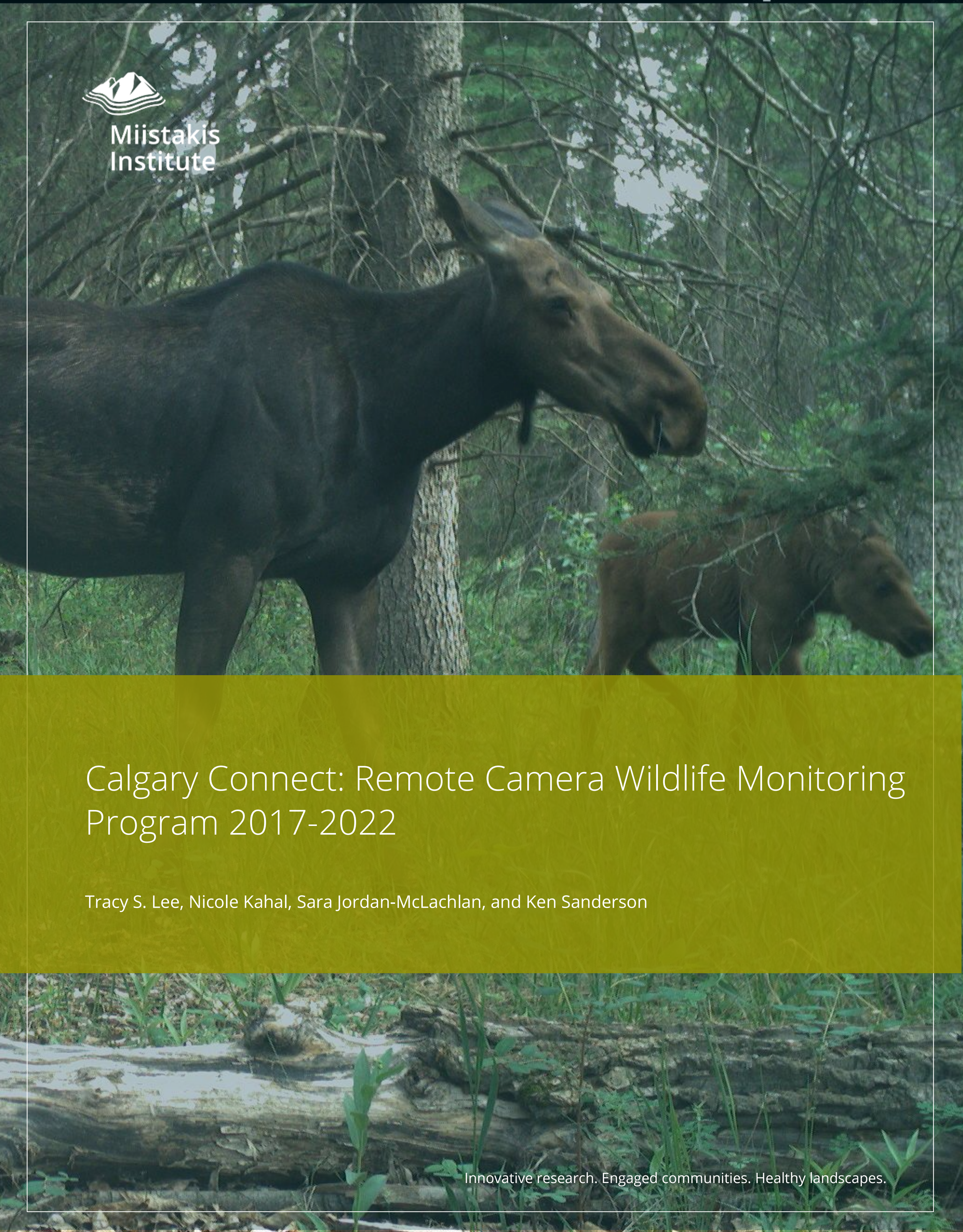

Miistakis Institute

Calgary Connect: Remote Camera Wildlife Monitoring Program 2017-2022

Tracy S. Lee, Nicole Kahal, Sara Jordan-McLachlan, and Ken Sanderson

Innovative research. Engaged communities. Healthy landscapes.

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Prepared by Tracy S. Lee, Nicole Kahal, Sara Jordan-McLachlan and Ken Sanderson

November 2023

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Acknowledgements

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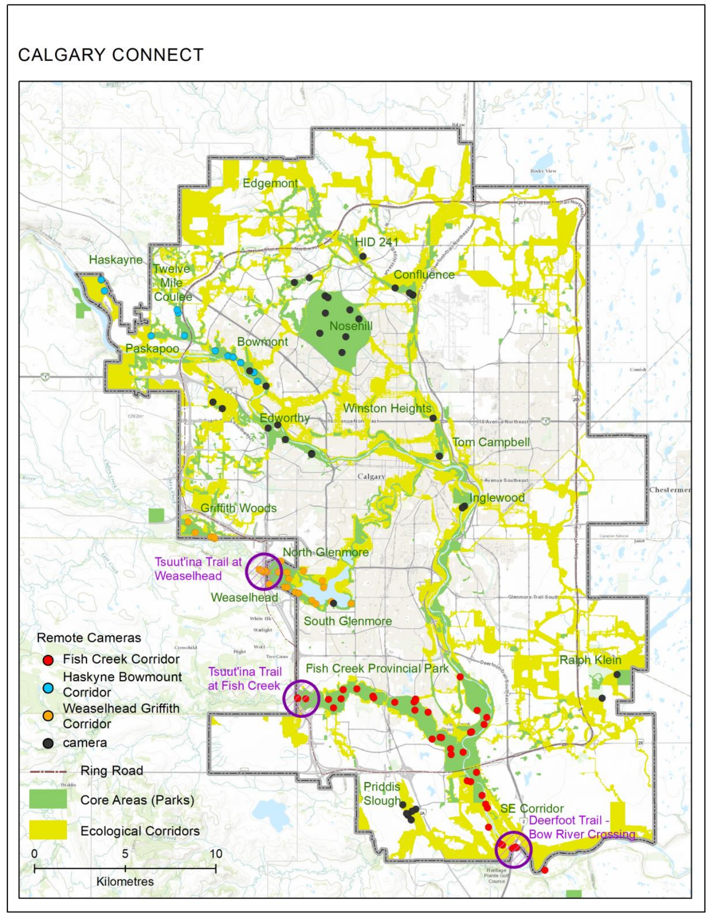
We used the Wild Trax platform for classification developed by Alberta Biodiversity Monitoring Institute and WildCo Coexistence Lab R-code for data preparation and cleaning.

Thank you to The Calgary Foundation, TD Friends of the Environment Foundation, and Enbridge Inc. for their generous support.

We would also like to acknowledge our program partners: The City of Calgary, Alberta Environment and Parks, Friends of Fish Creek Provincial Park Society, and Weaselhead/Glenmore Park Preservation Society for their guidance, contributions, and enthusiasm for the project.

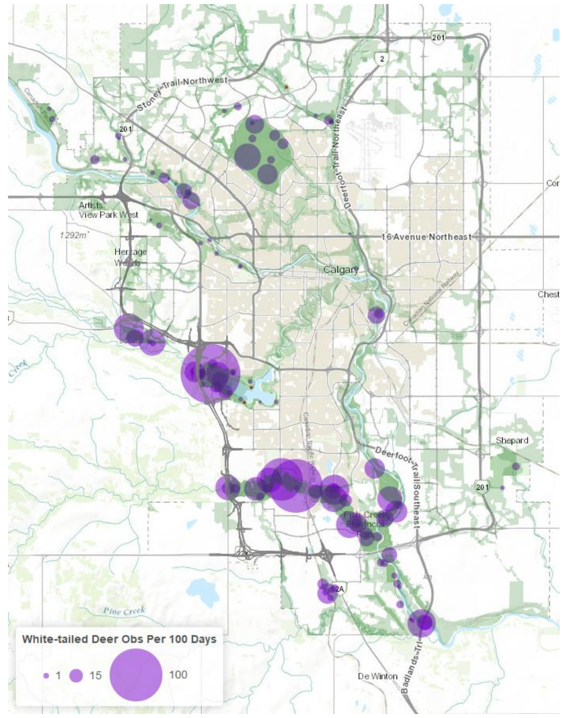
Executive Summary

The City of Calgary manages a diverse network of designated natural areas that cover over 70 km^2. Connecting into the 13 km^2 Fish Creek Provincial Park, this network provides ample habitat and movement corridors for a variety of wildlife. The Calgary Connect program aims to improve our understanding of how medium- to large-sized terrestrial mammals are using natural areas and moving through the urban landscape. Calgary Connect is a multi-year wildlife monitoring and ecological connectivity program that, in part, uses motion-activated camera traps placed in key natural environment parks and natural movement corridors. The resulting images provide insight into which animals live in Calgary, how they move around the built environment, and how they respond to the presence of people in these parks.



To monitor wildlife, cameras were placed on game trails and non-paved human-use trails within natural areas and road mitigation sites designed for wildlife movement. Between May 9, 2017, and May 31, 2022 (123,874 camera trap days), we set up 128 camera traps across 19 natural area parks, in three ecological corridors, and at three road mitigation sites. We found that humans are exploring Calgary's parks beyond the paved pathways, as 80% of detections on cameras are human, and 33% of human detections include a domestic dog. The other 20% of detections were wildlife, including white-tailed deer (9%), coyote (5%), and mule deer (3%) as the most prevalent. The remaining 3% of wildlife detections are made up of diverse species including moose, badger, cougar, bobcat, black bear, red fox, common raccoon, striped skunk, multiple weasel spp., porcupine, and beaver. Overall, wild ungulates (deer, moose, and elk) were detected 31,040 times, and carnivores were detected 11,656 times. Larger rodents including beaver and porcupine were detected 613 times. These results highlight parks in Calgary are supporting a variety of medium- to large-sized mammals.

Wildlife activity and spatial distribution



Medium to large-sized terrestrial mammals were detected in all natural areas, ecological corridors, and road mitigation sites on our camera traps. Distribution across natural areas varied among species, with human, white-tailed deer, coyote and mule deer detected at almost all camera sites. White-tailed deer had the highest activity levels in the city with 9% of all detections and deer species (both mule and white-tailed) generally were the most active in natural areas accounting for roughly 14% of all detections. These species are considered “urban utilizers” as they appear to be well adapted to the urban environment.

We monitored wildlife activity in three ecological corridors identified as a part of the City of Calgary’s ecological network, Weaselhead-Griffith Woods Corridor, Haskayne-Bowmont Corridor, and Fish Creek Corridor. Five years of camera analyses demonstrated that diverse wildlife are using Calgary’s ecological corridors. Medium to large-sized mammals were found in all three corridors with mule deer, white-tailed deer, moose, coyote, and bobcat being found in all corridors across all years. Other species, including striped skunk, porcupine, raccoon, red fox and cougar, were detected in multiple years but not in all corridors. More species occurred in ecological corridors that remain naturally linked to neighbouring jurisdictions, such as Weaselhead-Griffith Woods and Fish Creek Corridors where we detected cougar, black bear, and moose in most years of the study. We also detected moose in a portion of the Haskayne-Bowmont Corridor to the east of Stoney Trail from Twelve Mile Coulee to Haskayne. There was less wildlife activity to the east of Stoney Trail in the Haskayne-Bowmont Corridor. These results help support the City’s efforts to invest in maintaining an ecological network in Calgary.

Cameras were set up at three road mitigation sites to monitor wildlife movement: Weaselhead at Tsuut’ina Trail, Fish Creek Park at Tsuut’ina Trail, and Bow South at Deerfoot Trail. Cameras were also set up within 500m of all three sites to monitor if the same species were present adjacent to mitigations. Wildlife movement was captured at all three sites but not all species present in an area used road mitigation sites. White-tailed deer, mule deer, coyote, and moose were detected at all three mitigation sites as well as on the reference cameras, while bobcat and striped skunk were detected on the reference cameras but not at the mitigation sites. As we did not monitor wildlife at these sites prior to road construction, we cannot say how movement has been affected over time. Nevertheless, roads are widely considered to be wildlife movement barriers. Thus, the use of these road crossings by wildlife validates investing in infrastructure to create safe passage at both current and future sites.

