

Canadian Rockies Carnivore Monitoring Project:

Examining Trends in Carnivore Populations and their Prey Using Remote Cameras

Year 1 Progress Report: 2011-2012

Prepared for:
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Alberta Tourism, Parks and Recreation

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DISCLAIMER

This progress report contains preliminary data from ongoing academic research directed by the University of Montana, Parks Canada and Alberta Parks that will form portions of graduate student theses and scientific publications. Results and opinions presented herein are therefore considered preliminary, are to be interpreted with caution, and are subject to revision.

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EXECUTIVE SUMMARY

A primary goal of this project is to develop a unified multi-species monitoring protocol for carnivores and their prey that can be applied throughout the Canadian Rockies and across the globe. This report summarizes our project motivations, objectives, occupancy modeling frameworks, and preliminary analyses from the first year of research in the Canadian Rockies, 2011. This project will directly benefit individual parks and broader landscape management by improving power to monitor trends of carnivores and it will provide some of the first methods for effectively monitoring grizzly bears, large cats, and other elusive carnivores over large remote areas.

During the first year of this study, we developed common field sampling protocols among the parks for remote camera trapping (camera positioning, selection of microsites, database management, etc.). This coordination enabled the combination of data and analysis for all parks. Our focus for the first year of data analysis was to identify covariates that influence detection probabilities (and hence statistical power) for multiple species across the Canadian Rockies Mountain parks. We also piloted a study to assess the effectiveness of scent lure to increase detection probabilities. Here we compared detection probabilities among cameras with lure on wildlife trails to cameras placed on human-use trails with no lure. The effects of trailtype, camera type and bear rubtree presence were also evaluated to guide field efforts in year two. We finally conducted preliminary analysis to select the optimal session length of temporal replicates for occupancy analysis.

The following recommendations are made from these analyses:

- There was no significant effect of lure on detection probabilities, when comparing lured cameras off trails and non-lured cameras on trails. The use of lure, therefore, would not likely improve detection probabilities in the National Parks because lured cameras need to be set off of human-use trails for human-safety reasons.
- Many parks are starting to upgrade their cameras models (for example, replacing older models of Reconyx with new models). The analyses, however, showed that camera type did not significantly affect detection probabilities. Thus, changing cameras may increase the longevity of camera operation, reduce startle from visible flashes, and quantity of data, but not the quality of the data.
- Placing cameras on different trail types (human-use, wildlife or road bed) did not appear to affect detection probabilities; therefore, cameras can be placed without much consideration of trail type.
- Rubtrees may increase detection probabilities for most species other than bears and did not appear to decrease detection probabilities for any species. Therefore, placing cameras on rubtrees will likely improve camera trapping efficacy for most species.

1.0 BACKGROUND

1.1 Goals of this report

This report summarizes activities during the first year (2011-2012) of the project under the title “Developing multi-species habitat connectively and climate monitoring using remote-camera-based occupancy modeling across the Canadian Rockies”. This is the first Investigators Annual Report (IAR) for this project and also serves as the final report for the research and collection permit number BAN-2011-8715, fulfilling the reporting requirements for this permit. A continuation of this project has been established until 2015 under the research and collection permit number BAN-2012-11113.

Results from research during 2011-2012 are presented using data collected in 2011. This report focuses on the field logistics of maximizing detection probability through site-specific choices of using lure, trail type, camera type and using rub trees. Considering these results and the current sampling scheme, a more robust design for Parks Canada’s sampling protocol is recommended. The data collected in 2011 also allowed for preliminary analysis into the effect of sampling session length on both detection and occupancy probabilities, as well as how large mammal communities may be assembled.

1.2 Motivations for remote camera trapping in the Canadian Rockies Mountain Parks

In the face of continued human development and climate change, wide-ranging species require large tracks of suitable habitat to allow for change in species distributions (Parmesan et al. 2003, Thomas et al. 2004). Large protected areas serve a key role, but are not immune to climate change (Brashares 2010, Carroll et al. 2010). Understanding the response of wide-ranging species to climate change requires an understanding of abiotic interactions (Peterson et al. 2002) and multi-species interactions at large spatial scales (Post et al. 2009). A significant challenge in understanding these relationships is the development of multi-species monitoring capabilities across broad spatial scales. Land management agencies throughout the Canadian Rockies are coordinating remote cameras to standardize sampling strategies and analytical techniques to address these large-scale conservation issues using remote cameras.

One of these agencies, Parks Canada, is mandated to manage protected areas to allow visitation while maintaining “ecological integrity”. Section 2 of the Canada National Parks Act defines “ecological integrity” as: “a condition that is determined to be characteristic of its natural region and likely to persist, including abiotic components and the composition and abundance of native species and biological communities, rates of change and supporting processes” (Canada National Parks Act. S.C. 2000, c.32).The Parks Canada website continues with this definition to explain in plain language that: “ecosystems have integrity when they have their native components (plants, animals and other organisms) and processes (such as growth and reproduction) intact”.

Remote cameras offer a new method for monitoring at large-scales for both these aspects of ecological integrity (components and processes). For this reason, many Parks have adopted this technology for monitoring in both backcountry and frontcountry areas. At a workshop hosted by Miistakis Institute in Feb 2011, participants requested coordination of remote camera trapping across Parks Canada and Alberta Provincial Parks. This project has been integrating field efforts, standardizing sampling protocols, and harmonizing data management and analysis.

1.3 Remote cameras as an emerging technology

Remote cameras are an emerging technology being used around the globe to monitor biodiversity, especially in the mammalian order (O'Connell et al. 2011). Many species captured on cameras are individually identifiable due to spotting or striping, and remote cameras offer a means to estimate changes in abundances of these species using mark-resight methodologies (Efford et al 2009). Most mammal species in the Canadian Rockies, however, lack spots and strips and are, therefore, not individually recognizable (with at least one exception: wolverine; Royle et al. 2011). For all other species, occupancy modeling is the most appropriate method for using remote camera data to monitor population trends (MacKenzie et al 2002).

There are many areas within ecology where measures of occupancy are of interest (Royle and Dorazio 2008). In metapopulation biology, occurrence dynamics among habitat patches (e.g. islands, fragments, protected areas) changes in relation to the characteristics of the patch landscape (*i.e.* through inter-patch distance, patch size and configuration) (Levins 1969, Hanski 1998). Secondly, occupancy is related to abundance and may be used as a surrogate for abundance if the right model is used and assumptions are met (He and Gaston 2000, Royle and Nichols 2003). Thirdly, the extent of occurrence can be used for assessing the conservation status of a threatened species (*e.g.* IUCN 2012), understanding the increase in range of a pioneering species, or mapping the habitat suitability for a given species (Boyce and MacDonald 1999). Lastly, occupancy may be used as an index of population status when, in many cases, occupancy estimates are more appropriate than using abundance estimates for monitoring trends in populations, especially when a species is rare or elusive, or abundances estimates are too costly (MacKenzie and Nichols 2004).

Remote cameras also facilitate new ways to address contemporary ecological questions and provide a means to ask new ones. Training a camera on a bear rubtree, for example, captures much more data than genetic hair analysis, because animals' curiosity is also captured on cameras and may be relevant to understanding interspecific relationships, especially when animals are attracted to such trees but do not rub. Community composition data, thus, becomes more readily available for these non-sessile organisms in remote terrestrial environment. This project hopes to address questions related to ecological role of rubtrees for non-bear species and questions about how medium-large mammal communities changes across large-scale gradients such as latitude and elevation.

To date, many remote camera studies have targeted specific species, often charismatic carnivores, umbrella, or indicator species (Kucera et al. 2011). The sampling design is then tailored to the specific species to maximize probability of detection and match the sampling scale to the scale of movements of the focal species, often at the scale of the home range. There have been many advances in our understanding of species occurrence and density from such species-specific studies (Mackenzie et al. 2006) and such approaches maximize the power to detect trends in the focal species. However, remote cameras inadvertently collect much more data on non-target species than target species. This "superfluous" data spans the spectrum of species abundance, trophic levels and daily activity patterns. Little research has gone into capitalizing on this extra ecological data.

1.4 Objectives of this project

This project was originally motivated by the recent listing of grizzly bears in Alberta as threatened (Alberta Grizzly Bear Recovery Plan 2008) but multi-species monitoring is now the main focus.

We are testing methods to monitor population trends that are cost-effective, multi-species and applicable at large scales. The overall goals of this project can be broadly categorized as driven by either methods- or ecology-focused questions.

1.4.1 Methods-focused questions

1) What sampling design should Parks Canada use to choose sites for remote cameras across large landscapes?
2) How effective is using lure to increase detection probability of multiple species at remote camera locations?
3) How do camera attributes affect detection rates?
    a. Trail type (human-use, wildlife, road)
    b. Camera model (hyperfire, rapidfire, silent image)
    c. Bear rub trees (on and off bear rub trees)
4) What are the benefits of maintaining a remote camera site in a 10x10km cell versus regularly moving camera locations?
5) What power does occupancy modeling have to monitoring grizzly bear population trends?
6) What trade-offs in statistical power to detect trends in multispecies occupancy are made when sampling is designed for a focal-species?
    a. How generalizable are sampling grid designs for multiple species using a nested grid design?
    b. What is the appropriate scale of inference for multiple species with differing home-range sizes?
    c. What power remains to make inferences for multiple species when the data was collected under a sample design targeting one particular species?
    d. What is the effect of the sampling scale on patterns of multispecies occupancy and hence, power to detect trends in occupancy?
7) How do occupancy models compare to other known methods?
    a. How does trend monitoring of grizzly bears using occupancy models compare to trend estimates from rub-tree hair snags (see Stetz et al. 2010 for methods) through partnerships with Foothills Research Institute; Alberta Tourism, Parks and Recreation; and the University of Alberta.
    b. How do occupancy models extrapolated across the Canadian Rockies Mountain Parks compare to RSFs created for wolves, grizzly bears, elk and caribou?
    c. How to occupancy models from summer remote cameras compare to occupancy models from track surveys on skis in winter?
    d. How do occupancy models differ from trends in elk densities in the YahaTinda Ranch area?
8) With what precision can we estimate abundance of white-tailed and mule deer in Jasper National Park using remote cameras and a mixture of collared and uncollared deer?

1.4.2 Ecology-focused questions

9) How do large-mammal communities change across landscape gradients and how will future climate change affect the distribution of these communities?
    a. How do large-mammal communities change across biophysical variables such as climate, vegetation type, elevation, distance-to-stream?
    b. Using the change in latitude between Waterton Lakes to Jasper National Parks as a proxy for future climate change, how will different climate change scenarios affect medium-large mammal communities?
    c. As an additional objective, in collaboration with the University of Calgary, I will investigate the use of remote plant-phenology camera monitoring to understand effects of climate change on medium-large mammal habitats through bottom-up processes.
    d. What are the annual changes in occupancy of pioneering species that might be benefitting from climate changes? (*e.g.* white-tailed deer, red fox, bobcat)
10) How are large mammal communities affected by human activities and development?
    a. What is the effect of human development (*e.g.* urban, trail use) on the occupancy of multiple species in the Canadian Rockies Mountain Parks
    b. How does human use on trails affect use of trails by wildlife temporally and spatially? Do humans provide a predator refuge for prey?
11) What is the ecological role of bear rub trees for other species; how do detection probabilities change for multiple species for cameras on rub trees compared to cameras not on rub trees
12) What is the effect of fire (time since burn) on multi-species occupancy?
13) How does wildlife use/movement differ between human-made pinch points (highway crossing) and natural pinch points (high elevation passes)?

1.5 Objectives of this report

The objectives of this first-year annual progress report are to outline the research objectives, describe the analytical methods to be used throughout the project and to address some of the site-specific characteristics for selection of camera locations. The sampling design of 2011 is examined and changes to are recommended for sampling in 2012. The specific objectives above that will be addressed in this report include #'s 1, 2 and 3 as well as preliminary analyses for #'s 9, 10 and 11.

2.0 METHODS

2.1 Study Area

The Canadian Rockies Carnivore Monitoring Project study area spans over 4 degrees of latitude from the northern extent of Jasper National Park to Waterton Lakes National Park in the South, encompassing 5 national parks, and adjacent provincial lands in Alberta's foothills, including a portion of Spray Lakes Provincial Park (figure 1). Topography is extreme and the weather is temperate, with 360 cm of annual snowfall on average. Currently ~200 cameras are deployed in the study area.

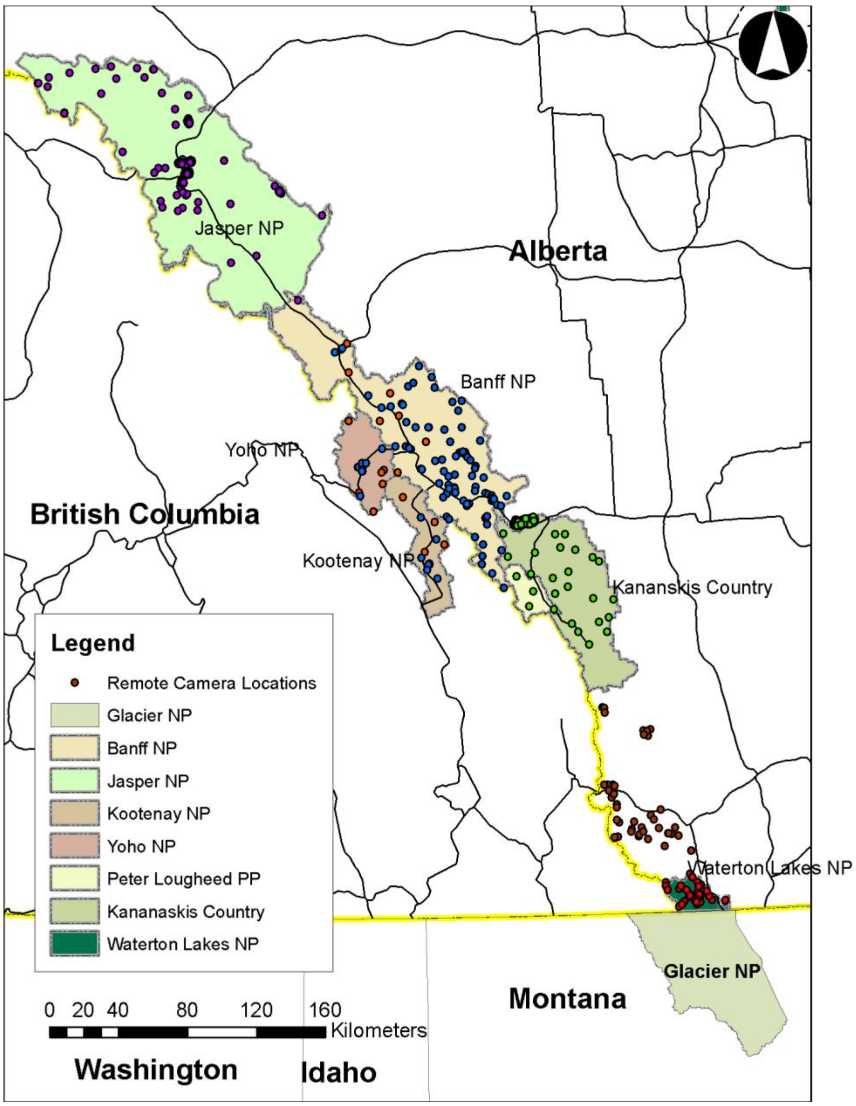

Figure 1: Canadian Rockies Carnivore Monitoring Project study area across Alberta and British Columbia, Canada.

