys), making the comparison of effects among the covariates somewhat more complex. Overall, the most important variables for predicting sighting probability are habitat (lower probability for all habitats relative to alpine meadows), group size (as a continuous variable), terrain (lower probability for very broken), and behavior (lower probability for bedded). These analyses will guide future collection of data (i.e., data will be recorded only for these variables) to make it feasible for survey biologists to record information for all goats seen, not just those that are marked, which is required to use these functions to estimate population sizes. Development of the individual covariate models to estimate population size based on these functions is ongoing and will be further refined in the future.

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

In addition, we fit logistic models to predict average sighting probability for all goats in an area during a survey as a function of survey level covariates including survey date, time of day, aircraft type, temperature, sky conditions, wind (median and maximum), and the number of observers (<=2 vs. 3) ; models were fit using Bayesian procedures with the program OpenBUGS using data through 2011 (Table 2). Bayesian models allow for including results from each survey along with covariate-based sighting functions produced across many surveys to improve the precision of the population estimates (relative to Lincoln-Petersen type estimates) and provide estimates when no marked goats were seen or when there were no marked goats in the area (with certain assumptions). These models also account for observed goats whose collar status could not be determined (i.e., the view was insufficient to determine whether the goat was collared or not); the prevalence of goats with unknown status was greatly reduced in later surveys through changes to field methods. The most important survey level covariates for predicting sighting probability are aircraft

Table 2: Summary of mountain goat aerial surveys conducted in 2010 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							
2010							
East Berners	9/11/2010	51	Clear	0	5	10	0.50
East Berners	9/22/2010	42	Mostly Clear	0-10N	6	10	0.60
Lions Head	9/6/2010	44-48	Mostly Clear	15N	7	11	0.64
Lions Head	9/21/2010	36-42	Clear	0-5S	7	11	0.64
Sinclair Mtn.	9/6/2010	44-48	Mostly Clear	15N	6	10	0.60
Sinclair Mtn.	9/21/2010	36-42	Clear	0-5S	4	10	0.40
Mt. Villard	9/12/2010	41-48	Clear	20	4	11	0.36
2011							
Mendenhall-Davies[1]	8/25/2011	36	High Overcast	0-20	3	5	0.60
East Berners	9/27/2011	35	High Overcast	0-10	4	5	0.80
Lions Head	9/18/2011	39-42	High Overcast	0-10	5	5	1.00
Sinclair Mtn.	9/18/2011	39-42	High Overcast	0-10	9	14	0.64
Mt. Villard	9/18/2011	39-42	High Overcast	0-10	1	4	0.25
Haines/Skagway							
2010							
Porcupine	9/16/2010	43-45	High Overcast	0-10	1	3	0.33
Takhin	9/16/2010	50	High Overcast	0-10	3	4	0.75
Takshanuk	9/8/2010	50	High Overcast	5	5	6	0.83
Chilkoot/Nourse	9/22/2010	35-39	Mostly Clear	0-15	5	7	0.71
2011							
Takhinsha	9/26/2011	27	Mostly Clear	10-15	1	2	0.50
Takhin[1]	9/12/2011	46	Mostly Clear	5-10	2	8	0.25
Takhin	9/26/2011	32	High Overcast	5-15	6	8	0.75
Porcupine[1]	9/12/2011	50	High Overcast	5	3	3	1.00
Porcupine	9/26/2011	36	High Overcast	10-15	1	3	0.33
Takshanuk	9/27/2011	35	High Overcast	0-10	3	4	0.75
Chilkoot/Nourse	9/25/2011	34-37	Mostly Clear	5-10	4	4	1.00
Baranof							
2010							
Central Baranof	9/21/2010		No Mark-Resight Conducted		--	--	--
2011							
Central Baranof[2]	8/25/2011		No Mark-Resight Conducted		--	--	--
Central Baranof	9/25/2011	36-39	High Overcast	0-10	12	18	0.67
Cleveland Peninsula							
2010							
Lower Cleveland			No Survey Conducted		--	--	--
2011							
Lower Cleveland			No Survey Conducted		--	--	--
Total					**107**	**176**	**0.61**

[1] Supercub on floats
[2] Helicopter

type (lower probability for surveys from a Helio Courier relative to a Hughes 500 helicopter or Piper PA-18 super-cub), time of day (higher probability earlier in the day), and sky condition (lower probability when clear). Efforts to derive population estimates using these models are ongoing.

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, 87 mountain goats are deployed with radio-collars in four study areas throughout southeastern Alaska. Additional radio-collar deployment efforts are planned for late-summer 2012 and will occur in the Lynn Canal, Baranof island and, possibly, the Haines-Skagway study areas. Overall, 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 2012. In addition, during 2012, 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. laska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

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