# TESTING THE EFFICACY OF CAMERA-TRAP SURVEYS FOR ESTIMATING HABITAT OCCUPANCY OF *PUMA CONCOLOR*


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# INTRODUCTION

## Carnivores and Noninvasive Survey Methods

Basic knowledge of population status and trends is essential for the proper management and conservation of any wildlife species. However, some species evade enumeration by common methods due to low density, small populations, large ranges, low detectability, avoidance of humans, and preference for remote or inaccessible habitat. Attempts to assess populations of the order *Carnivora* (hereafter referred to as *carnivores*) are hindered by the tendency of these species to exhibit several of the above traits (Long and Zielinski 2008). Many carnivore populations are at risk due to historic persecution, sensitivity to human activity, and global trends in habitat loss and fragmentation (MacKay et al. 2008). Thus, lack of population status data compromises proper management and conservation.

Early work on carnivore enumeration focused on mark-recapture techniques, often associated with trapping and radio-collaring individuals to collect spatial and behavioral data (e.g., Mech 1966; Craighead et al. 1963; Seidensticker and Hornocker 1973). Besides the exorbitant costs associated with such studies, the risk inherent in handling wildlife- both for the animals and humans involved- is a common concern. To counter these concerns, advances in technology have been increasingly applied to wildlife research for the purpose of noninvasively monitoring populations. “Noninvasive” refers to study methods that do not require human handling of animals, and as such generally minimize stress (MacKay et al. 2008).

Current carnivore research and management emphasizes efforts specifically focusing on noninvasive methods to monitor carnivore populations (synthesized in Long et al. 2008; see also Zielinski and Kucera 1998; Kelly et al. 2012). Different methods have been optimized for various species in a range of landscapes (e.g., Zielinski et al. 2005; Karanth et al. 1995; Long et al. 2007). Techniques employ baited track stations, genetic analysis of hair or scat samples, camera-traps, and novel statistical approaches to evaluate these elusive species. However, the formalization of species-specific noninvasive surveys is the exception rather than the rule, and further exploration and refinement of noninvasive methods is necessary for confident application to new species, new populations, and new landscapes.

## The Cougar

*Puma concolor*, also known as the cougar, mountain lion, puma, or panther, is the most widely distributed carnivore of the Western Hemisphere. Nonetheless, the status of individual cougar populations is extremely difficult to determine due to their wide-ranging nature, low density, and elusiveness. While an extensive body of scientific literature is available on *Puma concolor* (e.g., Hornocker and Negri 2010), no cost-efficient method has been found for confidently assessing population status- despite repeated calls to explore the topic by wildlife scientists and managers alike (UDWR and the Cougar Advisory Group 2015; Becker et al. 2003; Cougar Management Guidelines Working Group 2005; Toweill et al. 2008).

Currently, wildlife managers often rely on indirect indices such as track surveys and hunt data to set harvest quotas. The uncertainty associated with these indices is a widespread concern in wildlife management that prompts investigation into better indicators of cougar population health, especially with threats of habitat fragmentation and overhunting (Choate et al. 2006). The lack of information on cougar populations is surprising considering recent concerns about the high probability of local extinctions due to habitat fragmentation (Benson et al. 2016), as well as the risk associated with setting harvest limits without referencing any explicit measure of the population's status. The latter concern has been voiced by many Utahns in the past few months as the state continues to raise harvest quotas for cougars despite any lack of direct population estimates (Maffly 2016). These concerns are valid, as anthropogenic influences such as hunting have been proven in multiple cases to be capable of limiting cougar populations in Utah, with these effects exacerbated when connectivity is limited between heavily hunted "sink" populations and more resilient "source" populations (Stoner et al. 2006; Wolfe et al. 2016). Hunting of cougars, range-wide habitat fragmentation, and the ecological significance of this apex predator all warrant investment in effective survey methods for the species.

**Camera-traps and Habitat Occupancy**

The maturation of noninvasive methods geared specifically towards monitoring carnivores provides a promising knowledge base for assessing cougar populations. Camera-traps in particular show great potential because they have proven highly effective for monitoring other large felids. Camera-trapping involves field setup of remote-sensor cameras, automatically triggered by motion and heat, to detect and photograph wildlife. Camera-traps have the added advantage of collecting information on all animals within an ecological community and enabling spatial and temporal comparisons to be made within and between species. The primary disadvantage is the sensitivity of detection to camera placement.