2.2 Occupancy modeling

Occupancy is a site-level binary state (z) of whether or not a species is present or absence from a site. If a site, patch, or cell (*i*) is occupied, $z_i = 1$, and if it is unoccupied, $z_i = 0$. The probability of occupancy ψ (pronounced "psi") describes the probability that a site *i* is occupied, such that $\psi_i = \Pr(z_i = 1)$. When this stochastic process is realized at the level of the study area for *n* spatially-indexed sites, the estimates of ψ can then be summarized to calculate the Proportion of Area Occupied (PAO=$\sum_{i=1}^{n} \psi i$) (Royle and Dorazio 2008). PAO can be used as an index of population trends and status.

Recently, occupancy has been given more attention with the ability to incorporate imperfect detection into the modeling of occupancy (MacKenzie et al. 2002). Detection probability (p) is used to estimate the proportion of sites where species were present but not detected. Detection probabilities can be added to occupancy models in a hierarchical fashion, whereby p is contingent upon whether or not an individual was present to be detected (*i.e*. ψ=1). In order to estimate detection probabilities, we need multiple sampling (*e.g.* over time). For example, if a site were surveyed 4 times (or if camera data were split into 4 one-week intervals) then we can create detection histories with 0s and 1s for non-detections and detection, respectively. For example, if we detected a grizzly bear at a camera at site *I* the 1st and 3rd week but not the 2nd and 4th, the detection history would be '1010'. The likelihood at site *i* would then be: $\psi_i(p_i)(1-p_i)(p_i)(1-p_i)$ where 1-p is the probability of not detecting a grizzly bear. In words, this is the product of the probability the bear was present, times the probability it was detected, times the probability it was <u>not</u> detected, times the probability it was detected, times the probability it was <u>not</u> detected. This computation is straight-forward for all possible detection histories except for '0000' which may indicate the bear was present but never detected or not present. Therefore the likelihood for this detection history at site *k* would be $\psi_k \prod_{t=1}^{4}(1 - p_k)$ + $(1 - \psi_k)$. The product of all likelihoods calculated in this manner (one per site) gives a model likelihood that can be maximized given data, through changes in parameters ψ and p. Note that in these examples, p remained constant across sampling sessions but occupancy was allowed to vary across sites; this methodology allows for different p across sessions and a constant ψ across sites. Covariates for both ψ and p can also be added to the equation, and missing data can also be accounted for easily (MacKenzie et al. 2002). For this report, we used the unmarked package in R to model occupancy using this maximum likelihood approach (Fiske and Chandler 2011).

2.3 Effect of the length of sampling session on grizzly bear detection and occupancy probabilities

We ran the null model across different sampling session lengths in order to examine the trade-off between the length of sampling session and the number of sampling occasions, and how this affects model parameters. While keeping the same total length of data, the number of sampling sessions decreases as the length of the sampling session increases. Presence-absence data from Banff National Parks cameras for a 12-week period between 18 Jun and 17 Sept, 2011 was split into sampling session of 1, 2, 3, and 4 weeks per session and analyzed separately. This sampling results in 12, 6, 4, and 3 sessions per analysis, respectively. Estimates of occupancy, detection probability and their standard errors were estimated for each analysis.

2.4 Effect of using lure on multi-species detection probability

In Banff National Park and Spray Lakes Provincial Park, we deployed 12 cameras to sites off of human-use trails, normally on wildlife trails. Half of these cameras received lure upon deployment in early July and the other half received lure 6 weeks following deployment. All cameras were revisited approximately 6 weeks after setup to remove lure from those with lure, and add lure to those sites that did not have lure initially. Wooden shelters were created for the lure, to allow removal of lure from the site. Each off human-use trail camera was paired with a previously deployed camera on a human-use trail for a total of n=24 cameras. To minimize the differences between cameras on and off trails, similar elevation/aspect/habitat type for were used for off-trail cameras and their on-trail camera counterpart and the same camera type. Each off-trail camera location was >2km from its on-trail camera partner to avoid any spill-over effect of the lure. Each lured camera location was also >300m away from any human-use trails for public safety reasons.

Using the null occupancy model (no covariates for p or psi) and a sampling session length of 1 week, p was modeled for 11 species: grizzly bear, wolf, lynx, cougar, black bear, coyote, elk, moose, mule deer, white-tailed deer and red fox. Results are presented for when cameras were on human-use trails, off human use trails with lure, and off human use trails without lure.

2.5 Effects of camera type and trail type on detection probability

Site-specific camera placement may affect detection probabilities for multiple species. Detection probabilities for 11 species are analyzed across different camera model types and different trail types. Three Reconyx camera models were used: Hyperfire, Rapidfire and Silent Image, in increasing order of model age. The most important advancement between model types is the inclusion of a covert Infrared flash in the Hyperfire and Rapidfire models which have been hypothesized to cause fewer animals to be startled when photos are taken, when compared to the regular white LED flash of the Silent Image model. A startled response may cause some species to avoid known camera locations in the future, creating a trap-shy bias (Wegge et al. 2004). Cameras were deployed on 3 different trail types as well: wildlife trails, human-use trails and road beds.

2.6 Effect of rubtrees on multi-species detection probability

In order to increase the probability of detecting grizzly bears, many cameras across the study area were placed on bear rubtrees (also known as communication trees). These trees are hypothesized to be used for chemical communication among bears during mating season with rubbing peaking in June (Green and Mattson 2003). In the Northern Continental Divide Ecosystem, Montana, a large grizzly bear abundance survey using rub trees found that females did not rub during May and June but that by August, the sex ratio on rub trees was ~50:50 (K. Kendall Per. Comm. 2011). Little more is known about grizzly rub trees, and nothing is written about what how they affect other species, except black bears, which also frequently rub these trees.

2.7 Preliminary community structure analysis

We set out to explore how large mammal species were assembled on low-valley and high-pass trails. Our first hypothesis (H_1) was that communities would show evidence of a human-caused trophic cascades where the presence of humans is correlated with the lack of predators, a refuge for prey species (Hebblewhite et al. 2005, Muhly et al 2011). Our second, competing hypothesis (H_2) was that carnivores would be present in areas where their most common prey species were present, for example: cougars and deer together, wolves and elk together (Kortello et al. 2007).

Non-metric multi-dimensional scaling (MDS) is one of a group of ordination methods that allow for the display of relationships among many variables in a more comprehensible number of dimensions (*i.e.* 2 or 3). Unlike more common ordination methods like Principle component analysis (PCA), MDS does not reduce the data to a smaller number of variables, but rather redisplays the data without a dimensional reduction, using only the non-parametric relationships between the variables (Kenkel and Orloci 1986). Here, we used species presence as the variables of interest and camera locations as replications of species' presence or absence.

Species presence-absence data from June 2011 cameras in Banff National Park were used for analysis in the R package vegan (Oksanen 2011). All human activities (walking, horse-back riding and biking) were categorized together as 'human' and 11 large mammal species were included (grizzly bear, wolf, lynx, cougar, black bear, coyote, elk, moose, mule deer, white-tailed deer, red fox). No covariates for camera locations were included, only presence or absence for each species.

To interpret an MDS plot, the actual position on the plot in not important, but rather the relative position of each species. The distances among species indicate their tendency to be present at the same sites, such that the further apart species are from one another, the less they are to occur at the same sites. Because no site covariates were included in this analysis, the MDS axes represent dissimilarities calculated from the Euclidean distances in the dissimilarity matrix and have no biological meaning.

2.8 Assessment of existing camera trap design

Complete temporal coverage, *i.e.* continuous simultaneous sampling at each camera location is important to increase confidence in parameter estimates. The fewer gaps in sampling time, the smaller the confidence intervals around estimates in p and psi. Spatial coverage and standardized sampling protocol will affect the scale of inference. The current sampling design for 2011 across the 5 national parks is examined.

3.0 RESULTS AND DISCUSSION

3.1 Effects due to length of sampling session

As the length of sampling session doubles from 7 days to 14 days, detection probability (p) also nearly doubles (figure 2), but a further increase in sampling sessions to 21 or 28 days does not significantly affect p. The standard error, on the other hand, continues to increase with increasing length of sampling session. Occupancy probabilities (psi) do not change across models, although the error does increase as session length increases. Using one week intervals seems appropriate for future analysis in order to decrease error in both p and psi.

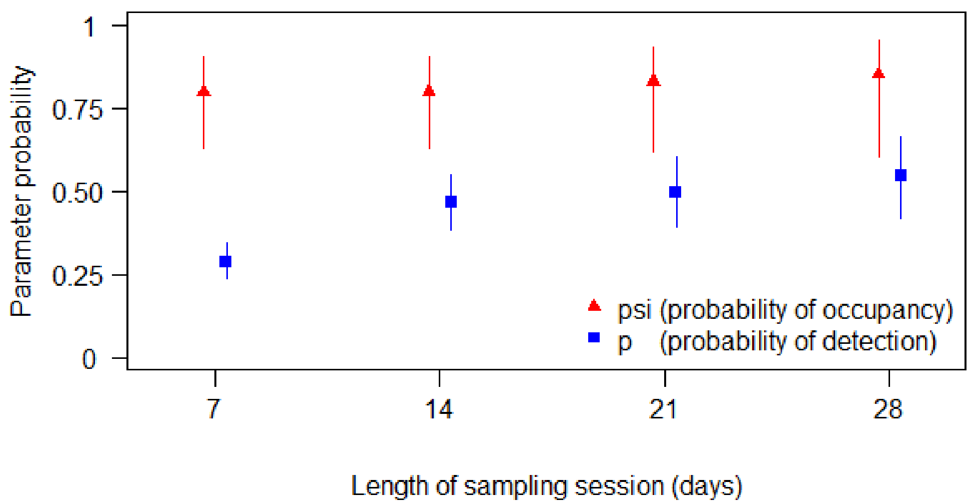

Figure 2: Effects due to length of sampling session on occupancy and detection probabilities. Each model used data from grizzly bears captured on n=45 camera sites in Banff National Park, 18 Jun – 17 Sept, 2011. Means and 95% confidence intervals are presented.

3.2 Effects of lure on detection probabilities

Grizzly bears have significantly higher detection probabilities with cameras set on human-use trails than off human-use trails when no lure is used (Figure 3). The use of lure off trails, however, seems to counteract this difference, possibly pulling grizzlies off of human-use trail to lesser used wildlife trails to investigate the lure scent. No other species showed significant differences among treatments, however, off human-use trail cameras tended to show lower detection probabilities when no lure was used, as would be expected. For 9 of the 11 species, human-use trail cameras tended to have higher detection probabilities than off-trail lured cameras (although differences are non-significant). These results suggest that the use of lure would not improve detection probabilities in the National Parks because of the safety requirement for lured cameras to be set off of human-use trails.

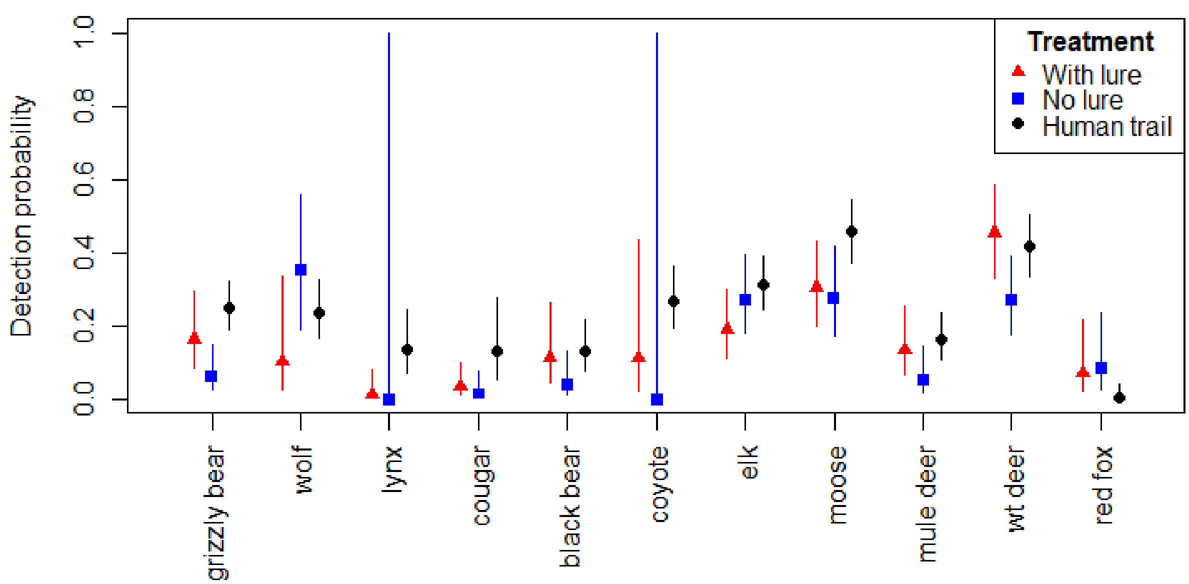

Figure 3: Effect of using lure on detection probability for 11 large mammal species in the Canadian Rockies (mean and 95% confidence intervals). Results are shown for 3 treatments: cameras set off human-use trails with and without lure and cameras on human-use trails without lure (n=24).