Temporal patterns of wildlife and human use

Diel patterns and peak activity times vary across species. Coyote, moose, and deer were found to be active during the day, but peak activity was crepuscular. Bobcat, red fox, and cougar exhibited crepuscular to nocturnal activity patterns.

Many studies indicate that wildlife avoid human activity, including both spatial and temporal avoidance. We focused our initial analysis on temporal avoidance. Eight species, including bobcat, coyote, cougar, black bear, red fox, mule deer, white-tailed deer, and moose were tested for overlap with humans with or without domestic dogs. Moose showed the greatest daily overlap with people (50%) and red fox showed the least (12%). All other species were arrayed between these end-points. When we categorized cameras into low and high activity based on the mean number of detections and re-ran the analyses, we noted that where human activity was high, moose daily activity was less during peak human activity and increased during crepuscular and nighttime hours. This suggests that moose, which appear to be otherwise tolerant of people, are nevertheless adapting their daily movements to avoid human activity. Bobcat also exhibited changes in activity patterns between low and high human detections on cameras. Mule deer did not.

We also calculated Avoidance Attraction Ratios (AAR) for four species: moose, red fox, bobcat, and mule deer to determine long-term temporal response to human activity. Temporal avoidance was evident for all four species indicating wildlife are adjusting movement in parks in response to human activity. The period of temporal avoidance of an area after human detections was longest for red fox followed by bobcat, mule deer and finally, moose. From a biodiversity perspective, these results inform management actions that encourage human activity to occur during daylight hours. A detailed assessment of camera detections for particular species could help identify closures, particularly in areas of low human activity, to enable wildlife 24-hour access (or longer) before human use.

Domestic dog activity in parks

Humans with domestic dogs either on- or off-leash made up 33% of all detections; 23% of dogs detected were off-leash. Even more concerning, after buffering dog off-leash areas by 50m, 72% of domestic dogs we detected were off-leash in designated on-leash areas. Spatial depiction of areas where dogs are off-leash in on-leash areas can inform where management actions and education are best focused to improve on-leash compliance.

Recommendations

Based on our findings, we make the following recommendations:

- City Council and Administration support the maintenance of the ecological network published in the Municipal Development Plan with particular emphasis on retaining corridors that connect the City of Calgary to the surrounding area. Supporting these corridors for wildlife movement will require collaboration with neighboring jurisdictions.
- While the inclusion of the ecological network in the Municipal Development Plan is a positive step towards acknowledging ecological connectivity in the urban environment, it needs to be integrated into development decisions. Prior final development plan approvals, a review of affects to the ecological network should be considered.

- Road mitigation sites around large volume roads support wildlife movement in and out of the city; however, their benefit and use can be improved. Suggestions for increasing their use include:
    - Add and maintain vegetative cover to create a more seamless habitat corridor across roadways.
    - Manage human and domestic dog use around mitigation sites. Fish Creek at Stoney Trail and Bow River South at Deerfoot Trail both had more humans and humans with dogs than wildlife.
    - Mitigate wildlife movement along corridors that they currently use. Stoney Trail currently has mitigation sites at two wildlife corridors on the west end of the city: along Fish Creek and the Elbow River in the Weaselhead. However, there are no wildlife mitigation sites currently along Stoney Trail in the northwest corridor, nor on more central roads such as Crowchild Trail or Glenmore Trail.
- Our results can be used to inform management and for public education to foster human-wildlife coexistence. Effective messaging regarding bear, coyote, bobcat, moose, and cougar can keep humans, their dogs, and wildlife safe.

Introduction

The Calgary Connect program aims to improve our understanding of how wildlife is using natural areas and moving in the urban landscape. A multi-year wildlife monitoring program, Calgary Connect uses motion-activated camera traps placed in key natural environment parks and natural movement corridors to gain insight into which animals live in Calgary, how they move around the built environment, and their responses to human activity. Managed by the Miistakis Institute, this partnership includes City of Calgary, Alberta Environment and Protected Areas, Friends of Fish Creek Provincial Park Society, and Weaselhead/Glenmore Park Preservation Society. Calgary Connect aims to use the information gathered to inform development and management decisions that protect and enhance Calgary's ecological network.

The program has the following objectives:

- Determine which species of medium- and large-sized mammals occur in Calgary's park system;
- Engage Calgarians in wildlife monitoring through the design and implementation of a citizen science program monitoring wildlife, and
- improve our understanding of how wildlife respond to human activity and use habitat corridors in the City of Calgary.

Methodology

Study area

The City of Calgary is the largest city in Alberta, home to 1.6 million people, and the largest metropolitan area in the three prairie provinces. Surrounded by picturesque prairie landscapes, Calgary is situated at the confluence of the Bow and Elbow rivers approximately 80 km from the Canadian Rocky Mountains. Calgary has a thriving park system that includes over 70 km^2 of land within city limits, further enhanced by the 13 km^2 Fish Creek Provincial Park (Figure 1). The City of Calgary has developed and mapped an ecological network in their Municipal Development Plan that outlines opportunities for wildlife movement. However, fragmentation of these areas due to rapid and sprawling urban growth, and high levels of human activity is an ever-increasing threat to maintaining ecological connectivity and healthy wildlife populations in Calgary and the surrounding region.

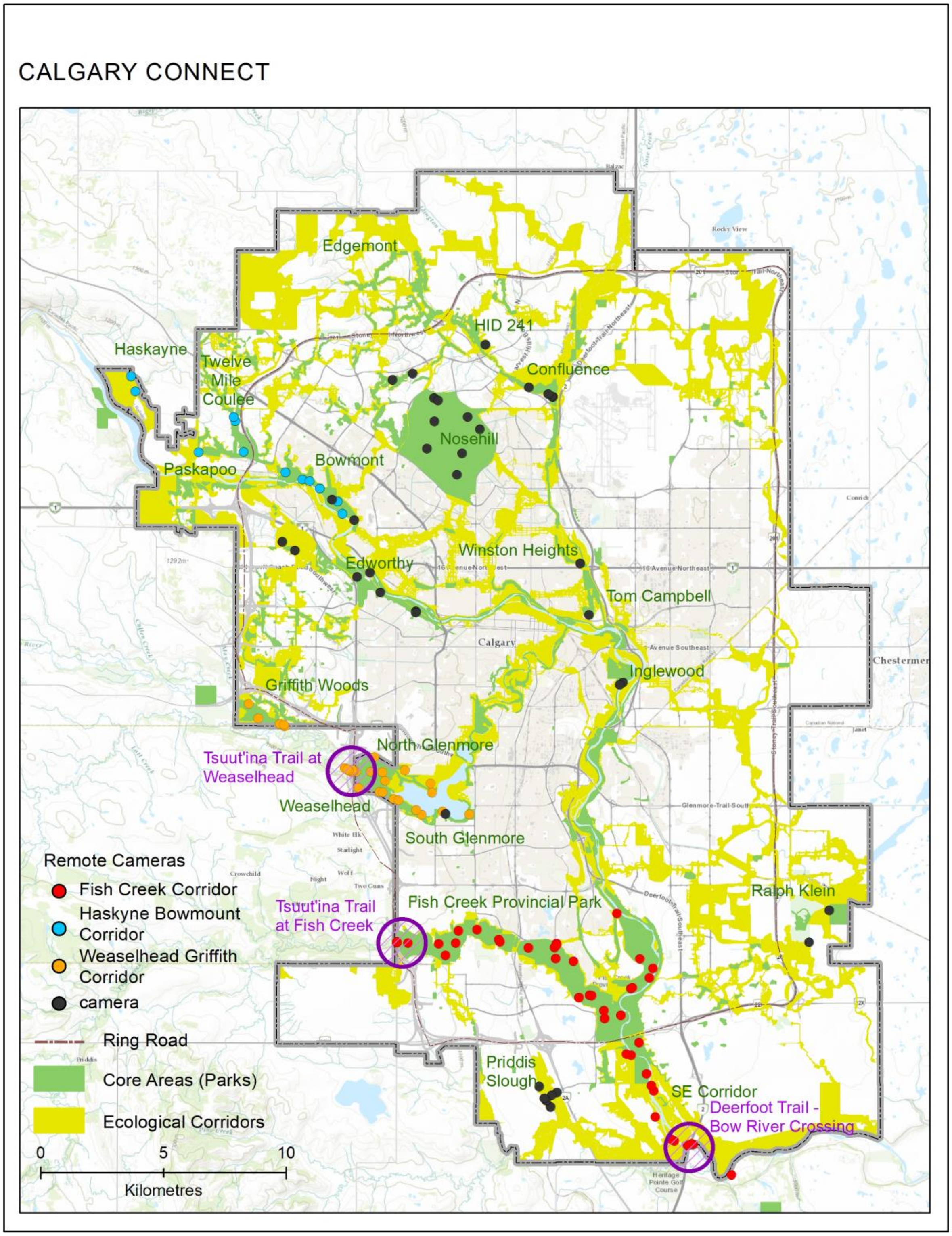


Figure 1: Remote camera locations, including ecological corridor cameras and road mitigation sites in Calgary, Alberta.

Remote camera deployment and data management

From May 2017 to May 2022, motion-triggered camera traps were active at 128 sites within 19 parks and ecological corridors in the study area of Calgary. Cameras were placed opportunistically along game and non-paved human trails within a 1 km grid system. Paved pathways were avoided due to high human activity; this reduced risk of theft and time spent classifying human images. The 1 km grid allowed roughly proportional camera coverage of each study area, with exceptions for additional camera coverage in smaller natural areas.

Citizen scientists classified images to species online at Zooniverse.org (2017–2021), while Miistakis staff and volunteers classified medium- to large-sized mammal images to species on Image Loader (2017–2019) and Wildtrax (2019–2022). Independent events were documented based on a 30-minute independence window. Data were verified and tested to ensure camera detections occurred during active camera deployments with Wildlife Coexistence Lab R-code. Data processing resulted in three datasets used for this analysis: daily events per species and camera, monthly events per species and camera, and total events per species and camera. We also calculated the number of active camera days to enable us to account for camera effort during analysis; not all cameras were active at the same time or for the same length of time. In total, we analyzed data from 128 active cameras from 2017 to 2022 (123,874 camera trap days).

Wildlife and non-wildlife activity

Wildlife detections per day

To determine daily wildlife and non-wildlife events, we divided daily species observations by the number of active camera days, which differed among cameras. We then calculated the mean daily wildlife (separated into ungulate, carnivore, and rodent) and non-wildlife events in the entire study area as well as in each park or corridor. Averaging the events per day across cameras accounted for differences in the number of cameras per park. Using this dataset, we also plotted daily wildlife and non-wildlife events (human and domestic animals, human events without dogs, human events with dogs), by fitting an activity model using 100 replications. We plotted daily temporal activity of select carnivore (cougar, black bear, red fox, coyote, bobcat) and ungulate (mule deer, white-tailed deer, moose) species by fitting an activity model using 1000 replications.

Species-specific spatial patterns

To account for camera trapping effort, we plotted the number of species per 100 camera trap days. We generated spatial activity maps for each species using a dot pattern of daily events per 100 camera trap days; the larger the dot size, the more activity per day occurred on a camera. Spatial activity maps were scaled similarly for humans, ungulates, carnivores, and rodents to compare species in each grouping.

24 Hour Temporal Activity

To determine species temporal activity within a 24 hour period, we used raw detection data (not unique events) and R package "activity" to determine the percentage of each hour of the day wildlife are active (Ridout and Linkie, 2009; Zanni et al., 2021). Confidence intervals were estimated with bootstraps at 1000 replications for each species, and 100 replications for humans.

We also used the R package "overlap" to compare species temporal activity patterns to human and humans with domestic dogs. The overlap coefficient measures the area under density curves comparing two species to produce a value from 0 (no overlap) to 1 (complete overlap) (Ridout and Linkie, 2009). We generated 1000 simulations with the nonparametric estimator bootstrap and ran a Watson-Wheeler test to detect statistical differences between species.