Camera placement and grid sampling techniques were originally developed for estimating tiger (*Panthera tigris*) population density in India (Karanth et al. 1995; Karanth and Nichols 1998). This method has been extended to survey other felines such as the jaguar (*Panthera onca*, Silver et al. 2004) and ocelot (*Leopardus pardalis*, Trolle and Kéry 2003). Kelly et al. (2008) demonstrated that a camera-trap grid could be used to estimate *P. concolor* density in the rainforests of South America, and many small-scale projects throughout the cougar's distribution are similarly assessing the use of camera-traps to improve population monitoring (Alexander 2016; various poster sessions in Becker et al. 2003 and Beckell et al. 2008). Comparing the efficacy of the same system in a unique landscape, such as the mountains of northern Utah, would contribute to the growing body of science on how to design camera-trap surveys to effectively monitor cougars in a variety of environments. Furthermore, our group has already conducted a pilot study and successfully used remote-sensor cameras to observe cougar behavior.

Habitat occupancy is an analytical model used to quantify population distribution in a spatially unbiased manner, with an output representing the estimated proportion of a study area occupied by the target species (MacKenzie et al. 2002). As opposed to abundance (i.e., the number of animals) and density (i.e., the number of animals per unit area) estimates, habitat occupancy relies solely on presence-absence data of a species- rather than identification of individual animals. As a result, occupancy has more realistic data requirements even while borrowing from sampling methods typically used in density estimation. Additionally, the occupancy framework can accommodate relatively low detection rates, enabling incorporation of covariates, and even allowing for missing observations (MacKenzie et al. 2002). As a result, it is an ideal method for surveying elusive species like cougars in which individuals are difficult to locate and distinguish. Using camera-traps also has the added benefit of collecting presence-absence data on all species in the study area, thus enabling for comparisons to be made between species and investigations of community dynamics like co-occurrence of species and avoidance between species (MacKenzie et al. 2002).

## OBJECTIVES

1. **Determine whether camera-traps are an effective tool for detecting *Puma concolor* presence in the Bear River Range.**
2. **Estimate habitat occupancy of *Puma concolor* in the Bear River Range and describe characteristics of cougar habitat where detected.**
3. **Establish a camera array for collection of presence-absence data on wildlife species within the Bear River Range. Use GIS methods to describe this design.**

## METHODS

### Study Area and Sampling Design

We will focus our survey efforts in a 768 $km^2$ area in the Bear River Mountains, located directly east of Logan, Utah. The Bear River Range was chosen because cougars are present but their distribution and status unknown.

The study area will be systematically divided into twelve *sample units* using a three-by-four grid with side length 8 kilometers, randomly designated using the “Fishnet” tool in ESRI’s ArcMap software *(See figure 1)*. Each sample unit covers an area roughly the size of an average home range for the target species, as suggested in Long et al. 2008. A Utah female cougar has a home range somewhere between 60$km^2$ and 100$km^2$ (Logan and Sweanor 2010; Stoner et al. 2006); females in particular will be our target for two reasons: First, females represent the breeding potential of the population, and as such are targeted by management to direct population growth (Logan and Sweanor 2010).