3.3 Effect of camera type on detection probability

Different camera models affect the detection probabilities for black bear and white-tailed deer, but not for any other of the 9 species investigated (figure 4). This suggests that older models such as Silent Image cameras do provide reliable data despite features such as a visible LED flash. This analysis does not, however incorporate any variability in the total length of time that these cameras are running, but does account for how much the cameras were running between Jun 18 and Sept 17. Therefore, ultimate battery life and other field logistics concerns may still warrant prioritizing using newer models, even if ecologically, the data collected are of similar quality.

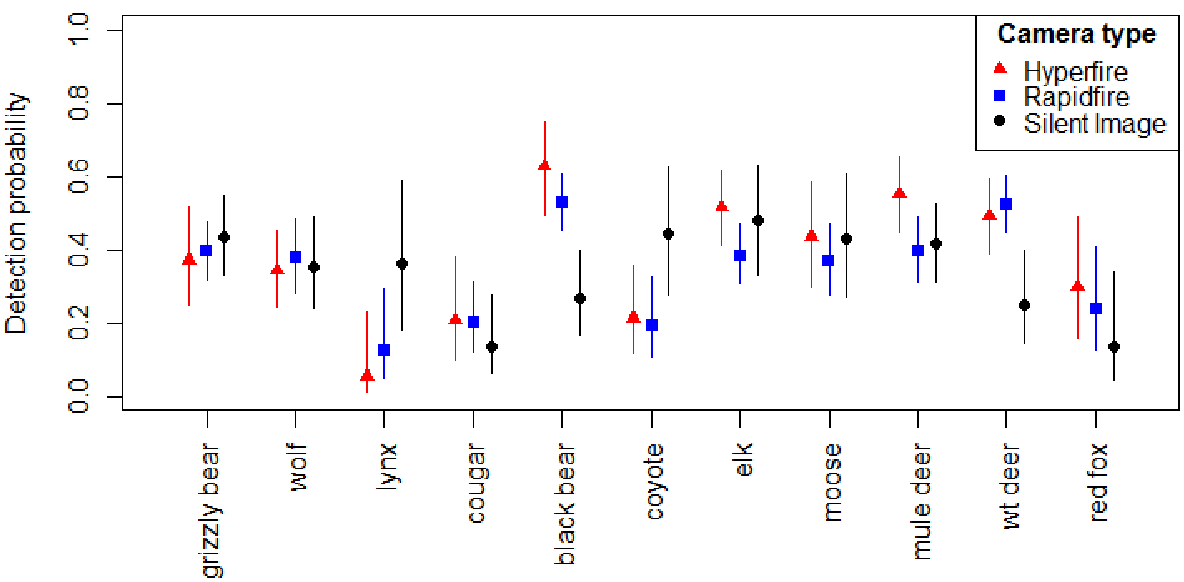

Figure 4: Effect of camera type on detection probability (mean and 95% confidence intervals) for 11 large mammal species in the Canadian Rockies (n=106).

3.4 Effect of trail type on detection probability

Trail type as a covariate does not capture much of the variation in detection probabilities. The only significant difference to note is that black bears are more likely to be detected on wildlife trails than on human-use trails (figure 5). Besides black bears and mule deer, it may be interesting to note that there is a tendency for detection probabilities to be higher on human-use trails than on wildlife trails, or for detection probabilities to be similar. Large confidence intervals for road bed camera sites are likley due to small sample size (n=6). Human-use trails, therefore, seem to have higher detection probabilities for multiple species, with the exception of black bear and possibly mule deer. Note that only sites where trailtype was known and was easily categorized as on a human-use trail (n=43), on a wildlife trail (n=17) or on a road bed (n=6) were used. No sites that used lure were included in this analysis.

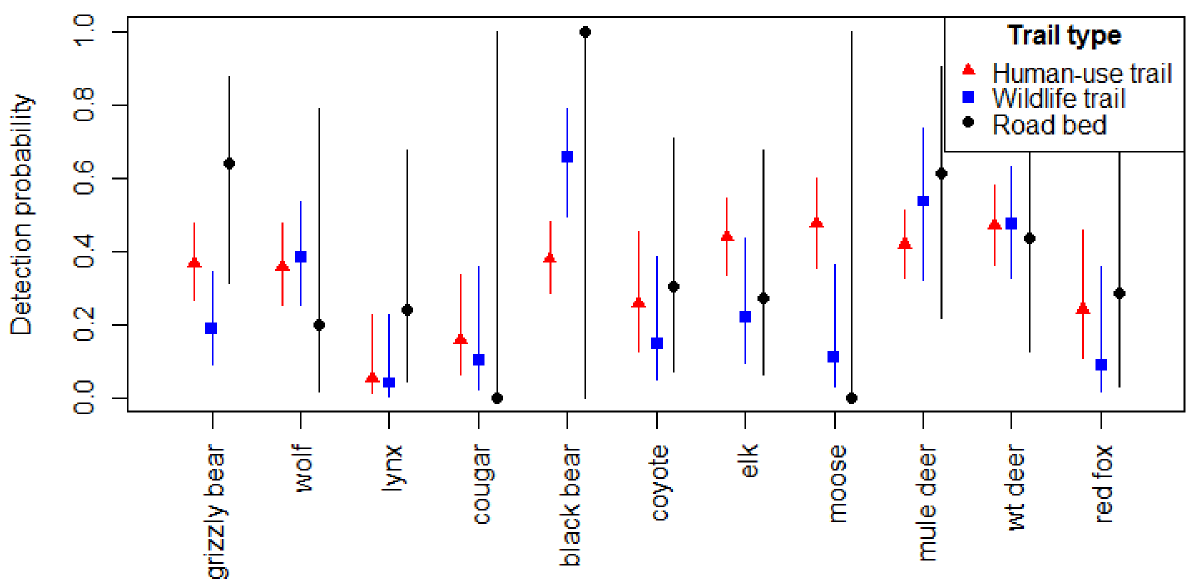

Figure 5: Effect of trail type on detection probability (mean and 95% confidence intervals) for 11 large mammal species in the Canadian Rockies (n=66).

3.5 Effect of rubtrees on detection probability

Due to small sample size (n=18), placing cameras on rubtrees along human-use trails in low valleys did not affect detection probabilities significantly when compared to cameras placed on non-rub trees in similar locations (figure 6). A number of trends, however, are interesting to note. Firstly, for all species, rubtrees increased detection probabilities. In this analysis, rubtrees provided the only camera sites where coyote, lynx or red fox were detected (with 1, 2 and 2 total detections, respectively). Furthermore, the smallest of the increases in detection probability can be seen for grizzly bears and secondly for black bears, while wolves and ungulates showed the largest increases in detection probabilities.

Little is known about the ecological role of rubtrees for bears or for other species (Green and Mattson 2003). The implications of this preliminary analysis are that bears (both grizzly and black) are using trails regardless of the presence of rubtrees and rub opportunistically when they are encountered. Other species (carnivores and prey), on the other hand, may be using these rubtrees to check for recent rubbing by bears or communications by other species. More analysis will proceed this report, involving the inclusion of data from other parks.

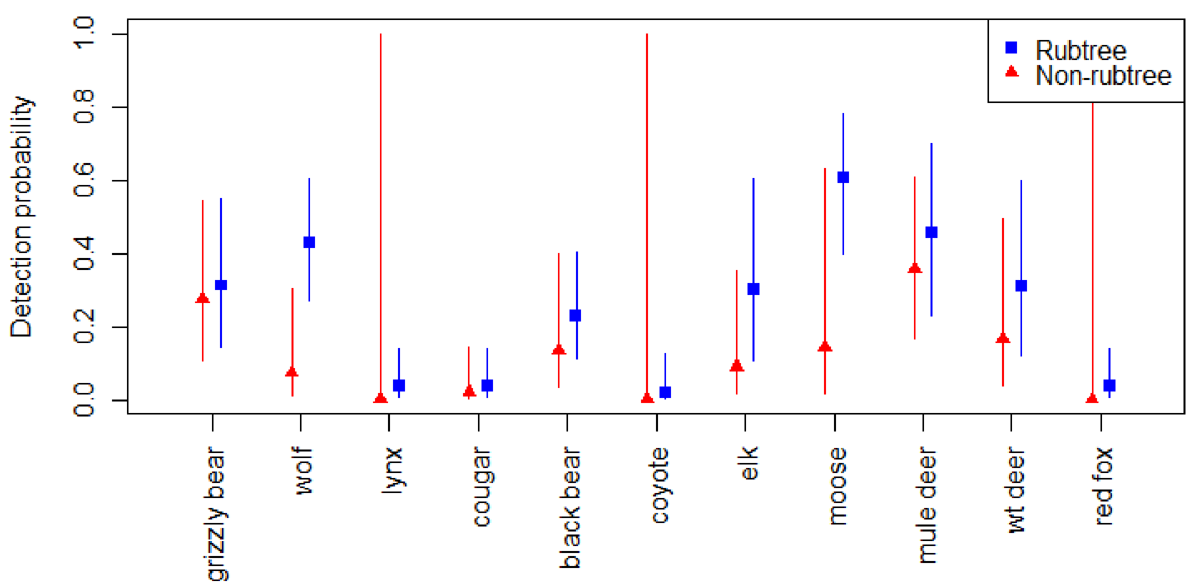

Figure 6: Effect of placing cameras on active bear rubtrees for detection probabilities of 11 large mammal species in the Canadian Rockies (mean and 95% confidence intervals). n=18 cameras with half on rubtrees, half on non-rubtrees

3.6 Preliminary community structure analysis

This preliminary analysis supports our H1 hypothesis, humans may provide some refuge from predators for ungulates. Humans, elk, mule deer and white-tailed deer are present at the same locations (figure 7). Grizzly bears, however, are also common where ungulates and humans are present, likely because cameras were put on trails that grizzly bears are likely to use. Wolves and coyotes, though less so, also seem to be close to this clustering. All other predators are spread out evenly in the graph, indicating they are not present where the above species are present, and furthermore, because they are not clustered together, they tend not to be present at the same locations. Bighorn sheep do not cluster with the rest of the ungulate species, which can be expected when considering their coarse-scale habitat requirements are very different.

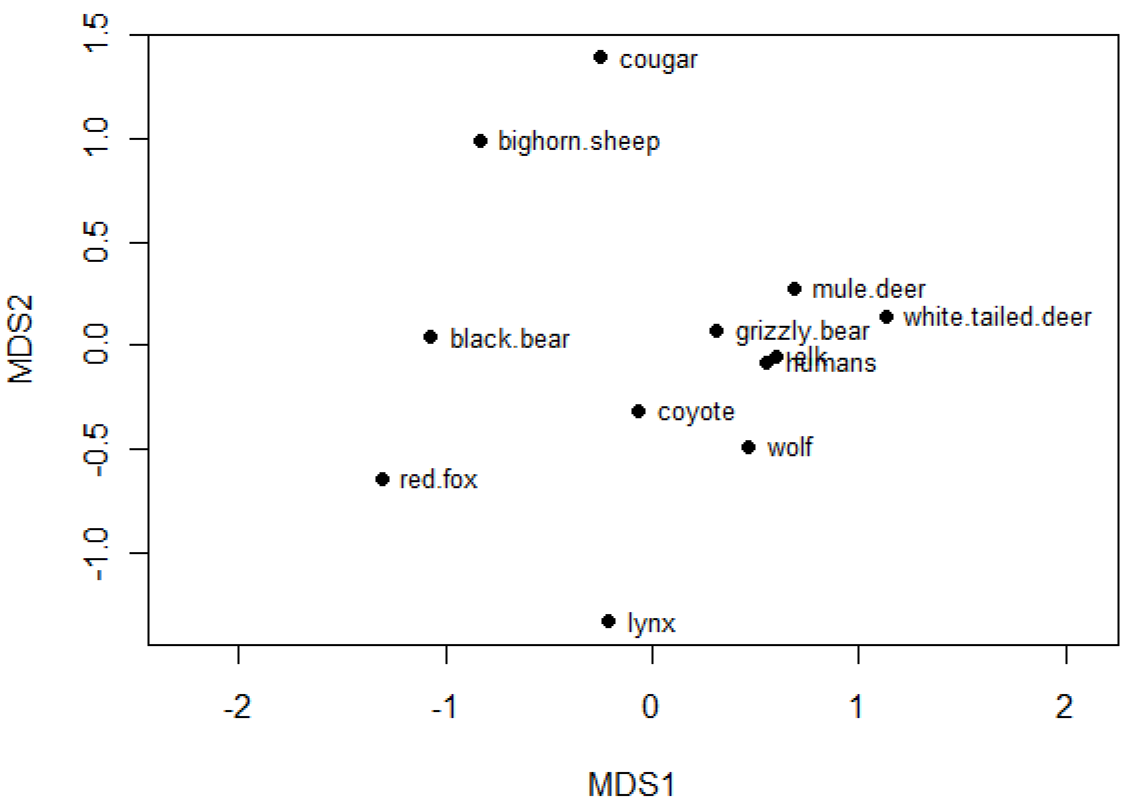

Figure 7: Ordination plot from non-metric multi-dimensional scaling analysis of presence-absence data from 29 camera sites in Banff National Park, June 2011. Note that elk and humans are difficult to visualize because they overlap on the plot.