Impacts of human activity on wildlife

Research has shown that the response of large and medium-sized mammals to human activity varies by time, space, species, and activity type. Although difficult to characterize, research suggests response to people tend to be negative; wildlife *in general* avoid humans (Patten et al., 2019; Patten and Burger, 2018). Wildlife responses may include spatial or temporal avoidance of areas with human activity.

We took three approaches to determine how human activity impacts wildlife activity in Calgary:

1. linear regression models of species and human detections to detect relationships between human and species activity,
2. overlap analysis of wildlife and low and high human activity categories to determine if wildlife diel activity patterns changed, and
3. Avoidance Attraction Ratio (AAR) to compare temporal displacement around camera sites when species observations are interspersed with human activity.

Avoidance Attraction Ratio

We used the Avoidance Attraction Ratio (AAR) to determine if human activity caused temporal displacement of wildlife in Calgary (Naidoo and Burton, 2020). AAR has been used in other studies to determine if prey are avoiding predators, or if wildlife generally are avoiding human activity or domestic dogs (Niedballa et al., 2019; Parsons et al., 2016; Weng et al., 2022). For each species of interest, we extracted four time intervals per camera based on detection timestamp, where T1 is the time interval between a species of interest and the next human detection, T2 is the time interval between a human and a species of interest, T3 is the time interval between a species of interest and the next detection of that species when there was no human detection in between, and T4 is the time interval between a species of interest with a human detection in between (Figure 2).

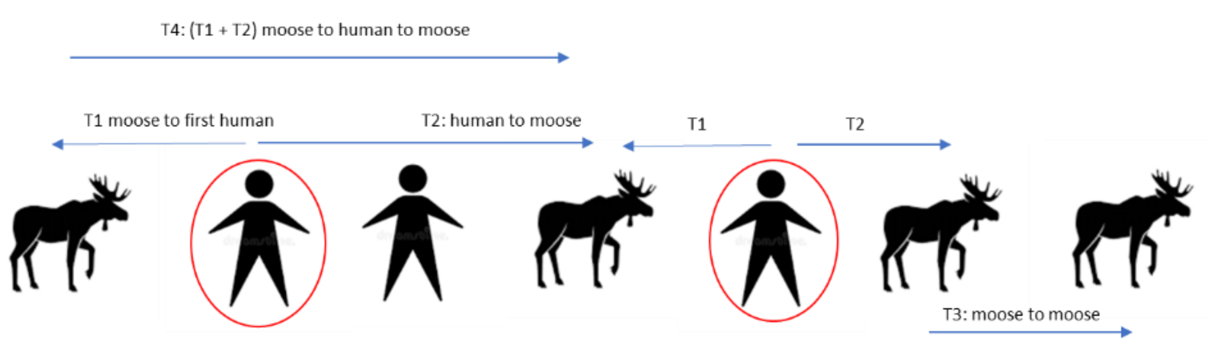


Figure 2: Depiction of time intervals (T1 to T4) calculated for each camera where a species of interest (moose) and human activity were detected. Arrows indicate time interval calculations are moving along a timestamp.

Using these time intervals generated per camera, we considered a ratio between duration pairs, the time interval for a focal species detection after/before a human passes (AAR1 = T2/T1) (Parsons et al., 2016). Values greater than one in either ratio indicate avoidance and values less than one indicate attraction (Naidoo and Burton, 2020). We predicted that at a particular temporal scale , by camera, all species of interest would avoid human activity. The higher the positive AAR1 value, the greater the wildlife avoidance after human detection. We plotted T1 and T2 pairs across all cameras with a line of equality and ran a Welch's t-test to determine statistical significance. Finally, we plotted T3 and T4 using a boxplot and calculated the mean number of days between intervals to determine if there were differences among detection intervals; we expect T4 to be longer than T3 for all wildlife species.

Results

What species were detected on remote cameras?

There were 213,443 detections of medium- to large-sized mammals over the five years, of which 80% were detections of humans, and 20% were detections of wildlife. Humans were the only species to be detected on all cameras in the study area (Figure 3). The most common wildlife detections were white-tailed deer, coyote, and mule deer (Table 1). Of the human detections, 47% where just people and 33% included dogs (24% off-leash, 9% on-leash).

Camera numbers varied throughout the five year period ranging from 44 to 80 deployed at any one time. Thus, the total number of detections per 100 camera trap days varied among years (Figure 4).

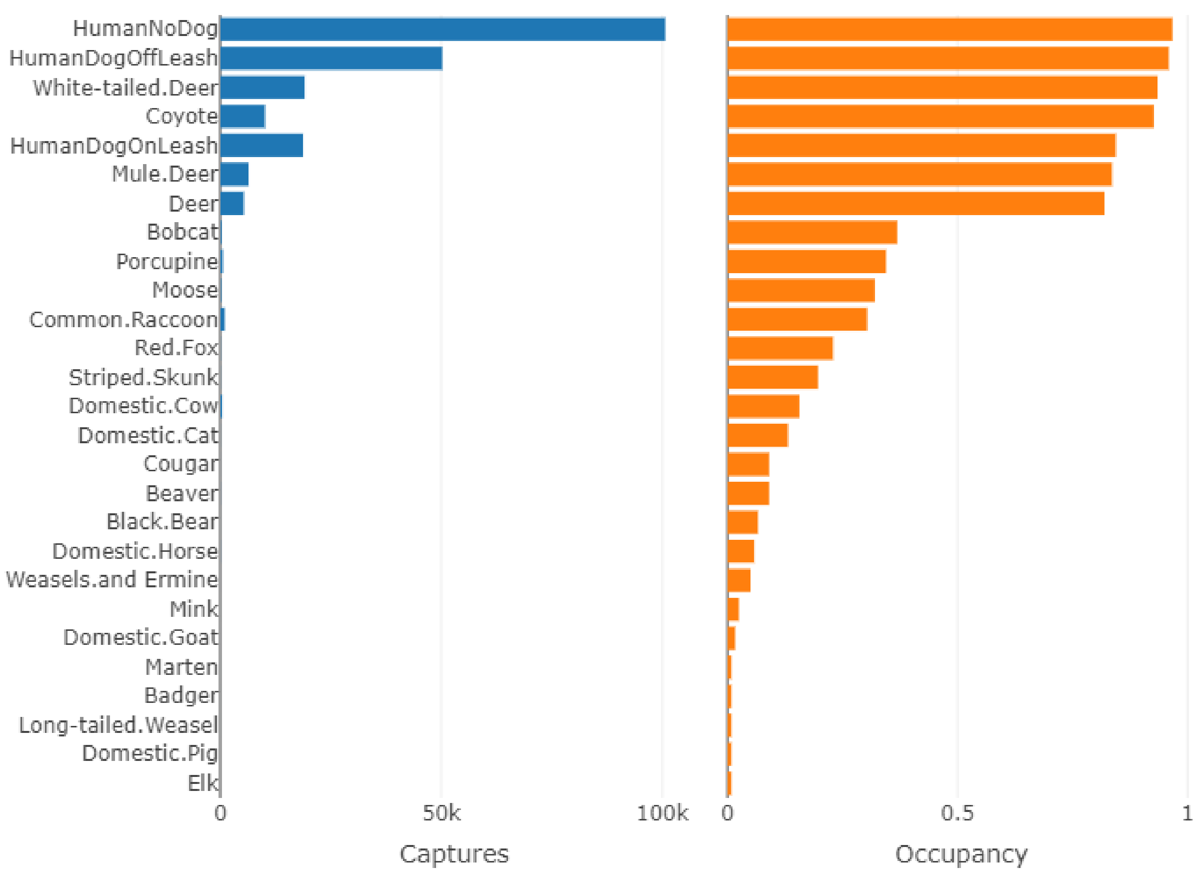


Figure 3: Number of captures (detections) on all cameras over five-year period by species (left panel) and number of cameras on which each species was detected (occupancy) (right panel).

Table 1: Number of detections per species throughout the study period. Human detections are reported as humans with a dog on-leash, humans with a dog off-leash, and humans without a dog.

Species	Number of Detections	% of Detections
Human (no dog)	100,664	47.1620
Human (dog off-leash)	50,247	23.5412
White-tailed Deer	19,088	8.9429
Human (dog on-leash)	18,681	8.7522
Coyote	10,129	4.7455
Mule Deer	6378	2.9882
Deer	5331	2.4976
Common Raccoon	983	0.4605
Porcupine	562	0.2633
Domestic Cow	430	0.2015
Bobcat	323	0.1513
Moose	242	0.1134
Red Fox	98	0.0459
Striped Skunk	66	0.0309
Domestic Horse	61	0.0286
Beaver	51	0.0239
Domestic Cat	41	0.0192
Cougar	21	0.0098
Black Bear	16	0.0075
Domestic Goat	9	0.0042
Weasel and Ermine	9	0.0042
Long-tailed Weasel	4	0.0019
Mink	3	0.0014
Badger	2	0.0009
Marten	2	0.0009
Elk	1	0.0005
Domestic Pig	1	0.0005

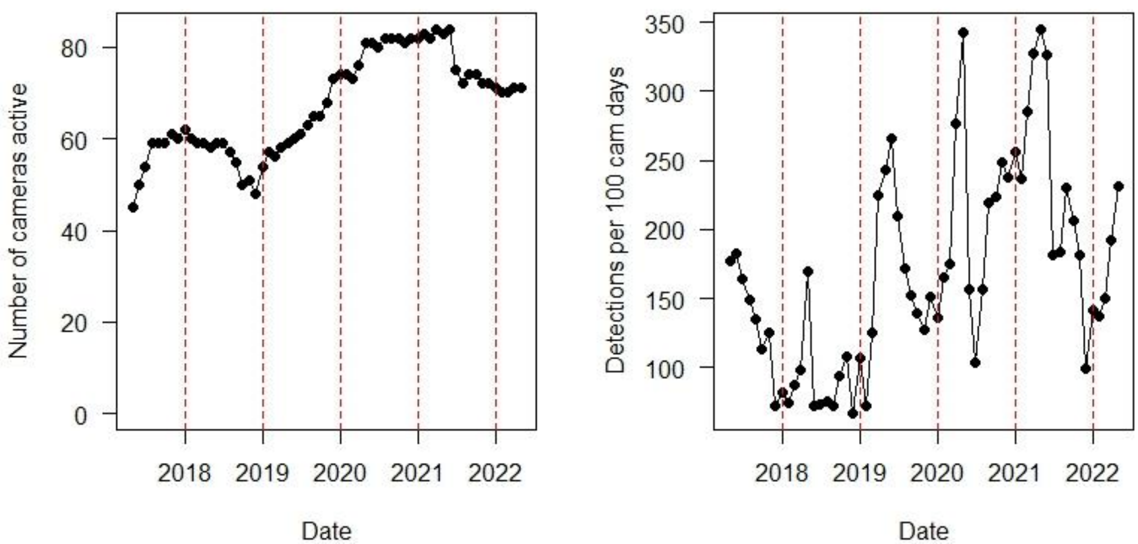


Figure 4: Number of active camera traps throughout study period (left panel); Total detections per 100 camera-trap days across study period (right panel).

Where are species active?

Species-specific spatial activity

The spatial activity maps below show a dot pattern of daily events per 100 camera trap days for humans, ungulates (Figure 5), carnivores and rodents (Figure 6). The larger the dot size, the more activity per day occurred on the camera. Red dots indicate no detections at that camera location. Maps are scaled using maximum human daily events to enable comparison of human and wildlife detections. See Appendix A for individual species activity maps.