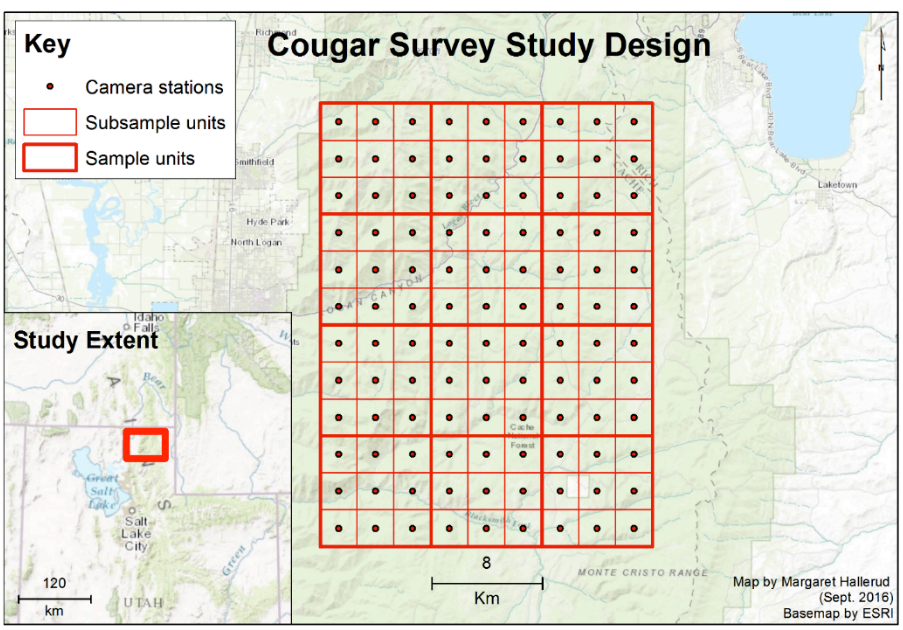


***Figure 1***

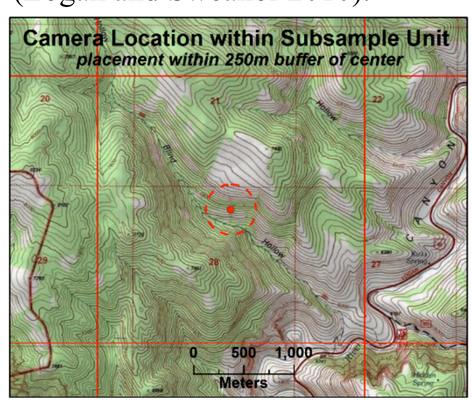


***Figure 2***

Second, female cougars tend to hold smaller home ranges compared to male cougars whose range encompasses multiple females' ranges, and female home ranges tend to exhibit a higher degree of overlap than males (Logan and Sweanor 2010)- factors suggesting that detection rates for females will likely be higher than those for males.

**Presence-Absence Surveys**

Each sample unit will be uniformly subdivided into a three-by-three grid with side length 2.67 kilometers. The center point of each of these nine grid cells, or *subsample units*, will designate a camera station. Camera stations will be installed within 250 meters of this center point *(See figure 2)* in such a manner that maximizes probability of detecting a cougar, based on available knowledge of the movements and behavior of the species (e.g., Hornocker and Negri 2010; Beier et al. 1995; Laundré and Hernández 2003). Compared to the individual range and daily movements of these animals, 250 meters is an insignificant distance. A visual lure (metal pie tin) will be hung directly in front of the camera to encourage animal investigation of the site for increased detection (D. Stoner, Utah State University, pers. comm.; E. Gese, Utah State University, pers. comm.). Corresponding with Moruzzi et al.'s (2002) recommendation for an exhaustive inventory of species present, cameras will remain in place for a four-week *survey period* for each sample unit. After those four weeks, all cameras will be removed from the field, checked for functionality, re-outfitted, and relocated to the next sample unit. Cameras will be moved a total of three times within each *survey season* so that three sample units are surveyed. The three-month timespan is consistent with assumptions of population closure in a large, slow-to-mature mammal such as *P. concolor* (Karanth and Nichols 1998; Kays and Slauson 2010). Additionally, limiting data analysis to a three-month survey period reduces the associated temporal and seasonal variation. A transition week between survey periods will be built into the schedule to allow for camera maintenance, data organization, and unforeseen complications.

Even though the study area is relatively homogeneous in terms of cougar habitat suitability, variation in camera station locations between sample units will also be controlled as possible. This is to satisfy occupancy assumptions by accounting for within-unit heterogeneity of detectability, meanwhile minimizing between-unit heterogeneity in detectability (Long and Zielinski 2010). For example, if one sample unit has three cameras located on ridges, two on dirt roads, three in drainages, and one on a trail, we will aim to match these proportions as closely as possible in the other two units surveyed during the same season. To help in this extent, the three sample units will be selected prior to the survey season and scouted using quad maps and publicly-available satellite imagery to investigate options for camera station placement. Sample units will be randomly selected from the twelve grid options available, with the restriction that a unit adjacent to one already selected during a given survey season will be rejected for the same survey season. Additionally, units sampled in the previous two survey seasons will not be considered for re-sampling yet. Lastly, to assess the heterogeneity inherent in the natural environment, habitat characteristics (e.g., dominant vegetation, slope, aspect, etc.) of every camera station will be recorded.