3.7 Temporal sampling coverage

There are many reasons that cameras in the field stop working properly. Batteries empty, SD cards fill up; cameras are disturbed by humans or animals; and at times, cameras simply malfunction. Due to the remoteness of many of the camera locations, these issues are hard to avoid, but it is still worth noting that simultaneous sampling is important for analysis. Absent data due to gaps in sampling (figure 8) can be accounted for in occupancy models, but it does increase the size of confidence intervals for parameter estimates.

Figure 8: Temporal sampling coverage for cameras in Banff National Park 2011. Lines depict which days of 2011 cameras were running and collecting data.

4.0 RECOMMENDATIONS

4.1 Site-specific camera location recommendations

To summarize the conclusions from the above analyses in order to make recommendations:

- There was no significant effect of lure on detection probabilities, when comparing lured cameras off trail and non-lured cameras on trail. The use of lure, therefore, would not likely improve detection probabilities in the National Parks because lured cameras need to be set off of human-use trails for human-safety reasons.
- Many parks are starting to upgrade their cameras models (for example, replacing older models of Reconyx with new models). The analyses, however, showed that camera type did not significantly affect detection probabilities. Thus, changing cameras may increase the longevity of camera operation, reduce startle from visible flashes, and quantity of data, but not the quality of the data.
- Placing cameras on different trail types (human-use, wildlife or road bed) does not appear to affect detection probabilities, therefore, cameras can be placed without much consideration of trail type.
- Rubtrees may increase detection probabilities for most species other than bears and do not appear to decrease detection probabilities for any species (though results are non-significant). Therefore, placing cameras on rubtrees will likely improve camera trapping efficacy.

4.2 Spatial and temporal sampling intensity

In order to make inferences across entire parks for future trend monitoring of carnivores, sampling should be spread out evenly across each park. Placing one camera per 10x10 km cell is convenient because this creates a density that is logistically feasible for most national parks, it ensures complete sampling of the park, and it provides more than one camera within each carnivore's home range. When current camera locations were overlaid on a 10x10 km grid (figure 9), most grid cells are currently sampled by cameras with decent detection probabilities (Appendix 7.1). These cameras are well suited for continued deployement which important for estimating changes in occupancy over time. Some cells have two cameras, some of which could be moved to vacant cells. For Waterton Lakes National Park, a 5x5 km grid is likely more appropriate given its relatively small size and excellent trail access (figure 10).

Temporal gaps in sampling (figure 8) can be accounted for in occupancy models, but this increases the size of confidence intervals for parameter estimates. These gaps (often caused by camera malfunction), therefore, should continue to be minimized.

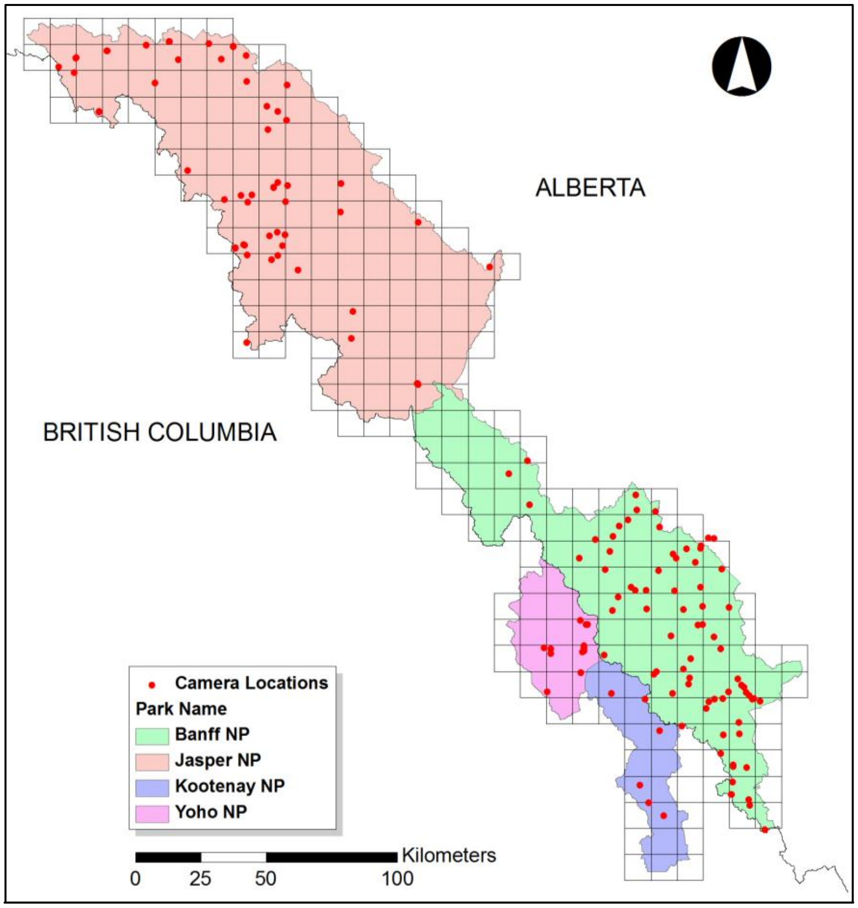

Figure 9: Approximate 10x10 km sampling grid for the Jasper, Banff, Yoho and Kootenay National Parks overlaid on 2011 camera locations

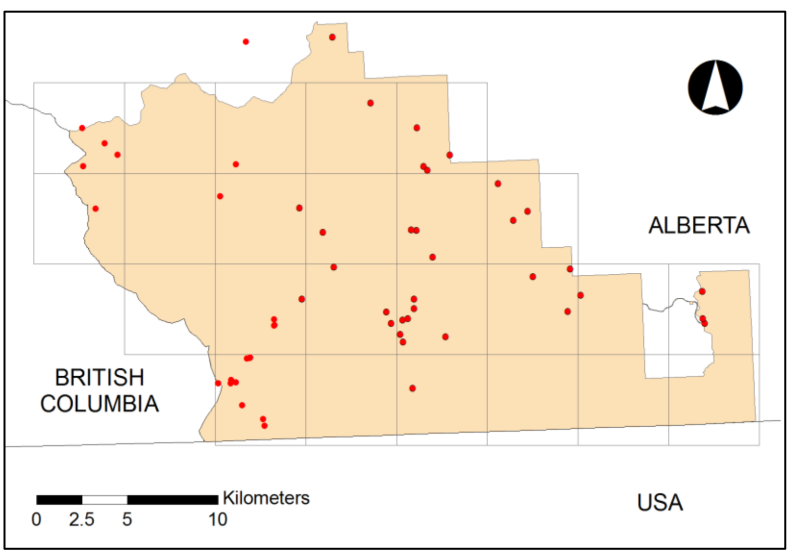

Figure 10: Approximate 5x5 km sampling grid for the Waterton Lakes National Park overlaid on 2011 camera locations

4.3 Starting to stratify sampling

The benefits of stratifying sampling include gaining precision (*i.e.* decreasing error) when strata explain some of the variation in the model; stratifying also allows for analysis among strata to investigate interesting differences among them (Krebs 1999). For the 2012 sampling, we suggest the following guidelines to start stratifying and help sample a wider range of sites and avoid pitfalls associated with only sampling valley-bottom trails.

- In each group of 4 adjacent 10x10 cells (*i.e.* within every 20x20 km cell), 2 of the 4 cameras should be placed on low-valley human-use trails. Locations on low-valley human-use trails will likely also offer important information about levels of human use and its effects on wildlife.
- For the other two cameras per 4 cells, place 1 camera on a pass (another high movement area) and
- Place the last of the 4 cameras in an "other" movement area. Sampling other types of occurrence hot-spots will increase the chance of detecting other carnivore species that may avoid human-use trails. These "other" sites include: wetlands/marshy areas, licks, anthropologically-created pinch points on the landscape, a bench, or some other defined wildlife trail in, for example, an alpine bowl, along the base of a cliff, etc.
- New cameras can be deployed using the above criteria. However, existing camera locations with decent detection probabilities should be left in the same location for multi-year data. Multi-year analyses use changes in occurrence at individual camera locations to estimate colonization and extinction rates.

5.0 STATUS OF OBJECTIVES AND FUTURE DIRECTIONS

Analyses presented in this report are preliminary because they included one season of data. We will expand upon most of these analyses with each additional year of data collection.

- Specific objectives met in this report include objectives 1,2,3 (to improve Parks Canada's sampling design; investigate the effects of lure; and analyze how other camera attributes affect detection rates).
- We provided preliminary analysis for objectives 9 and 10 for how do large-mammal communities change across landscape gradients and how they are affected by human activities
- Objective 11, the rubtree analysis, will be expanded to include data from all parks (rather than restricted to Jasper National Park) once all camera trees are identified as being on a rub tree or not and all 2011 data has been entered into the database.
- For Objective 6, revolving around questions of sampling intensity and scale, we are deploying cameras in a nested-grid design at 3 scales. The largest scale (20x20km) approximates the smallest home range size of grizzly bears area in this study area (~520 km^2 and 1405 km^2 for females and males respectively (Stevens and Gibeau 2005) and is roughly equivalent to the ABMI sampling grid size (Stadt etal 2006). The second grid scale (10x10km) approximates the home range of cougars (*Puma concolor*) in the Canadian Rockies (87-97 km^2 and 140-334 km^2 for females and males respectively, depending on the season; Ross and Jalkotzy 1992). Finally, these cells will be further subdivided into 5x5km cells at the home range scale of bobcats (*Lynx rufus*)

(~25 km^2; Knick 1990). Occupancy models will be created at all three scales for all mammal species captured on remote cameras with sufficient detection probabilities. Power to detect changes in occupancy will be compared across species and across sampling scales. We deployed the 3 scales of sampling across 1800 km^2 of Southern Banff National Park and Spray Provincial Park during 2012 (Figure 11). Waterton Lakes National Park is also sampling ~600 km^2 with a 5x5km grid. We will focus this hierarchal sampling in two other areas during 2013 and 2014 (potentially Ya Ha Tinda and Jasper) to make broad-scale inferences about the effects of sampling resolution on multi-species monitoring across a gradient of wildlife abundance

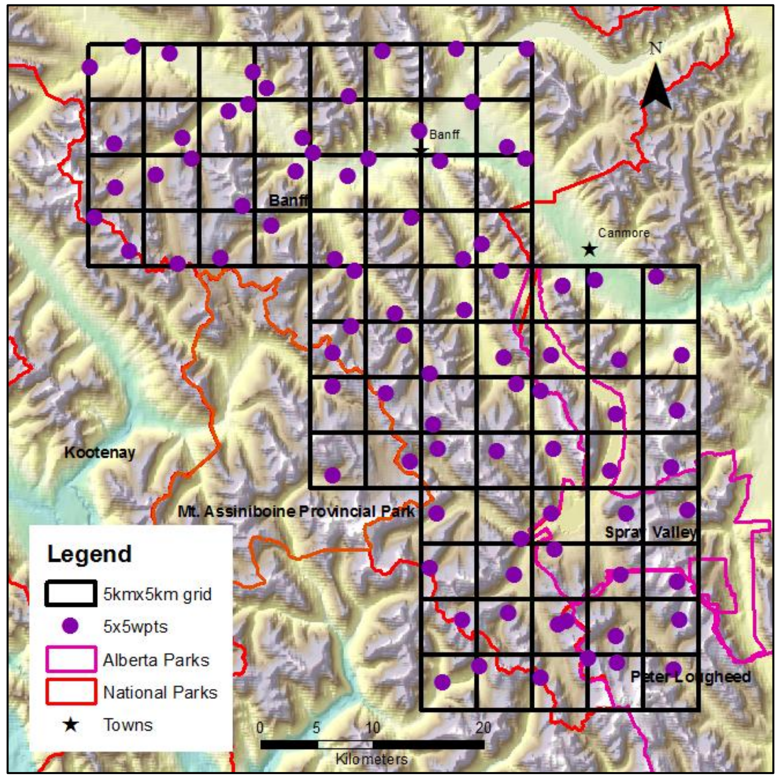

Figure 11 Approximate cameras locations nested at 3 scales of sampling intensity in Southern Banff National Park and Spray Provincial Park in 2012.

- Objective 4, comparing the benefits of moving vs stationary sampling, will involve subsampling the 5x5 sampling grid to simulate moving sites within a 10x10 grid.
- In order to address Objective 7, comparing methods of grizzly bear trend evaluation, relations are continuing to be solidified with the grizzly bear rub tree project south of Highway 3, Alberta.
- Further focus on objective 9, changes in mammal communities across spatial covariates has continued through communications with Miistakis and Dave Garrow (Parks Canada) in order to understand how data has been collected in areas between Banff and Waterton Lakes National Parks as parts of two past graduate theses. These data will fill a large sampling gap in our current camera distribution (see figure 1).
- To address objective 12, the effects of burns on large-mammal communities, cameras across the national parks have been prioritizing placing cameras in burns when possible during the 2012 camera deployment.

Remote cameras provide a potentially powerful and inexpensive tool to monitor trends in multiple species and their interactions across large geographic areas. This project will help Parks Canada, Alberta Provincial Parks, and regional land managers develop optimal sampling protocols for monitoring rare elusive carnivores and expanding species. Moreover, it will improve our understanding of how human use, fires, and changing climatic conditions will affect multi-species interactions and distribution.