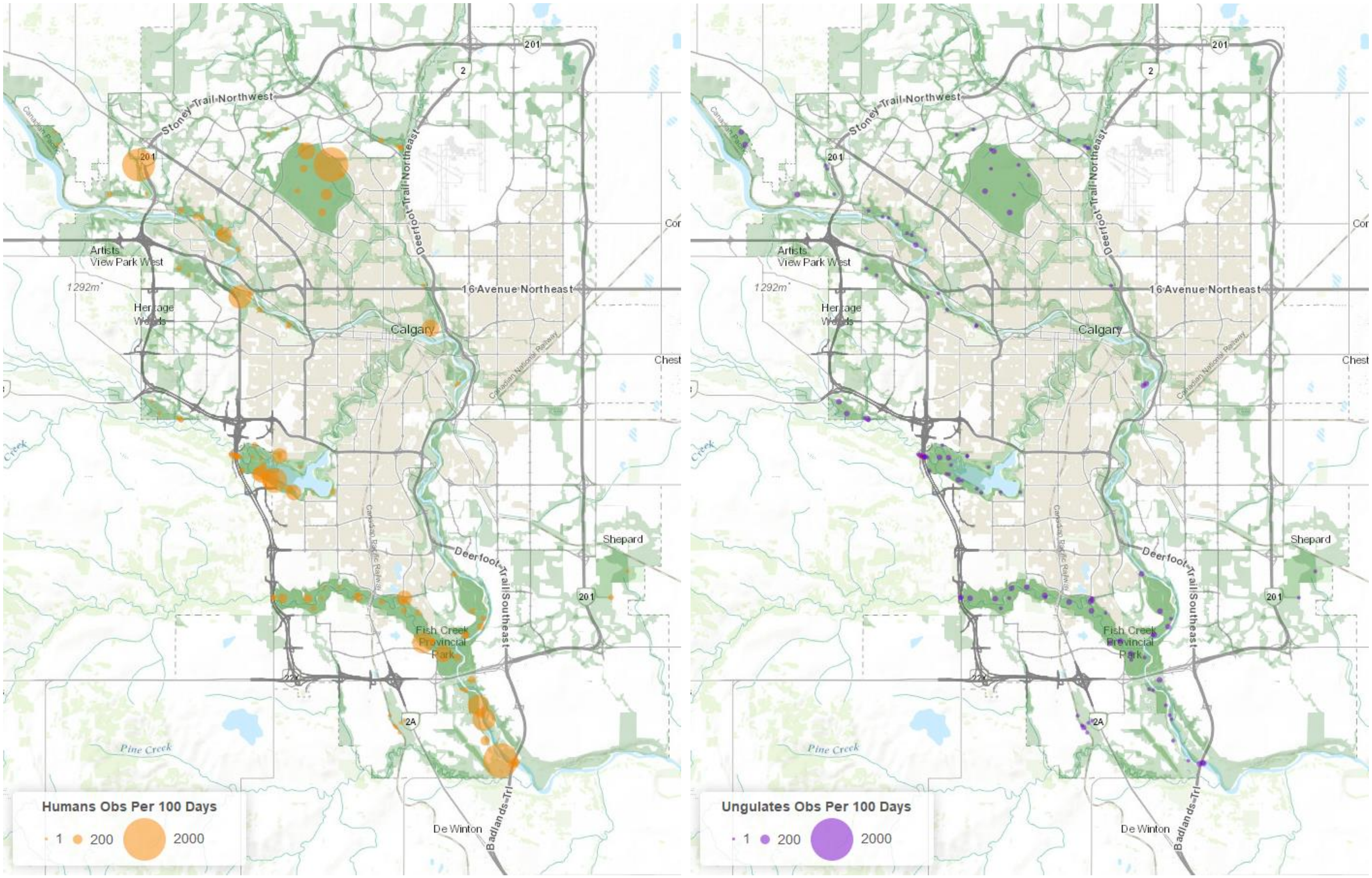


Figure 5: Human (left panel) and ungulate (right panel) detections per 100 camera trap days

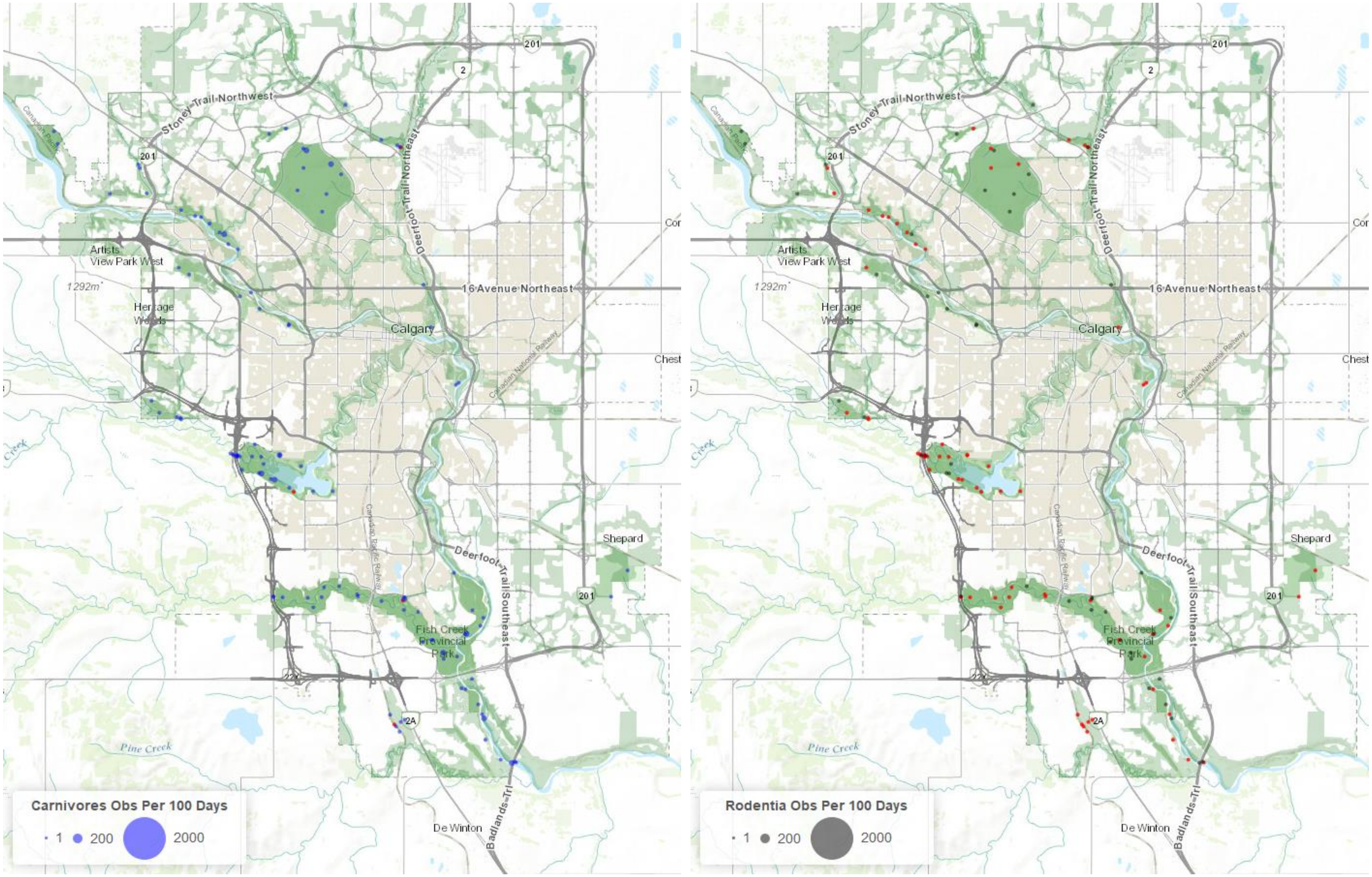


Figure 6: Carnivore (left panel) and rodent (right panel) detections per 100 camera trap days

Which wildlife use parks in Calgary?

Detections per day for human and domestic animals (Figure 7), ungulates (

Figure 8), carnivores (Figure 9) and rodent species (Figure 10) per park.

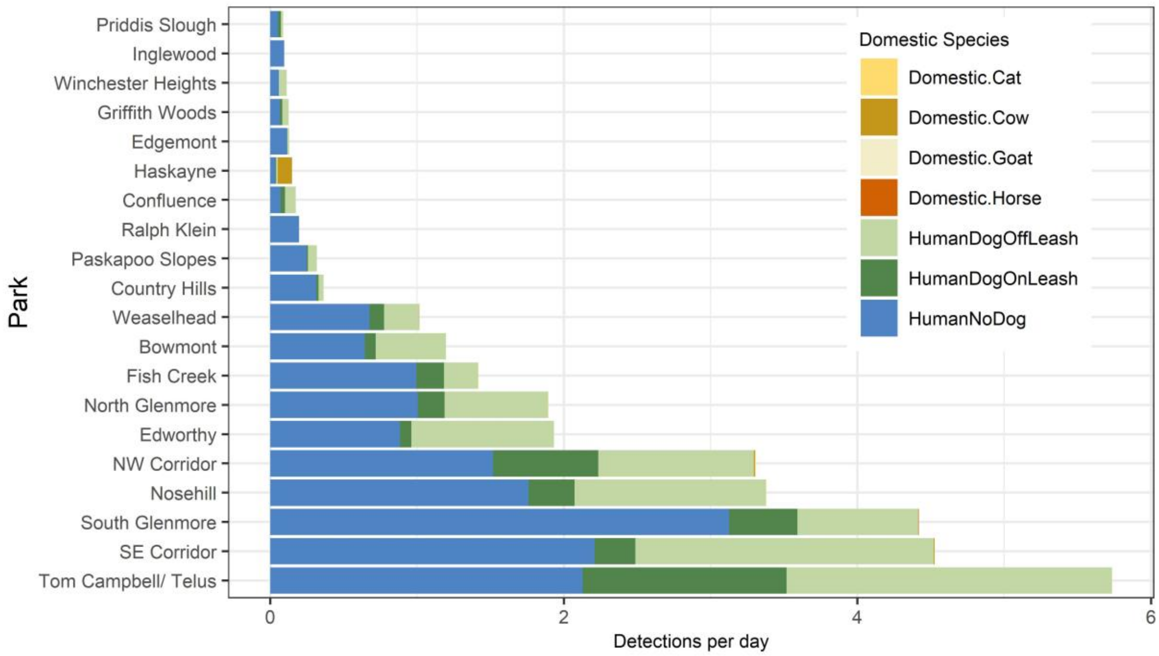


Figure 7: Human and domestic species detection per day per park.

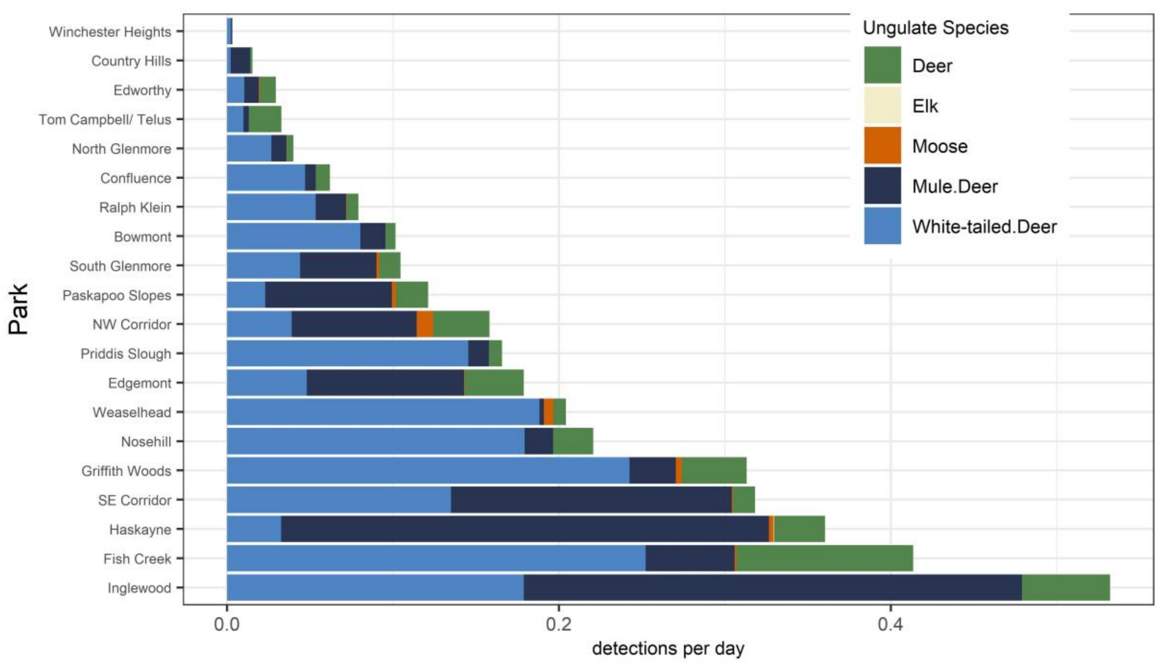


Figure 8: Ungulate species detections per park per day.