**Natural Sign Searches**

A core project crew of six students will be trained extensively in basic tracking skills and specifically in identifying and rating cougar sign. During each survey period, the project crew, paired with volunteers, will hike game trails throughout each sample unit in search of cougar sign including territorial scrapes, tracks, scats, and evidence of cougar predation events. Areas that do not qualify as cougar habitat (such as open areas, open water, etc.) will be excluded. These natural sign searches will serve as a comparison for the camera-trap data collected and may confirm presence in an area even if the camera data suggest absence of cougars. Survey effort will be measured by tracking the distance, time, and number of individuals actively searching for natural sign (Russell et al. 2012) and will be capped at a pre-determined amount to maintain consistency between the units. GPS locations, photographs, and other measurements will be collected in the field to confirm cougar sign, and sign of any other species encountered will also be recorded. An extra camera may be placed at sites that could potentially be revisited by the animal (such as carcasses, scrapes, or well-used trails) to confirm recent activity in the area. Furthermore, any hair or scat samples identified as cougar will be collected and stored using methods outlined in Kendall and McKelvey (2008) for potential use in future genetic analyses- another expanding area in noninvasive survey methods.

**Data Collection and Analysis**

Initial consideration of data will involve a comparison of the two detection methods to determine whether camera-traps are an effective method for detecting cougars. Similar or higher detection rates at camera stations compared to natural sign searches would indicate that a systematic camera grid may be a superior method for surveying cougars in this landscape. If natural sign searches confirm cougar presence significantly more often than cameras, a need for refined methodology or consideration of alternative noninvasive methods will be recommended.

Since the use of multiple detection methods is actually recommended in wildlife surveys, (Long et al. 2008), presence-absence data collected from both methods will be used to form the occupancy model. Data will be compiled by week, with each week considered a separate *visit* within MacKenzie et al.'s (2002) occupancy model. Presence-absence will be considered a binomial response within each sample unit over every 7-day visit period. Any detection within the full sample unit during will be recorded as "presence" during the given visit- regardless of number of total detections throughout the sample unit or method of detection. "Absence" would be a lack of any detections. A four-visit detection history and overall presence-absence output will then be compiled for each sample unit. At the conclusion of the survey season, "presence" or "absence" will be assigned to each of the three sample units surveyed. Within three survey seasons (expected to require about one year), enough units will have been sampled to confidently infer cougar distribution and use over the full study area. Additionally, detection probabilities allowing for false-error adjustments will be possible given multiple detections at a single sample unit during a survey period. This would allow actual habitat use over the entire study area to be estimated, regardless of un-surveyed units (MacKenzie et al. 2002). Time allowing, presence-absence data of non-target- particularly prey- species- collected may also be investigated for comparison with cougars.

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**LEARNING OBJECTIVES**

1. Contribute to existing knowledge on the status of *Puma concolor* within the Bear River Range and demonstrate the utility (or lack thereof for some species) of camera-traps for monitoring wildlife here.
2. Practice creating a robust study design for a potentially long-term wildlife population study. Given the nature of elusive species, careful consideration of assumptions and many discussions on how they will be dealt with will be necessary.
3. Develop networking and leadership skills. The scale of this project will give project members the opportunity to develop professional relationships with multiple professors. Working as a team of six will similarly provide lifetime professional connections and teach all involved how to cooperate on a large-scale research project. My personal role as project lead will give me invaluable experience in managing a research crew. In addition, bringing volunteers into the field will provide an opportunity for all project members to develop leadership skills in training others for fieldwork, a task which should necessarily prompt a higher understanding of the research process.
4. Solidify technical field skills. These primarily include gaining more experience with remote-sensor cameras and with tracking and natural sign investigation.
5. Experience the entire research process, including study design, protocol development and review, collection of data in the field, data processing and analysis, and presentation of study results to the scientific community, managers, and the public.