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7.0 APPENDIX

7.1 Naïve detection probabilities for 2011 camera locations across 11 species (18 Jun – 10 Sept)

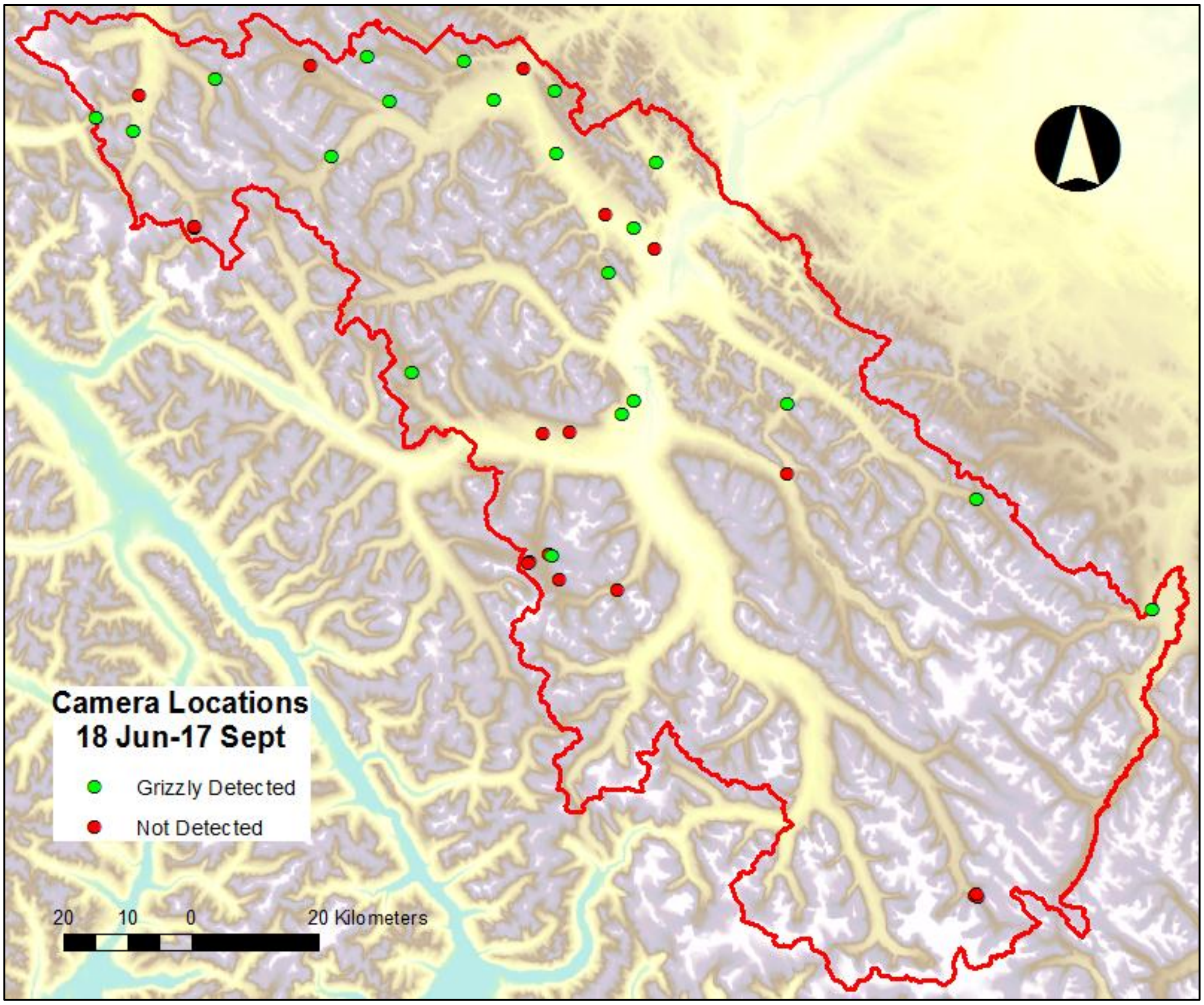
Camera Location	Park	Grizzly Bear	Black Bear	Wolf	Coyote	Cougar	Lynx	Red Fox	Mule Deer	WT Deer	Elk	Moose
Allenby Og Junction2	BNP	0.33	0.00	0.50	0.33	0.00	0.17	0.00	0.33	0.00	0.67	0.33
Badger Pass East	BNP	0.50	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barrier	BNP	0.50	0.00	0.33	0.00	0.00	0.17	0.33	0.33	1.00	0.83	0.00
Brewster Creek	BNP	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.67	0.00	0.00
Carrot Creek	BNP	0.00	0.33	0.00	0.00	0.00	0.00	0.00	1.00	0.50	0.50	0.00
Clearwater Lakes	BNP	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.80	0.20	0.00
Clearwater Upper	BNP	0.50	0.00	0.33	0.00	0.00	0.17	0.00	0.67	0.00	1.00	0.83
Cuthead Flints Off Trail	BNP	0.40	0.00	0.00	0.20	0.00	0.00	0.20	0.00	0.20	0.00	0.00
Cuthead Shortcut	BNP	0.40	0.00	0.00	0.20	0.00	0.20	0.00	0.00	0.40	0.40	0.00
Elk Horn Summit	BNP	0.00	0.00	0.60	1.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00
Elk Pass Trail	BNP	0.83	0.17	0.17	0.00	0.00	0.00	0.33	0.50	0.17	0.33	0.00
Fairholme Bench East	BNP	0.17	0.00	1.00	0.00	0.00	0.00	0.00	0.83	0.83	0.33	0.00
Fairholme Off Trail	BNP	0.50	0.25	0.25	0.00	0.00	0.00	0.00	0.00	0.75	0.50	0.00
Indianhead Creek	BNP	0.75	0.00	0.75	0.00	0.25	0.00	0.25	0.00	0.00	0.75	0.25
Ishbel Hillsdale	BNP	0.33	0.33	0.17	0.00	0.00	0.00	0.33	0.17	0.00	0.00	0.00
Ishbel Ink Pots	BNP	0.20	0.40	0.20	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00
Johnson Lake Junction	BNP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00
Johnson Lake Off Trail	BNP	0.33	0.33	0.50	0.17	0.17	0.00	0.17	0.50	1.00	0.67	0.00
Lone Pine Cascade	BNP	0.50	0.00	0.83	1.00	0.17	1.00	0.00	0.33	0.33	0.67	0.00
Malloch Flats	BNP	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.50	1.00	0.00
Marvel Lake	BNP	0.80	0.00	0.20	0.00	0.00	0.00	0.00	0.80	0.00	0.60	0.20
Marvel Pass2	BNP	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00
Mystic Pass West	BNP	0.67	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.17	0.00	0.00
Nasswald Pass	BNP	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
North Fork Cascade	BNP	0.60	0.00	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Palliser Pass	BNP	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.25
Peters Creek	BNP	0.20	0.00	0.40	0.00	0.20	0.00	0.00	0.20	0.20	0.00	0.00

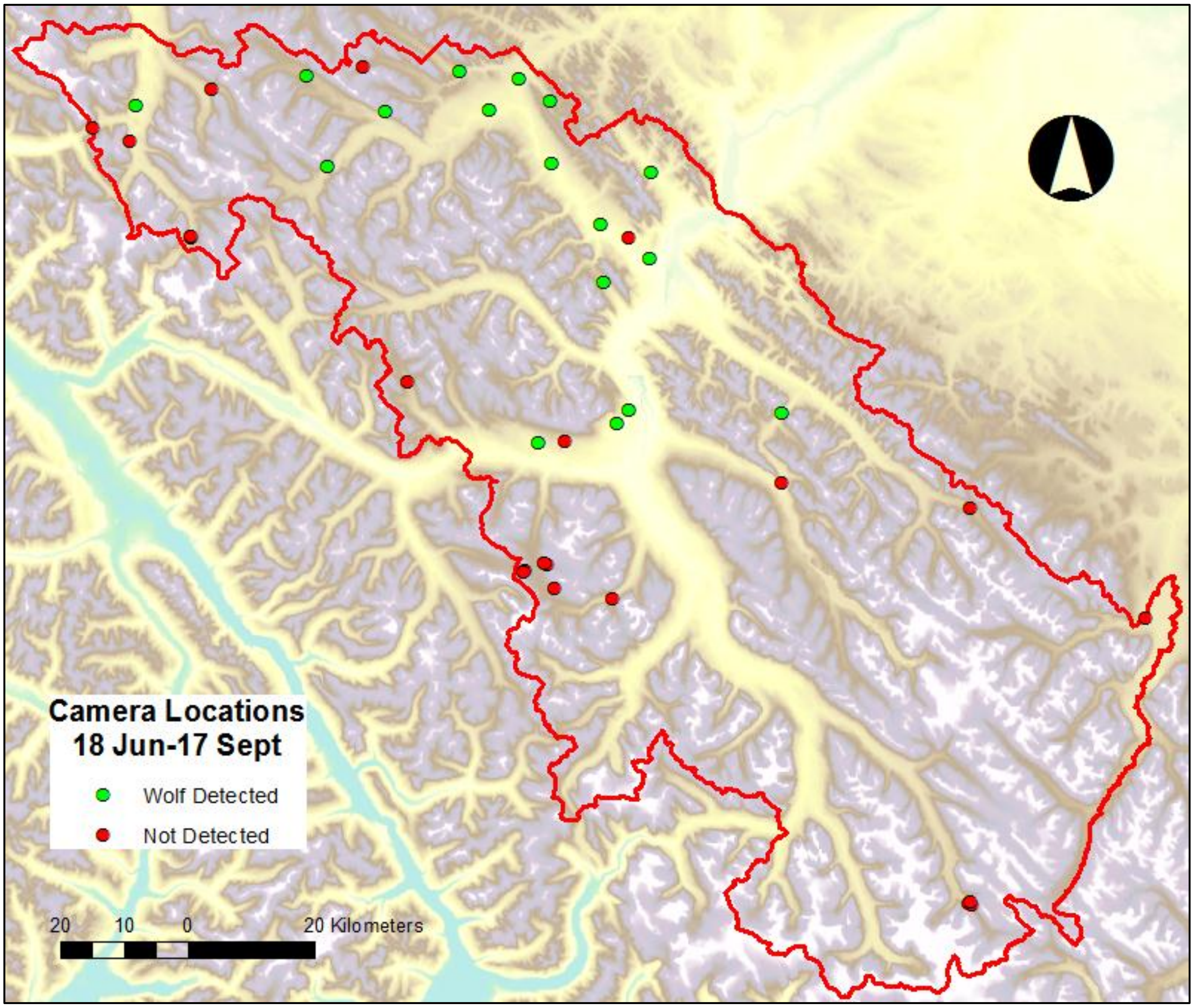
Camera Location	Park	Grizzly Bear	Black Bear	Wolf	Coyote	Cougar	Lynx	Red Fox	Mule Deer	WT Deer	Elk	Moose
Red Deer Boundary2	BNP	0.20	0.00	0.60	0.20	0.00	0.00	0.00	0.20	0.40	0.20	0.00
Red Earth	BNP	0.17	0.17	0.33	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.33
Scotch Camp	BNP	0.67	0.00	0.00	0.33	0.00	0.33	0.00	0.67	0.50	0.33	0.00
Scotch McConnel	BNP	0.00	0.00	0.50	0.50	0.00	0.00	0.00	1.00	1.00	0.67	0.00
Shale Pass	BNP	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.50	0.00	0.00	0.00
Spray 8 Lick	BNP	0.00	0.33	0.00	0.17	0.50	0.00	0.00	0.67	0.17	0.83	0.33
Spray Upper Off Trail	BNP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.40	0.20	0.60
Turbulent Creek Upper Off Tr	BNP	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.75	0.25
Tyrrell Creek	BNP	0.83	0.00	0.17	0.00	0.17	0.00	0.17	0.67	0.17	0.67	0.00
West Lakes Off Trail	BNP	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.33	1.00	0.50	0.00
West Lakes Ranch	BNP	0.00	0.00	0.50	0.50	0.00	0.00	0.00	0.33	0.83	0.33	0.00
Whiteman Pass Trail	BNP	0.83	0.33	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.50	1.00
Wigmore Lake	BNP	0.67	0.00	0.33	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00
Windy	BNP	0.83	0.00	0.67	0.00	0.17	0.00	0.00	0.00	0.67	0.17	0.00
20 Mile Loop	JNP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adolphus	JNP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adolphus	JNP	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.83	0.33	0.17	0.33
Ancient Wall	JNP	0.00	0.17	0.33	0.17	0.00	0.00	0.00	0.00	0.17	0.17	0.00
Beaver Cabin	JNP	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bess Pass	JNP	0.60	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60
Bike Toss	JNP	0.33	0.67	0.33	0.00	0.17	0.00	0.00	0.17	0.33	0.00	0.00
Brewster Skywalk C1	JNP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Brewster Skywalk C2	JNP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Brewster Skywalk C3	JNP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Celestine Lake	JNP	0.17	0.50	0.00	0.00	0.17	0.00	0.00	0.00	0.50	0.00	0.00
Celestine Trailhead	JNP	0.00	0.50	0.33	0.00	0.17	0.00	0.17	0.17	0.00	0.17	0.00
Clitheroe	JNP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Elysium Pass	JNP	0.00	0.00	0.50	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00
HoChiMin	JNP	0.33	0.17	0.50	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00