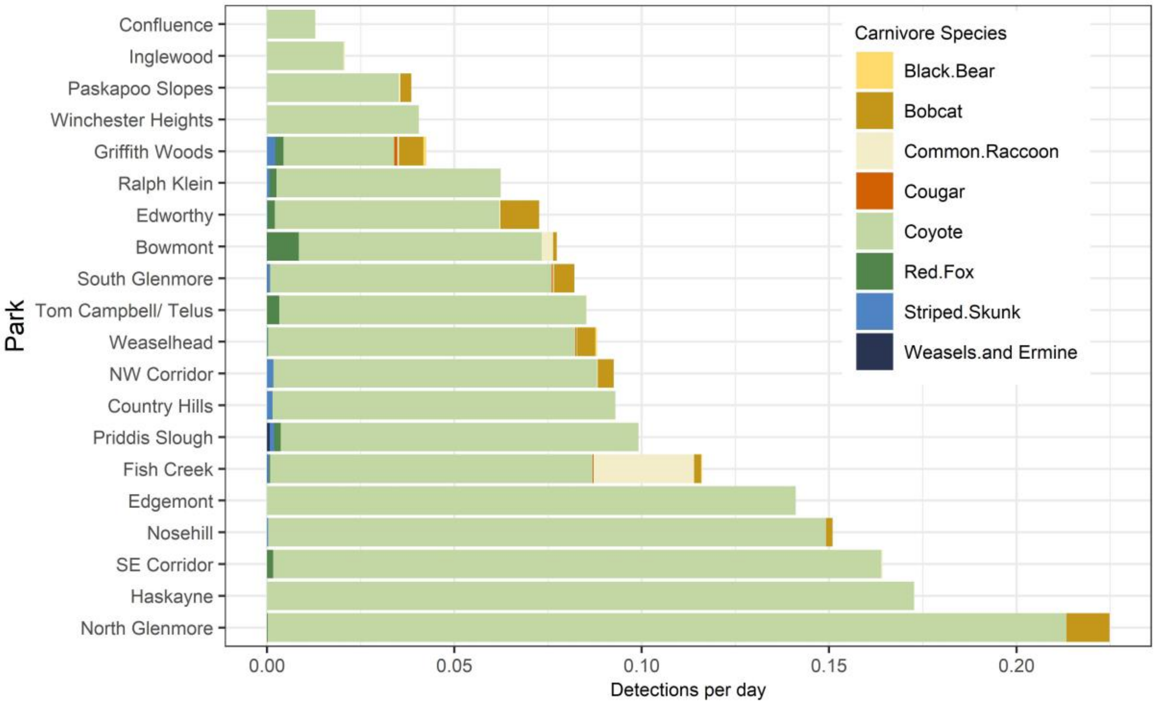


Figure 9: Carnivore species detections per park per day.

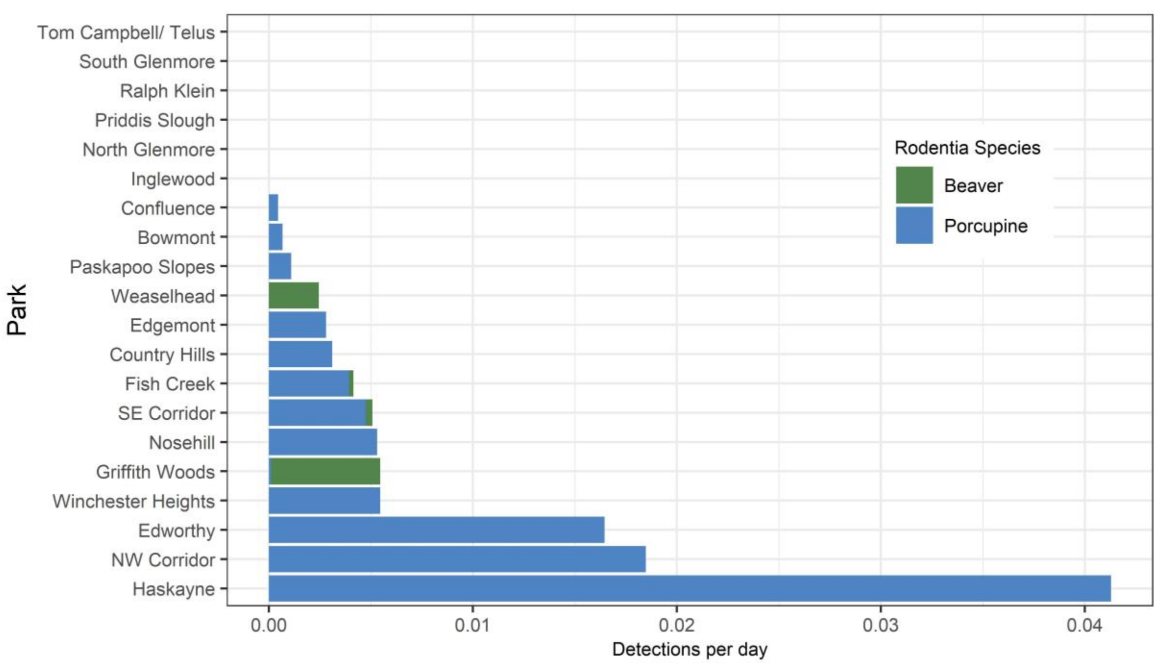


Figure 10: Rodent species detections per park per day.

When are species active?

We plotted human and domestic animal activity per month per 100 camera days throughout the study period (Figure 11). Monthly ungulate activity for deer spp., mule deer, white-tailed deer, elk, and moose indicate that all species except elk are present in Calgary throughout the study period (Figure 12). We were able to determine temporal activity for cougar, coyote, badger, black bear, bobcat, long-tailed weasel, marten, mink, striped skunk and red fox (Figure 13). Badger, long-tailed weasel, marten, and mink were rarer detections, occurring only in one or two years during the five-year study period.

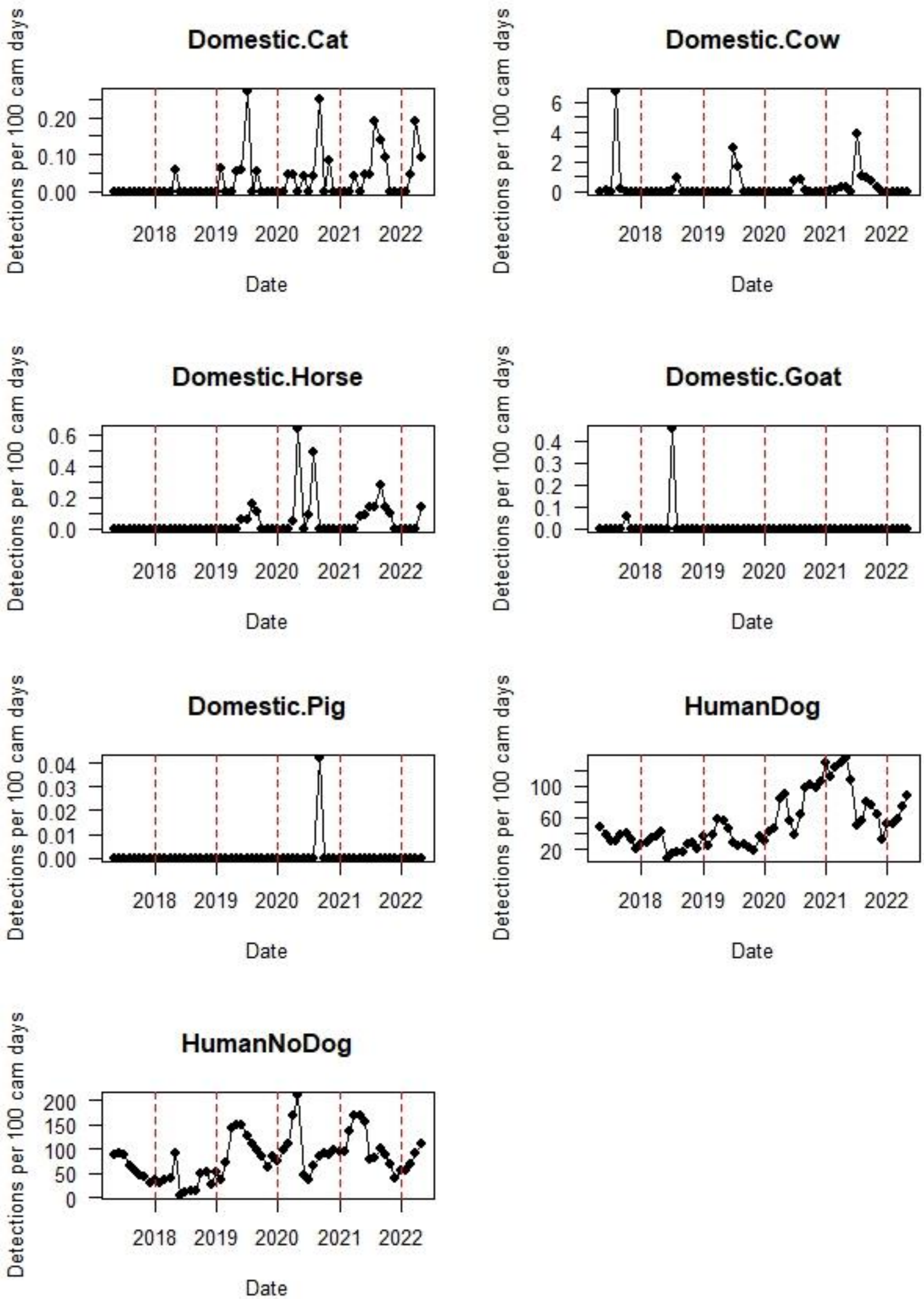


Figure 11: Human and domestic animal monthly activity per 100 camera days. Note the y-axis scale (detections per

100 camera days) is scaled per species and thus not the same for all species.