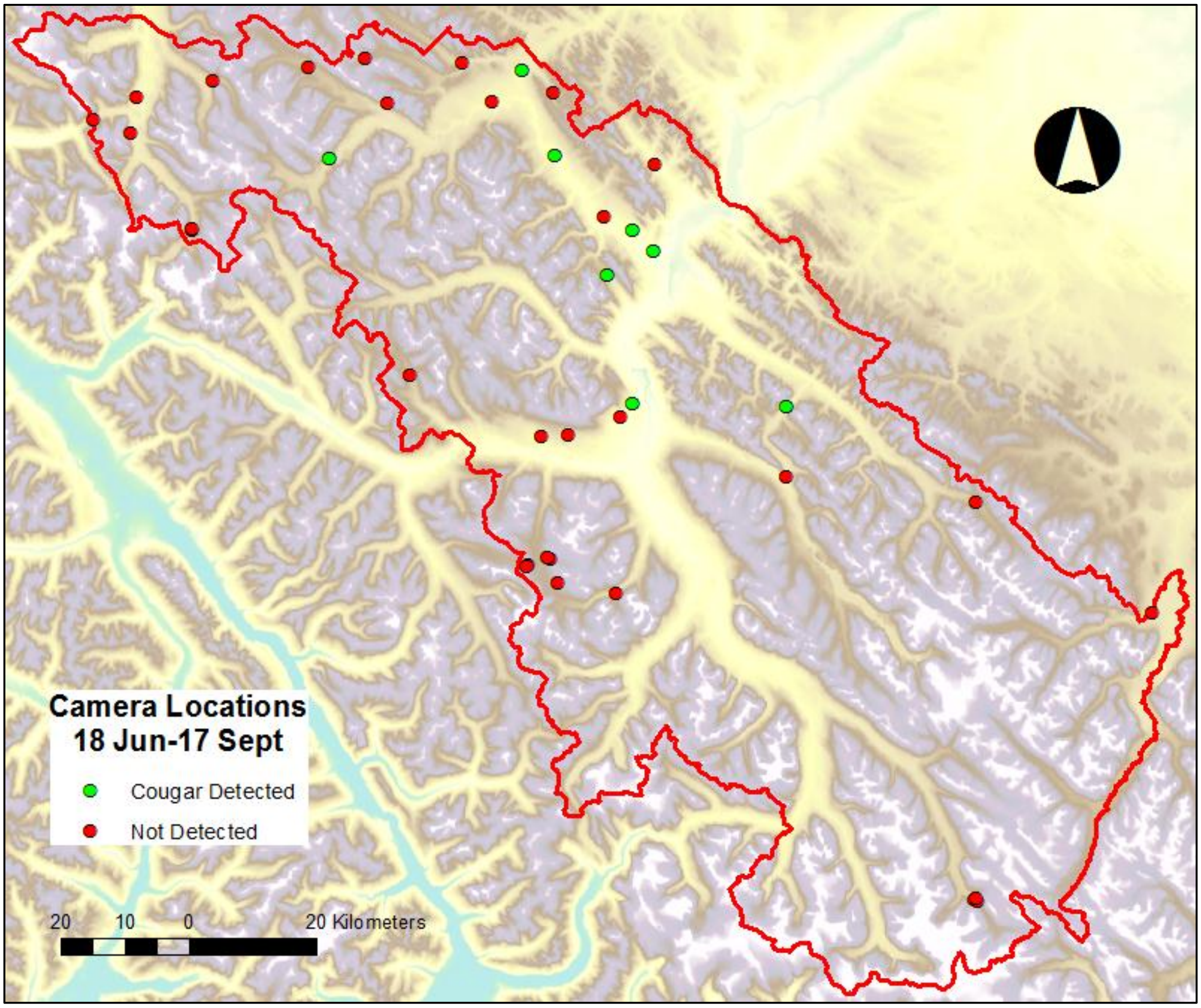
Camera Location	Park	Grizzly Bear	Black Bear	Wolf	Coyote	Cougar	Lynx	Red Fox	Mule Deer	WT Deer	Elk	Moose
Lower Smoky	JNP	0.00	0.67	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50
Maccarib	JNP	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00
McLarens	JNP	0.33	0.17	0.17	0.00	0.00	0.00	0.17	0.17	0.17	0.00	0.00
Meadow Creek	JNP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miette Lake	JNP	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00
Moat Lake North	JNP	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Moat Lake South	JNP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Moosehorn	JNP	0.17	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.50
Mud Creek	JNP	0.17	0.17	0.50	0.00	0.00	0.17	0.17	0.33	0.50	0.50	0.17
Rock Creek	JNP	0.00	0.17	0.83	0.00	0.17	0.00	0.17	0.17	0.67	0.00	0.00
Rocky Pass	JNP	0.20	0.20	0.00	0.00	0.00	0.20	0.00	0.80	0.20	0.40	0.40
Shalebanks	JNP	0.00	0.83	0.33	0.17	0.00	0.00	0.00	0.17	0.50	0.17	0.00
Snake Indian Falls	JNP	0.50	0.67	0.50	0.00	0.33	0.33	0.00	0.00	0.67	0.33	0.00
Southesk	JNP	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.67	0.00
Starlight	JNP	0.17	0.17	0.33	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.67
Three Slides	JNP	0.50	0.50	0.33	0.00	0.33	0.00	0.00	0.00	0.17	0.33	0.17
Timothy Slides	JNP	0.17	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00
Twintree	JNP	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.17	0.00
Vega	JNP	0.60	0.00	0.00	0.20	0.00	0.20	0.00	0.20	0.20	0.00	0.00
Verdant	JNP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vine Creek	JNP	0.33	0.33	0.33	0.00	0.17	0.00	0.00	0.17	0.00	0.00	0.00
Wolf Pass	JNP	0.50	0.17	0.17	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.50
H16 Crandell Mountain to Town	WLNP	0.17	0.83	0.00	0.00	0.17	0.33	0.00	0.00	0.33	0.17	0.50
H19 Carthew-Alderson to Boun	WLNP	0.60	0.60	0.00	0.00	0.40	0.00	0.00	0.80	0.00	0.00	0.40
H36 Bellevue Saddle	WLNP	0.00	0.25	0.50	0.00	0.25	0.00	0.00	0.50	1.00	0.25	0.50
H37 Parkline Trail near trailhead	WLNP	0.17	1.00	0.17	0.00	0.33	0.00	0.17	0.33	1.00	0.17	0.00
H9 Dipper at\near Rowe Old	WLNP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.33
W1 Akamina Pass	WLNP	0.33	0.17	0.00	0.00	0.00	0.00	0.00	0.50	0.17	0.00	0.00
W10 Golf Course Horse Trail	WLNP	0.00	0.67	0.00	0.17	0.33	0.00	0.00	1.00	0.83	0.50	0.00

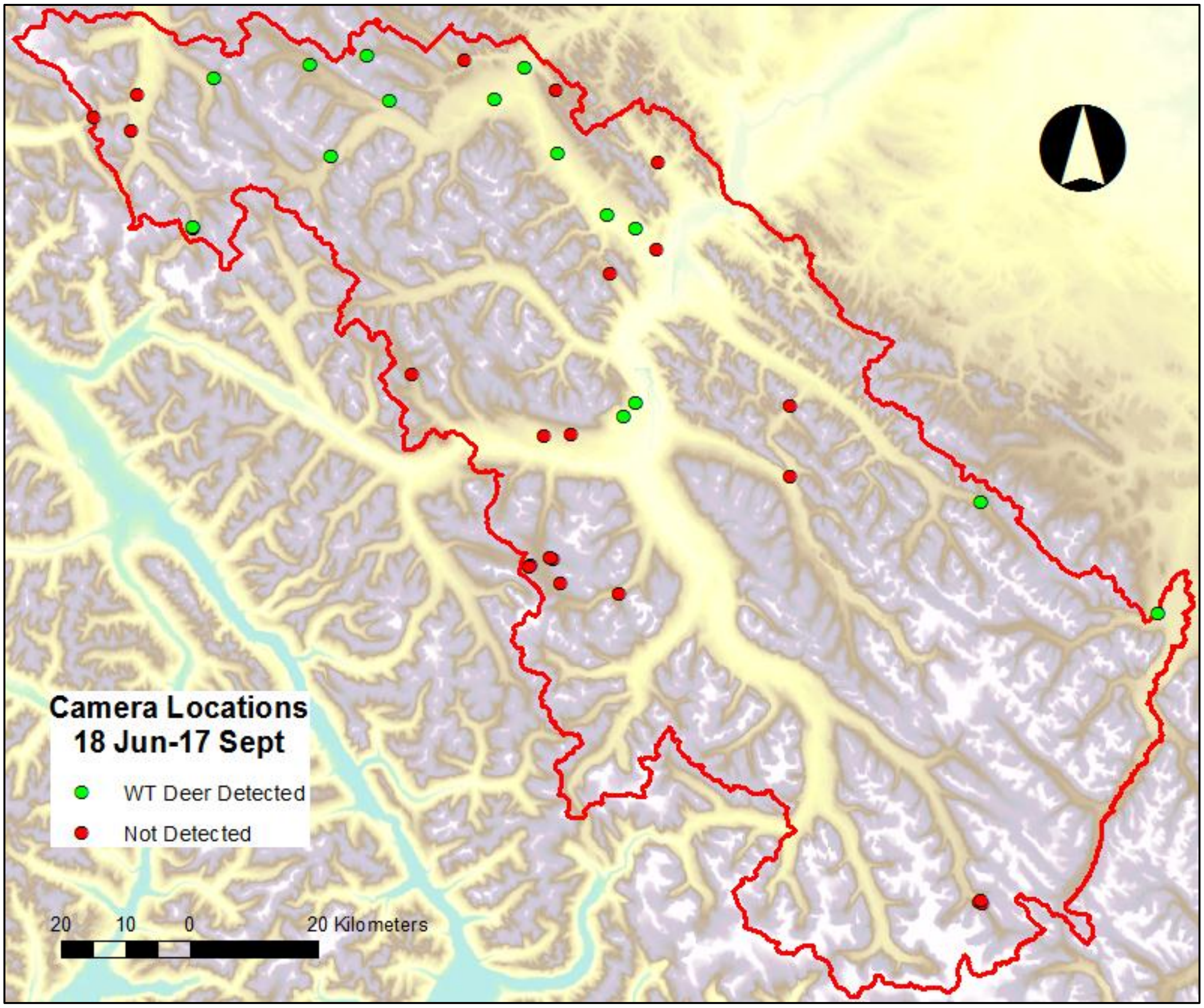
Camera Location	Park	Grizzly Bear	Black Bear	Wolf	Coyote	Cougar	Lynx	Red Fox	Mule Deer	WT Deer	Elk	Moose
W14 Upper Stoney Flats	WLNP	0.67	1.00	0.17	0.00	0.17	0.00	0.00	0.17	0.33	0.33	0.33
W15 Wishbone Landing	WLNP	0.50	0.75	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.75	0.25
W16 Wishbone Tr 2nd Meadow	WLNP	0.50	0.17	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.83	0.33
W18 Sofa Mountain Trail	WLNP	0.67	0.33	0.00	0.00	0.00	0.00	0.00	0.17	0.67	0.17	0.17
W19 Sofa Wildlife Trail	WLNP	0.50	0.83	0.00	0.00	0.00	0.00	0.17	0.17	0.50	0.67	0.83
W2 Crandell Trail at Cliff	WLNP	0.17	1.00	0.00	0.17	0.33	0.00	0.00	0.83	0.33	0.83	0.17
W21 Belly River Wagon Road N	WLNP	0.00	1.00	0.00	0.33	0.50	0.00	0.33	0.33	1.00	0.17	0.50
W24 Belly River near wolf den	WLNP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.50
W26 Bellevue Ridge Base	WLNP	0.00	0.83	0.17	0.33	0.00	0.00	0.17	0.83	0.33	0.17	0.17
W28 Ruby Creek waterline	WLNP	0.17	0.67	0.33	0.17	0.33	0.00	0.00	0.50	1.00	0.33	0.33
W31 Castle Divide at Boundary	WLNP	0.33	0.67	0.17	0.17	0.17	0.00	0.00	0.17	0.33	0.33	0.83
W32 Sage Pass	WLNP	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.17	0.17
W33 South Kootenay Pass	WLNP	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
W35 Old Indian Tr Hrseshoe Basin	WLNP	0.00	0.83	0.17	0.00	0.33	0.00	1.00	0.67	0.33	1.00	1.00
W36 Parkline-Cloudy trail junctn	WLNP	0.00	0.60	0.40	0.80	0.60	0.00	1.00	1.00	0.00	0.20	0.20
W38 Oil Basin at Kesler Corner	WLNP	0.00	1.00	0.00	0.00	0.50	0.00	0.00	1.00	0.50	0.00	0.00
W39 Cloudy Ridge	WLNP	0.50	0.83	1.00	0.33	0.17	0.00	0.00	0.67	0.67	0.83	1.00
W4 Cameron-Bertha Horse Trail	WLNP	0.00	1.00	0.00	0.00	0.17	0.00	0.00	1.00	0.83	0.00	0.00
W40 Oil Pipe	WLNP	0.00	1.00	0.20	0.00	0.00	0.20	0.00	0.00	0.20	0.00	0.00
W5 Cameron Bay Wildlife Trail	WLNP	0.00	0.25	0.00	0.00	0.25	0.00	0.25	0.50	0.50	0.00	0.00
W6 Lakeshore Tr S of Bertha Bay	WLNP	0.00	0.80	0.00	0.00	0.20	0.00	0.00	0.40	0.40	0.60	0.20
W7 Twnsite Tr behind Telus bldg	WLNP	0.00	1.00	0.00	0.00	0.50	0.00	0.25	1.00	0.00	0.00	0.00
W8 Linnet Lake near VRC	WLNP	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.67	0.33	0.00	0.17
W9 Compound Trail	WLNP	0.17	1.00	0.00	0.00	0.50	0.00	0.00	0.67	0.17	0.00	0.17