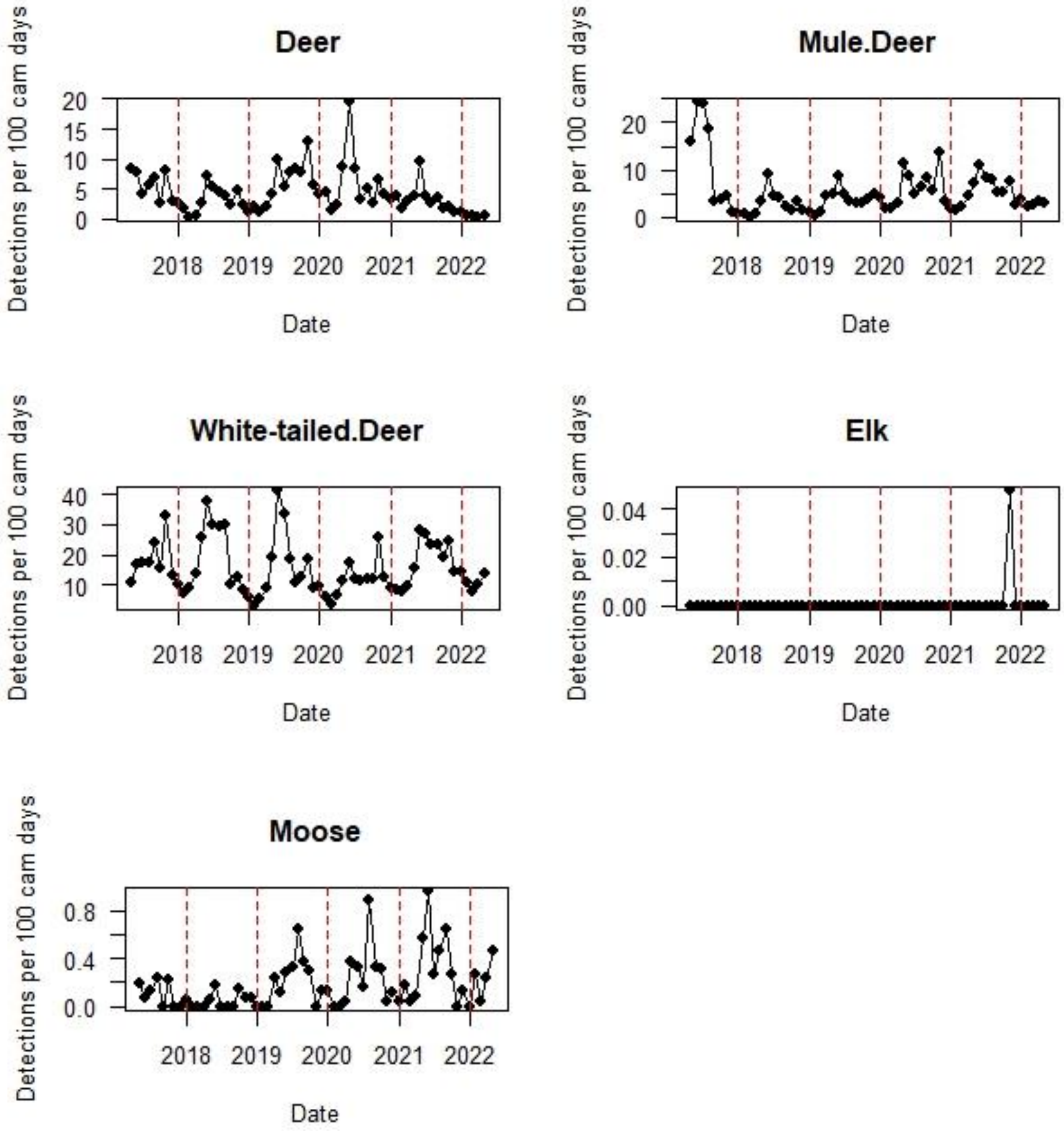
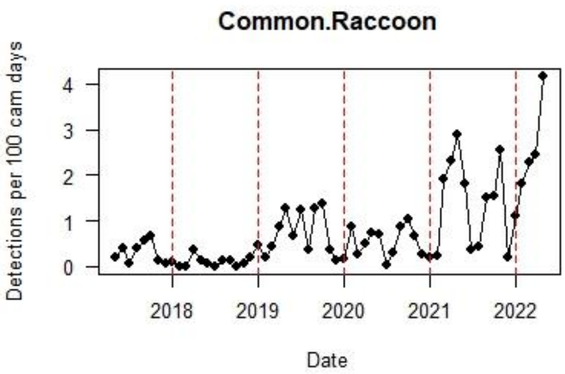
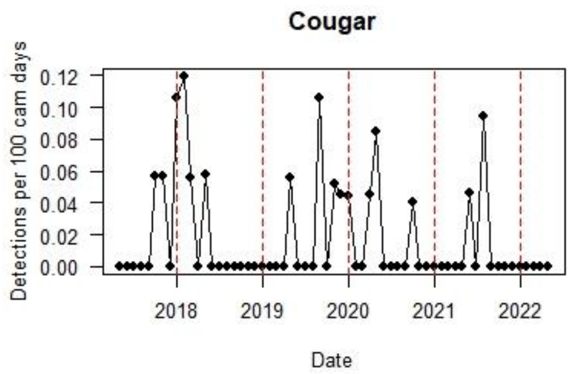
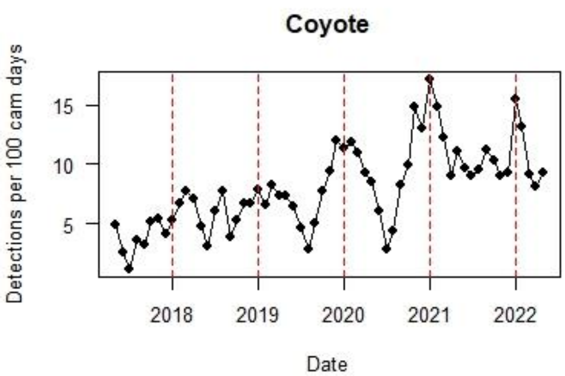
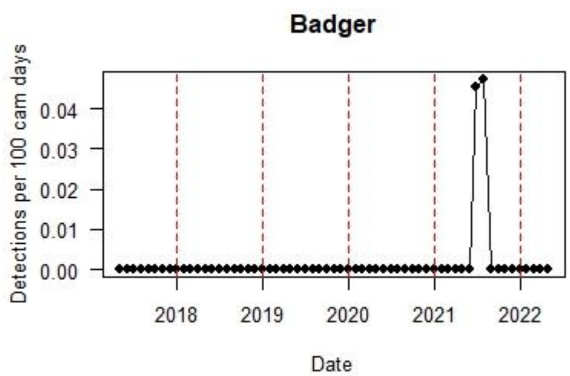


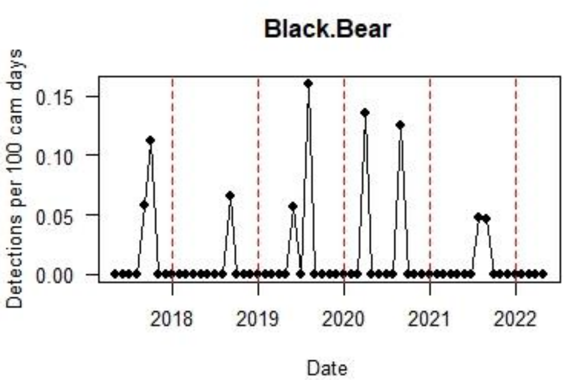
Figure 12: Monthly ungulate activity per 100 camera days across study duration. Note the y-axis scale (detections per 100 camera days) is scaled per species and thus not the same for all species.

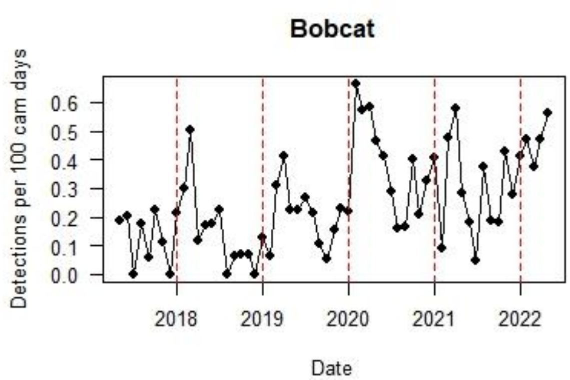

Common.Raccoon
Detections per 100 cam days
0
1
2
3
4
2018
2019
2020
2021
2022
Date

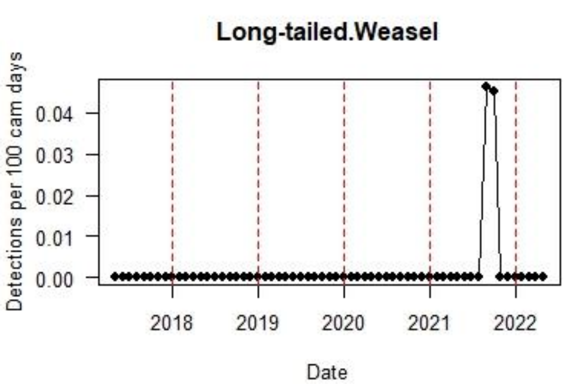

Cougar
Detections per 100 cam days
0.00
0.02
0.04
0.06
0.08
0.10
0.12
2018
2019
2020
2021
2022
Date

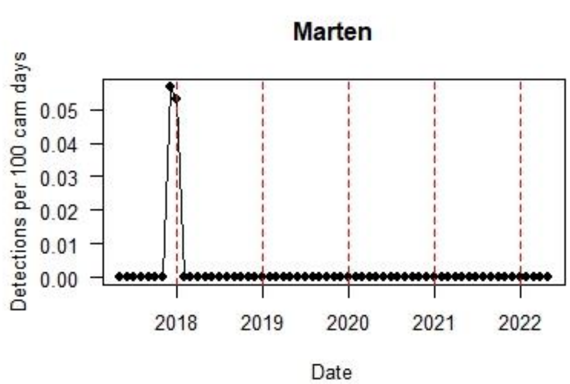

Coyote
Detections per 100 cam days
5
10
15
2018
2019
2020
2021
2022
Date


Badger
Detections per 100 cam days
0.00
0.01
0.02
0.03
0.04
2018
2019
2020
2021
2022
Date


Black.Bear
Detections per 100 cam days
0.00
0.05
0.10
0.15
2018
2019
2020
2021
2022
Date


Bobcat
Detections per 100 cam days
0.0
0.1
0.2
0.3
0.4
0.5
0.6
2018
2019
2020
2021
2022
Date


Long-tailed.Weasel
Detections per 100 cam days
0.00
0.01
0.02
0.03
0.04
2018
2019
2020
2021
2022
Date


Marten
Detections per 100 cam days
0.00
0.01
0.02
0.03
0.04
0.05
2018
2019
2020
2021
2022
Date

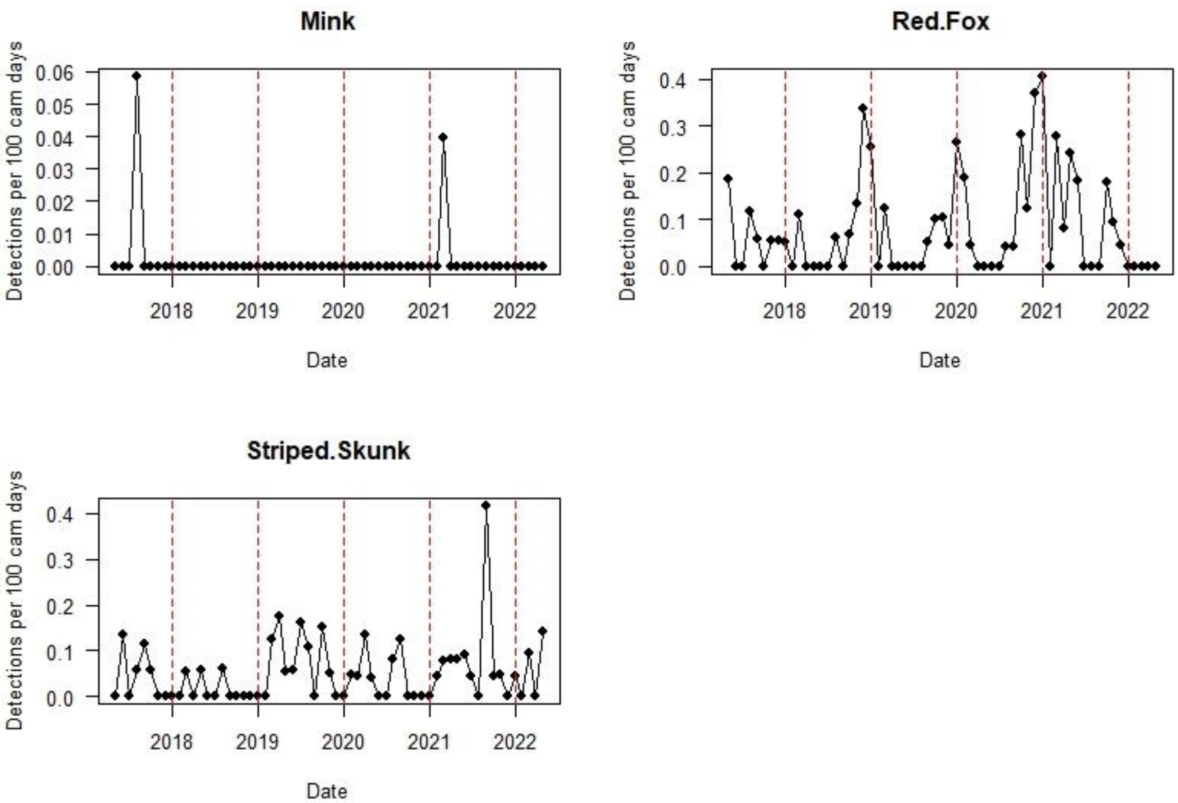


Figure 13: Carnivore species temporal activity. Note the y-axis scale (detections per 100 camera days) is scaled per species and thus not the same for all species.