7.2.1 Mapped Detections for Grizzly, Wolf, Cougar and White-tailed Deer in Jasper National Park, Summer 2011

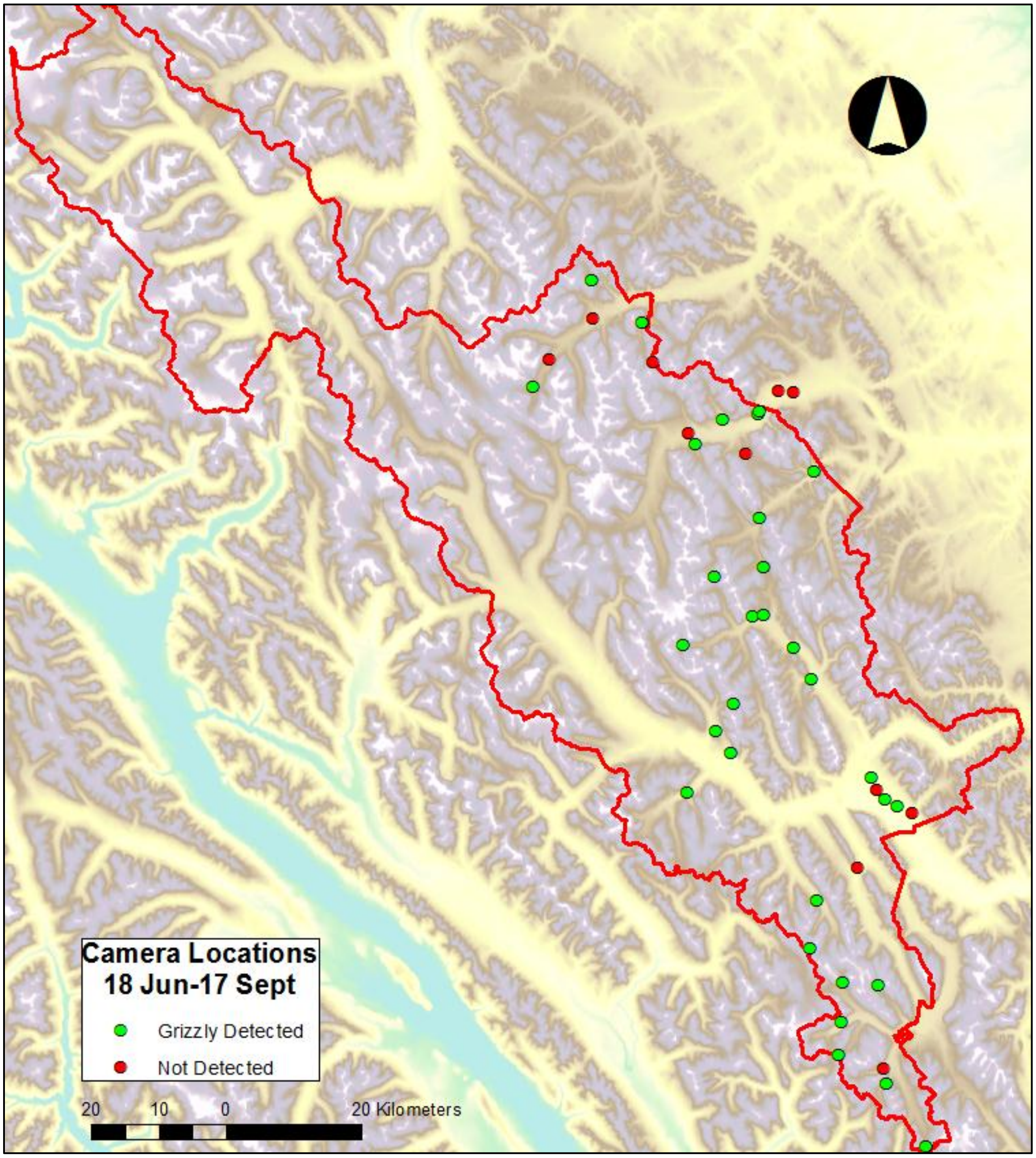


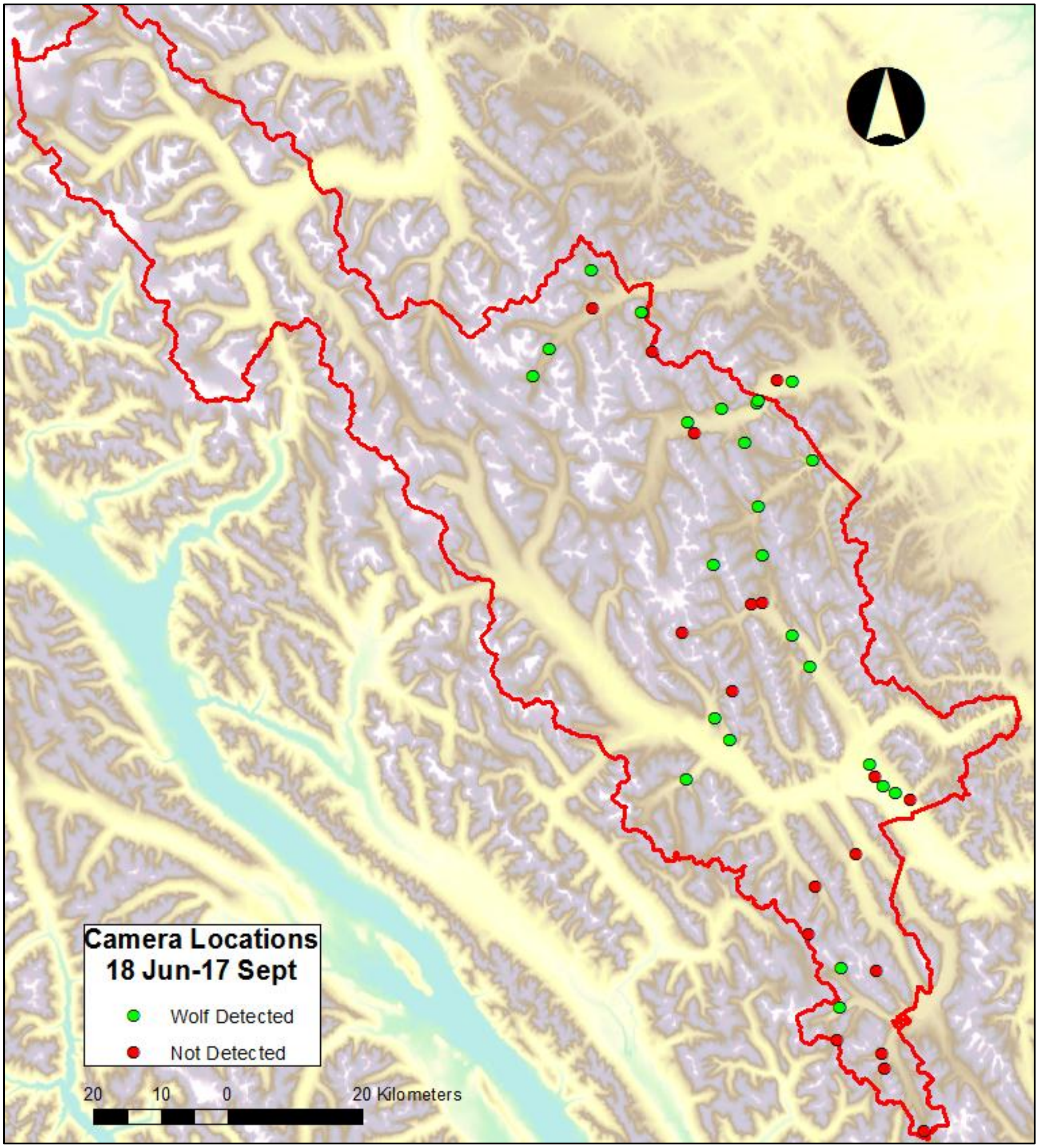

Camera Locations
18 Jun-17 Sept
Wolf Detected
Not Detected
20 10 0 20 Kilometers

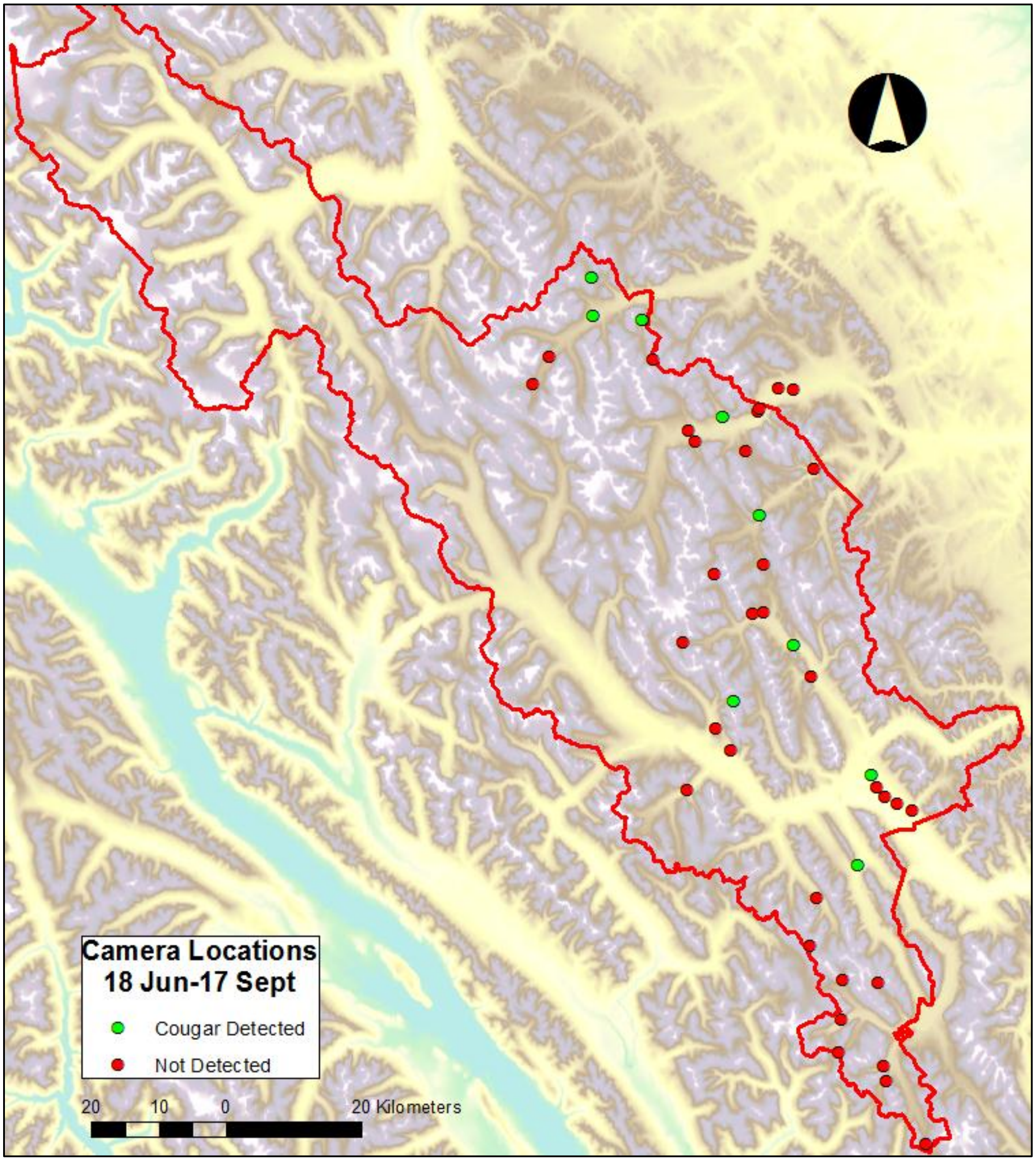

Camera Locations
18 Jun-17 Sept
Cougar Detected
Not Detected
20
10
0
20 Kilometers

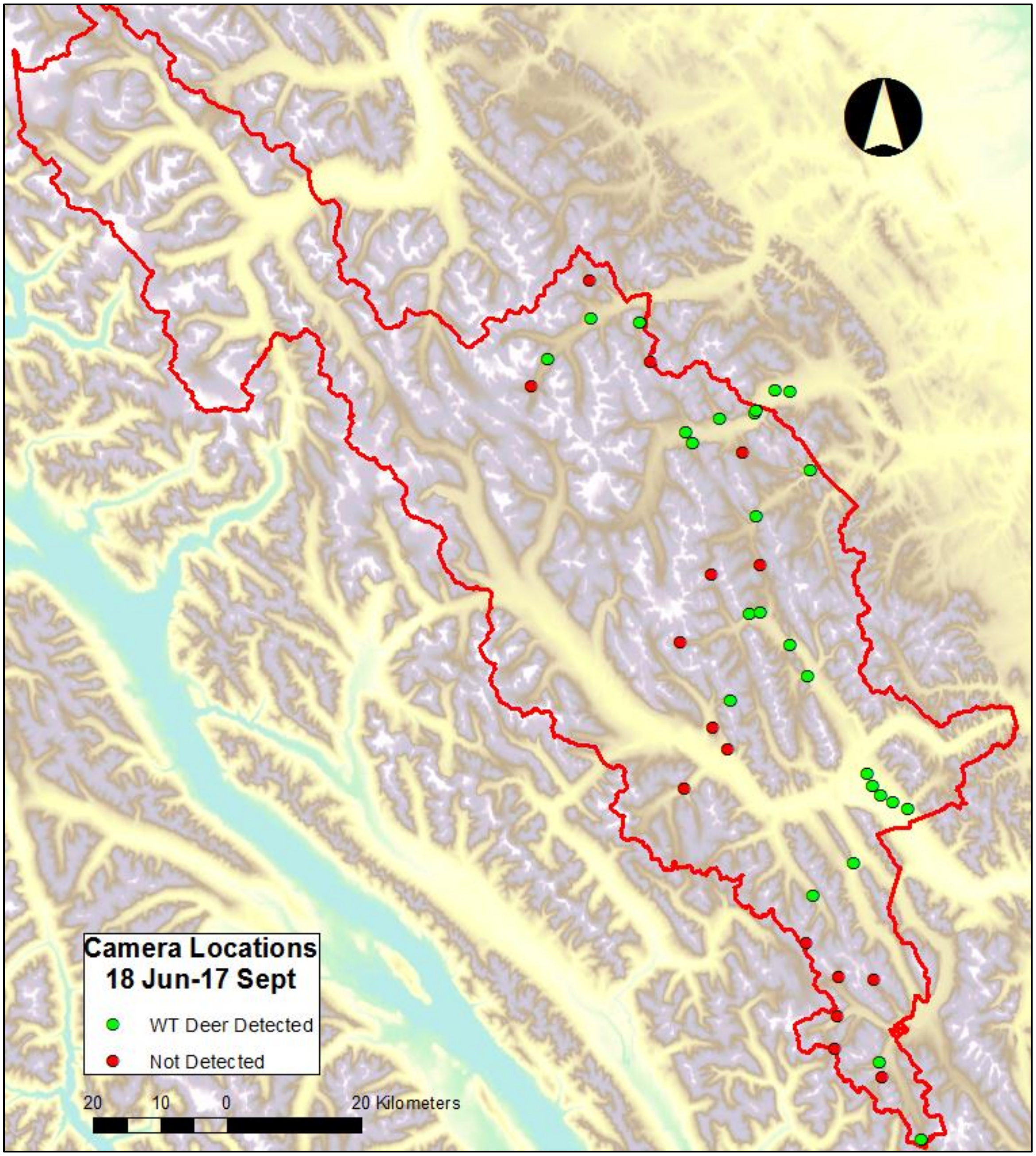

Camera Locations
18 Jun-17 Sept
WT Deer Detected
Not Detected
20 10 0 20 Kilometers

7.2.2 Mapped Detections for Grizzly, Wolf, Cougar and White-tailed Deer in Banff National Park, Summer 2011

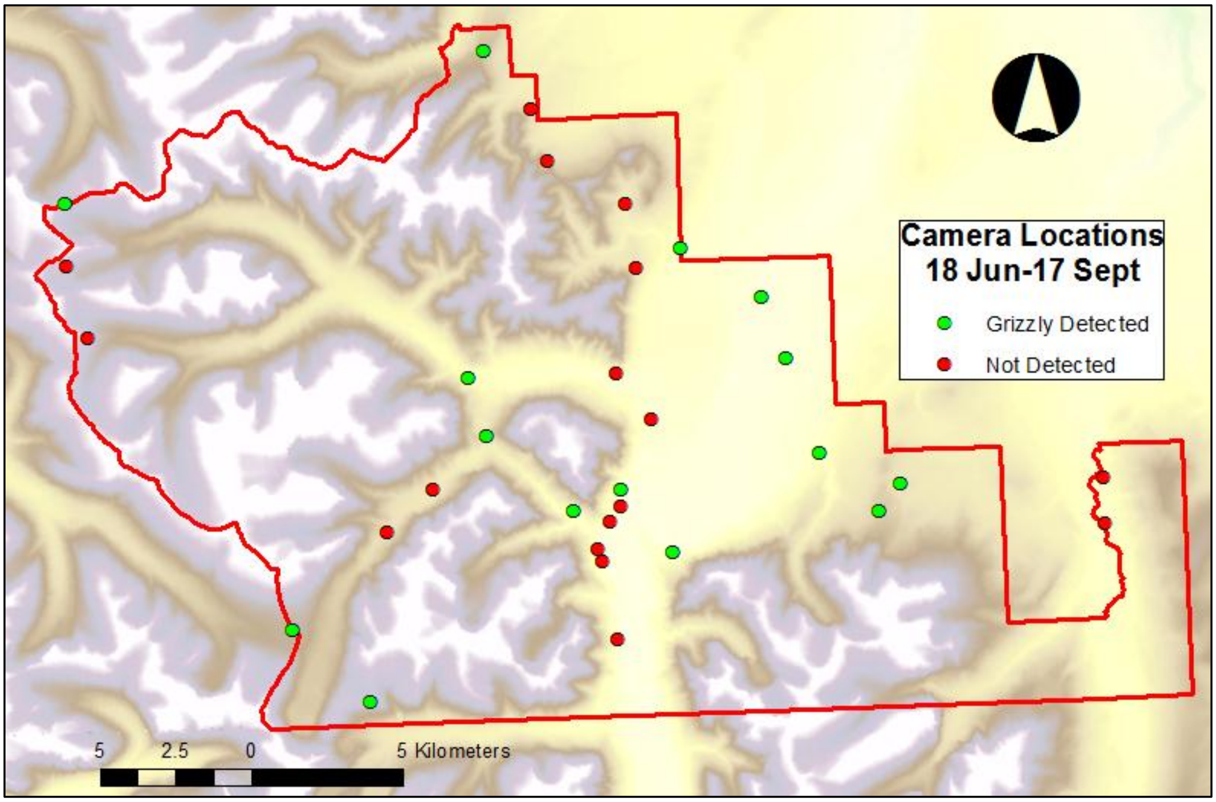


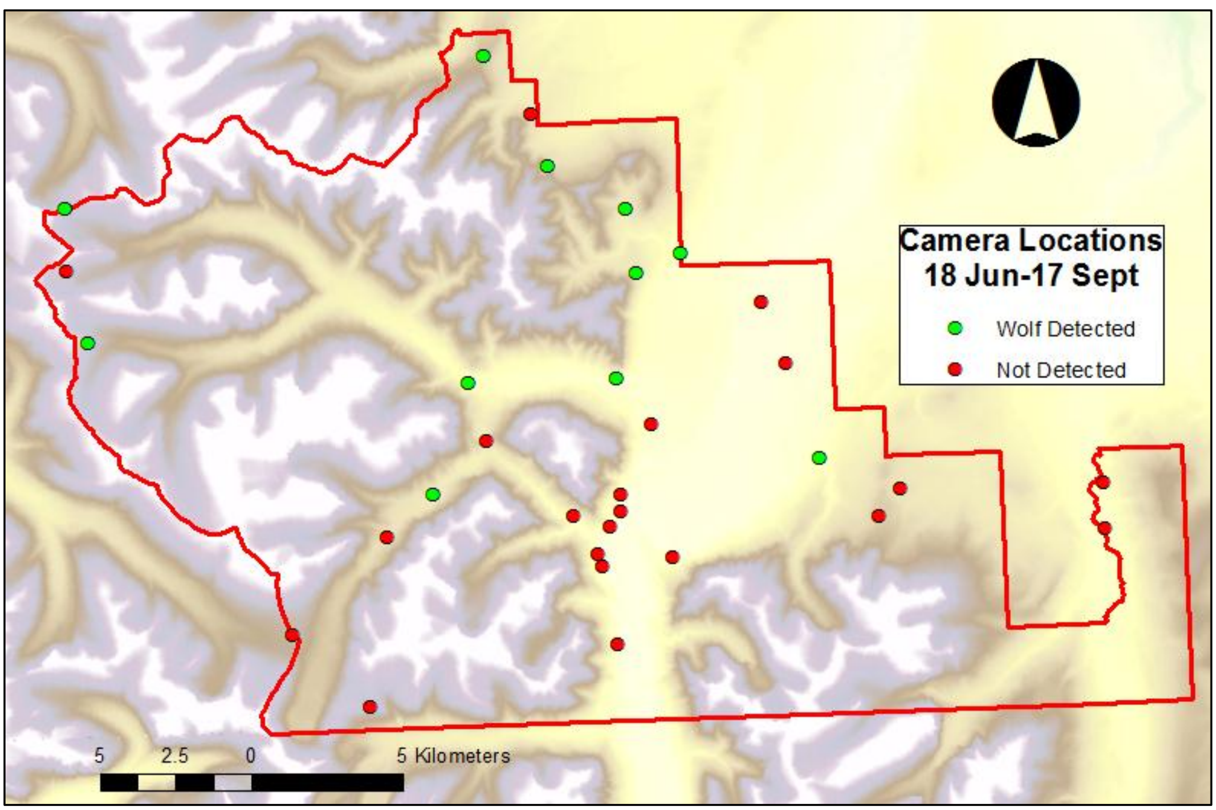

Camera Locations
18 Jun-17 Sept
Wolf Detected
Not Detected
20 10 0 20 Kilometers

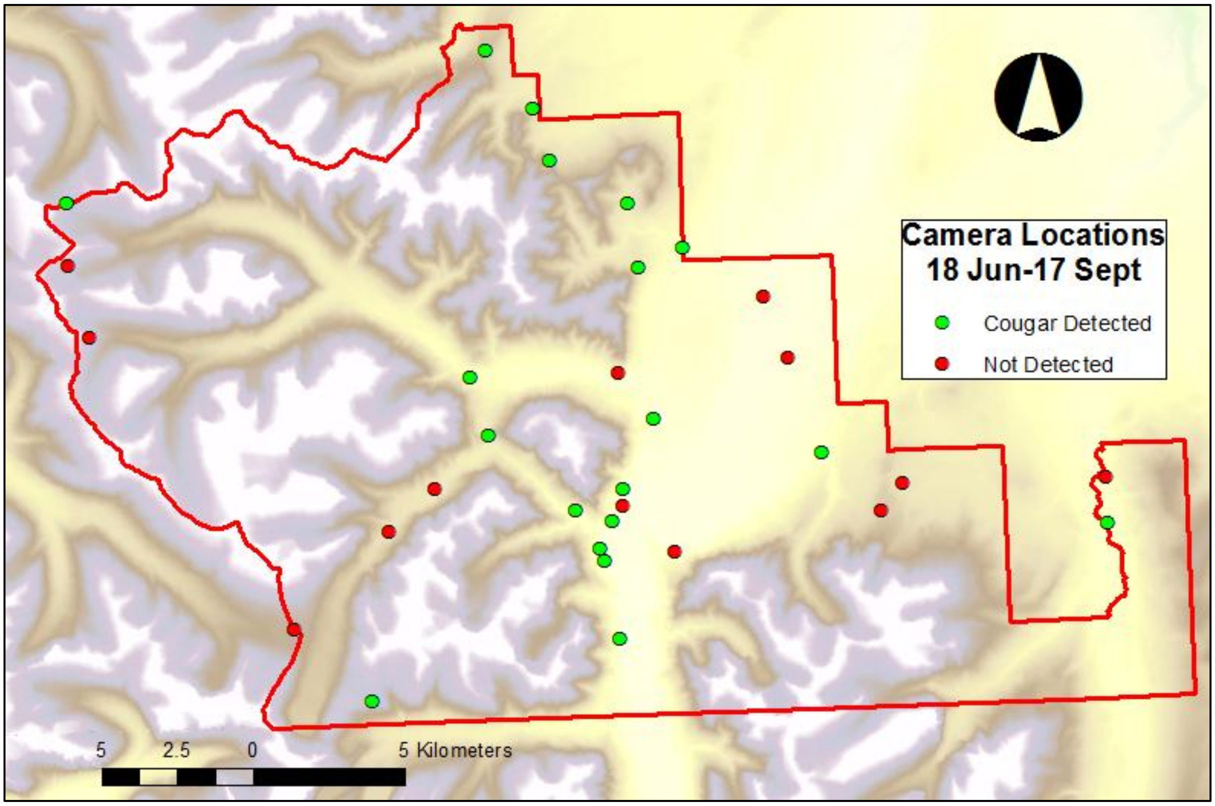

Camera Locations
18 Jun-17 Sept
Cougar Detected
Not Detected
20
10
0
20 Kilometers

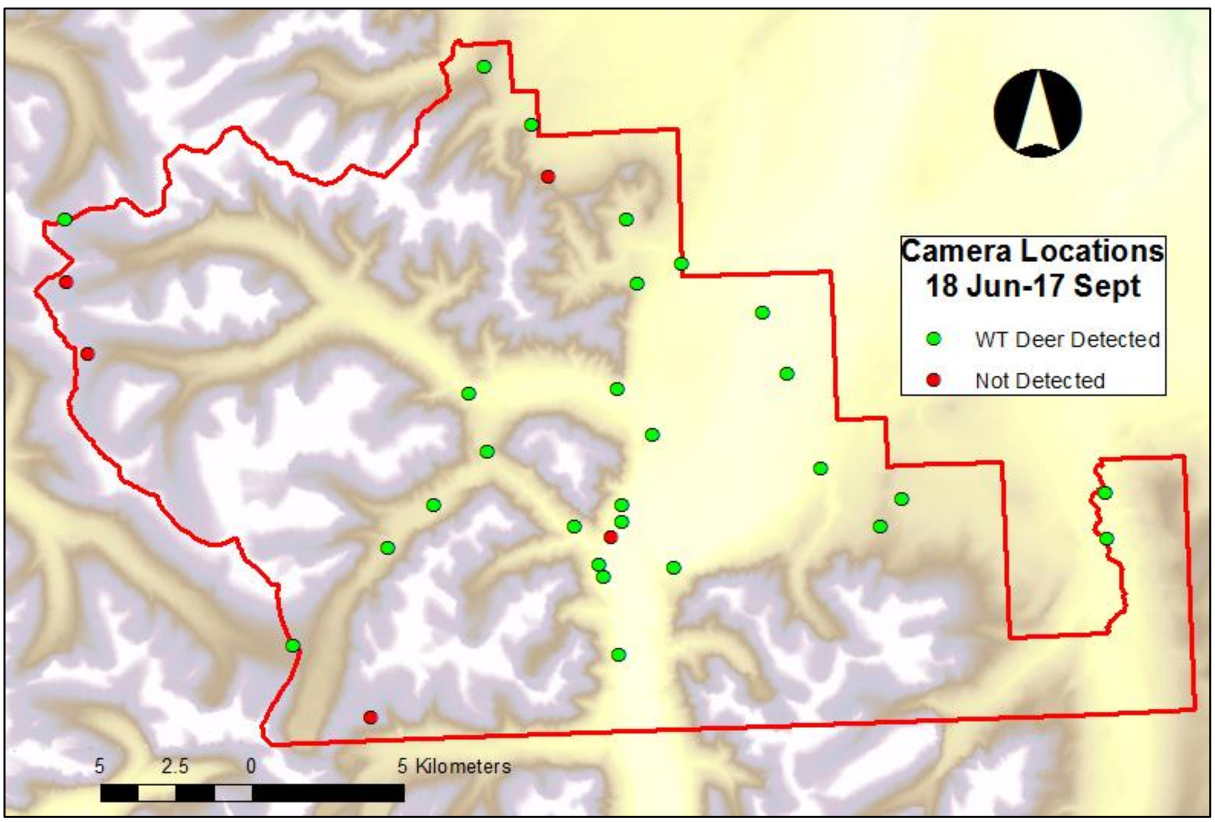

Camera Locations
18 Jun-17 Sept
WT Deer Detected
Not Detected
20
10
0
20 Kilometers

7.2.3 Mapped Detections for Grizzly, Wolf, Cougar and White-tailed Deer in Waterton Lakes National Park, Summer 2011






Camera Locations
18 Jun-17 Sept
Cougar Detected
Not Detected
5 2.5 0 5 Kilometers


Camera Locations
18 Jun-17 Sept
WT Deer Detected
Not Detected
5 2.5 0 5 Kilometers