Using activity density models to fit daily temporal activity pattern for ungulates (**Error! Reference source not found.**) and carnivores (Figure 15) across all sites and years, we can see that ungulate daily activity varies per species. Moose activity peaks from 6:00 pm – 9:00 pm with their lowest activity from midnight to 4:00 am. Mule deer activity has two peaks from 7:00 am – 9:00 am and from 7:00 pm – 8:00 pm with their lowest activity from 1:00 pm – 4:00 pm. And white-tailed deer activity peaks at the same time as mule deer with their lowest activity from 10:00 am – 5:00 pm.

Carnivore daily activity varies per species. Coyote are active day and night, but with an activity peak from 8:00 pm – midnight, and their lowest activity from noon – 6:00 pm. Bobcat activity peaks from 7:00 pm – 9:00 pm, with their lowest period of activity from 11:00 am – 6:00 pm. Red fox activity had two peak periods, from 4:00 am – 5:00 am and from 9:00 pm - 11:00 pm and with no activity from 7:00 am – 7:00 pm. Black bear were most active from 10:00 pm – midnight, and had two low activity periods from 1:00 am – 6:00 am and 4:00 pm – 8:00 pm.

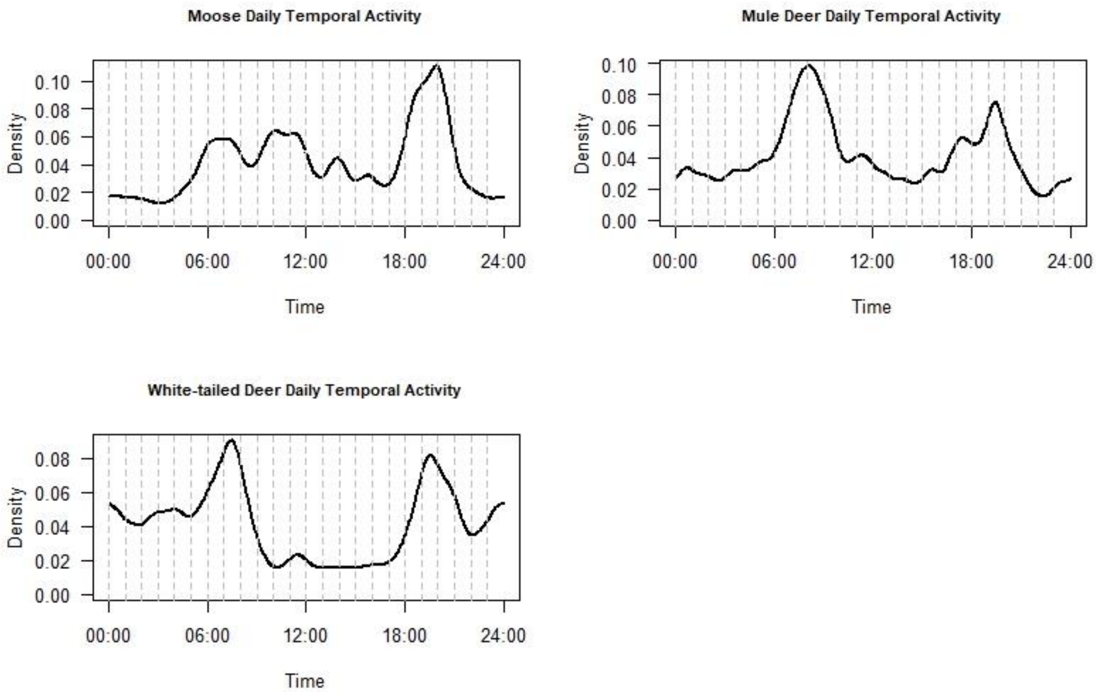


Figure 14: Daily temporal patterns for ungulate species across all sites. Note that detection density on the y-axis are displayed at different scales.

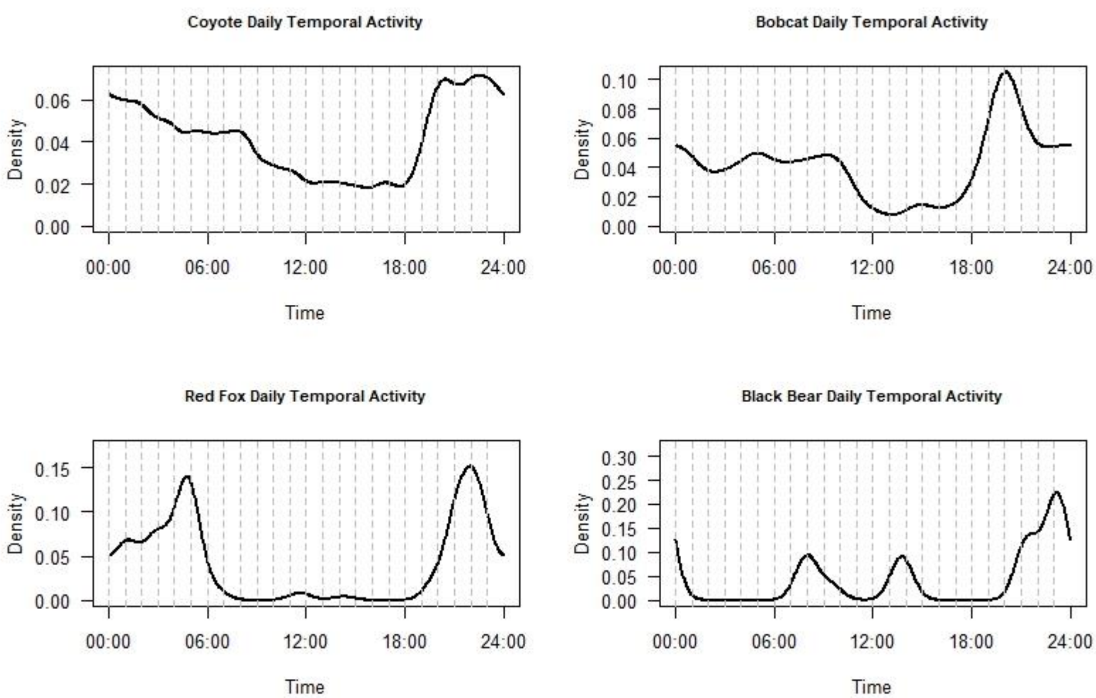


Figure 15: Daily temporal patterns for carnivore species across all sites. Note that detection density on the y-axis are displayed at different scales.

Does human activity affect wildlife?

Temporal overlap of human activity and wildlife activity

We plotted activity density to show temporal overlap between ungulates (Figure 12) and carnivores (Figure 13) with humans without dogs and humans with dogs. The shaded area in grey on the figures highlights where a species activity exhibits temporal overlap with human activity. We calculated an Overlapping Coefficient (OVL) that ranges from 0 (no overlap) to 1 (perfect fit). Moose have the most overlap with human activity and red fox the least (Table 2). The Watson-Wheeler test for human and individual wildlife species indicate a statistical difference between temporal activity patterns for species tested. Low P-values indicate results are unlikely to be due to random chance.

Black bears were the only species that had a slightly higher overlap with domestic dog than humans; however, overlap was still low, indicating black bears do not occupy parks at the same time as humans with or without domestic dogs.

Table 2: Overlapping coefficient (OVL) between species and human, and species and domestic dog. All Watson-Wheeler tests were significant (df = 2) ($P < 0.0002$, ** $P < 7.1e^{-6}$., *** $P < 2.2e^{-16}$)*

Species	**OVL: human**	**Watson-Wheeler (W) : human**	**OVL: dog**	**Watson-Wheeler (W): dog**
Bobcat	0.30	1029.3 ***	0.28	1037.9 ***
Coyote	0.37	23,411 ***	0.36	23,160 ***
Mule deer	0.46	34456 ***	0.46	33,577 ***
White-tailed deer	0.34	146,431 ***	0.33	138,718 ***
Moose	0.49	1411.9 ***	0.48	1358.1 ***
Red fox	0.12	270.23 ***	0.10	269.37 ***
Cougar	0.16	23.736 **	0.16	27.583 **
Black bear	0.25	18.179 *	0.26	17.506 *

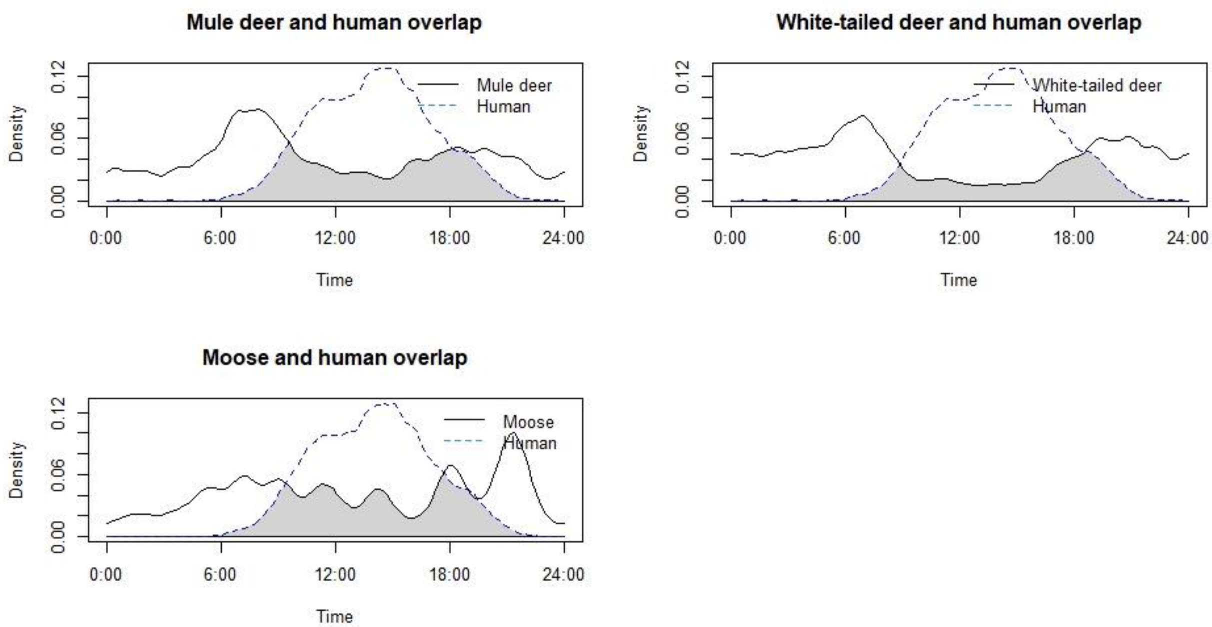


Figure 16: Daily temporal overlap between ungulate species and humans. The grey-shaded area is the time of day when species activity overlaps.

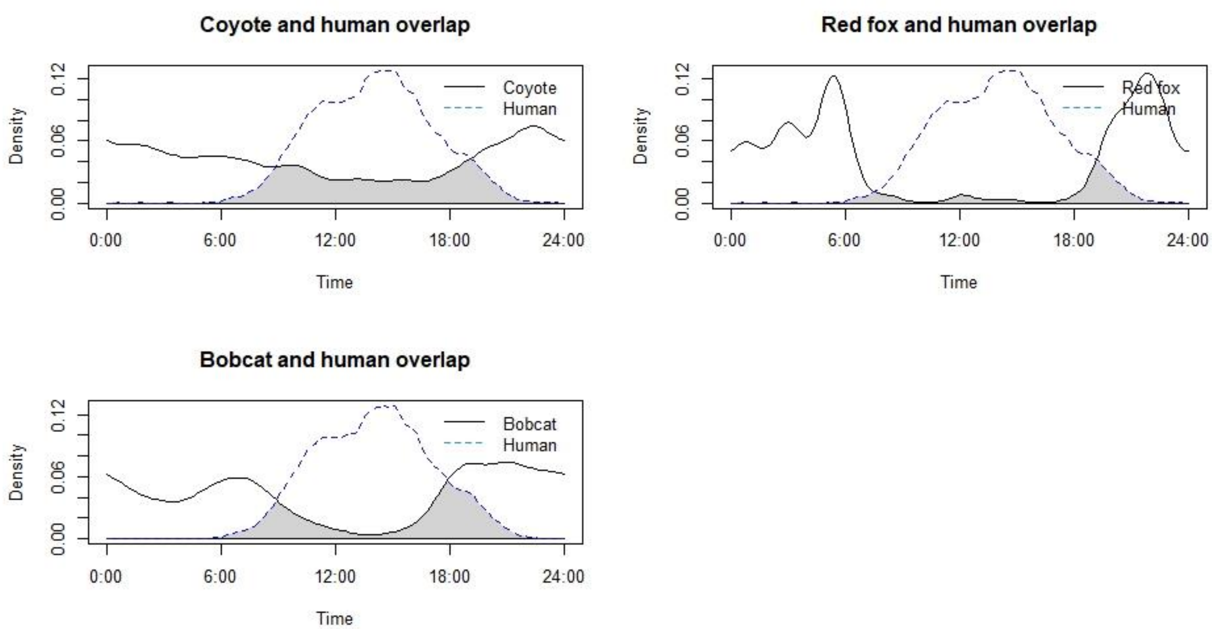


Figure 17: Daily temporal overlap between carnivore species and human. The grey-shaded area is the time of day when species activity overlaps.

Wildlife temporal response to human activity

To better understand the response of moose, bobcat, red fox, and mule deer to human presence, we plotted wildlife by species against human detections per camera throughout the study period. We calculated AAR to determine if a species is attracted to or avoiding human activity. We generated a series of time durations (T1–T4) for each camera between focal species and human detections. In general, wildlife avoid human activity; avoidance ratios for moose are 1.72, 6.96 for mule deer, 23.5 for bobcat, and 32.5 for red fox, where larger numbers represent longer temporal avoidance. In addition, we assessed the daily overlap on cameras with low or high human detections (divided at the mean). We found that all species avoid daily peak human activity by adjusting their activity. Linear regression models of each species versus human detections indicated that human activity alone is not a significant factor for moose, bobcat, red fox, or mule deer detections. Below we consider species-specific findings.

Moose

A plot of human and moose detections per camera throughout the study period (Figure 18) indicated 41 cameras with a least one moose detection, and 25 cameras with more than one moose detection.

These latter 25 cameras were used to generate time intervals per camera to assess the temporal interaction between species. A scatter plot of the T1 (moose to human) and T2 (human to moose) duration pairs for moose make clear that T2 durations are longer than T1. In addition, the AAR ratio for T2/T1 based on the mean T1 and T2 values across all cameras for moose is 1.72. Finally, the T4 (moose to human to moose) duration mean number of days is longer than T3 (moose to moose) duration, indicating temporal avoidance of moose to human activity. In summary, results indicate moose are significantly avoiding camera sites with more human detections (Figure 19).

Finally, we separated the 25 cameras into high and low human activity (divided at the mean human detections per camera: 2139). We generated an overlap model between moose daily activity patterns and low and high human activity and found differences in peak diel activity for moose. On cameras with high human activity, moose were not as active during peak human activity 10:00 am – 5:00 pm, and exhibit activity from 6:00 pm – 2:00 am, with a secondary peak at 6:00 am – 9:00 am. On cameras with less human activity, moose were active throughout the day with a peak at 9:00 pm –10:00 pm. An overlap model indicates a low overlap index (0.26) between moose on high human activity cameras and human activity (Figure 20).

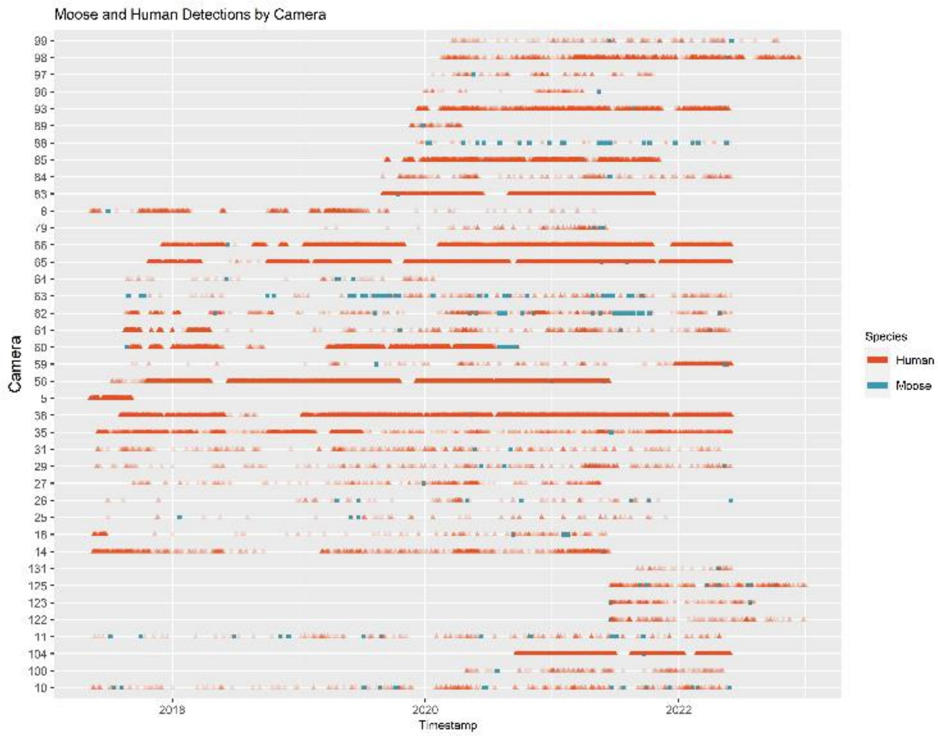


Figure 18: Human and moose detections by camera throughout the study period.

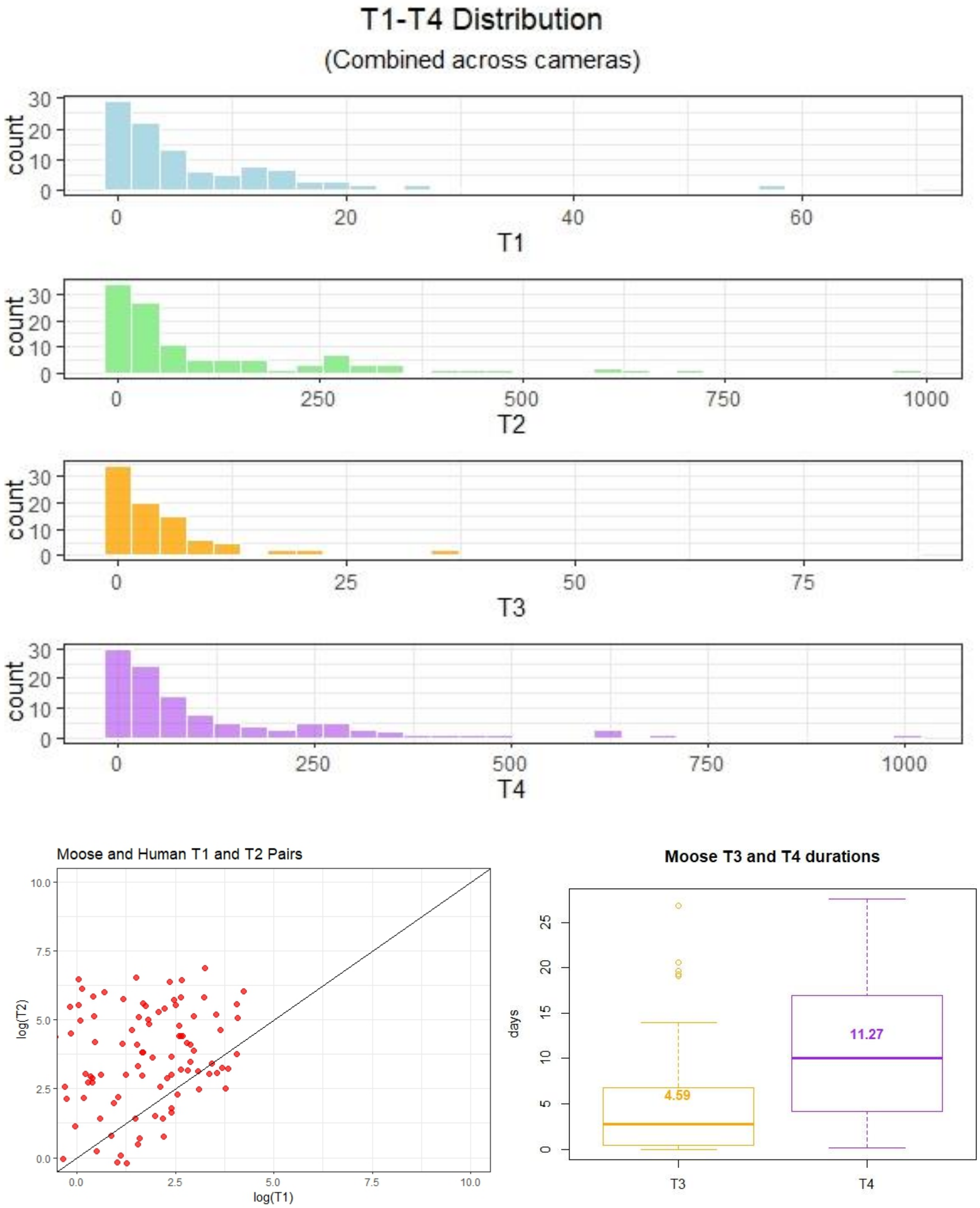


Figure 19: Moose AAR plots, including histograms of T1–T4 time durations, scatterplot of T1/T2 pairs with line of equality (black line) and boxplot of T3 (moose to moose) and T4 (moose to human/s to moose) durations.

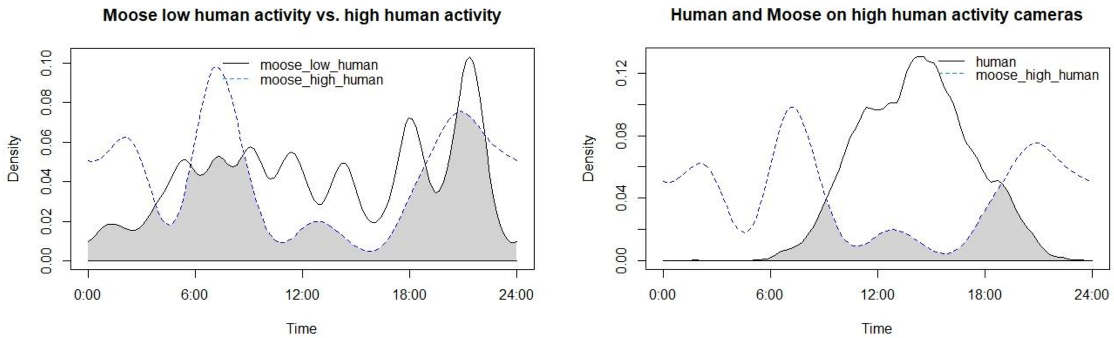


Figure 20: Overlap diel activity patterns for moose on high and low human detection cameras (left panel), and moose from high human detection cameras and human activity (right panel). Time of daily overlap is shaded in grey.

Bobcat

A plot of human and bobcat detections per camera throughout the study period (Figure 21) indicates 45 cameras had a least one bobcat detection, with 31 cameras having more than one bobcat detection. These 31 cameras were used to generate time intervals per camera to assess the temporal interaction between species. A scatter plot of T1 and T2 duration pairs for bobcat indicates T2 durations are longer than T1. In addition, the AAR ratio for T2/T1 using mean T1 and T2 values across all cameras for bobcat is 23.5. Finally, the T4 duration mean (based on days) is longer than T3 duration, indicating bobcat avoid human activity. In summary, results indicate bobcats significantly avoid camera sites with higher human detections (Figure 22).

Figure 21: Human and bobcat detections by camera throughout the study period.

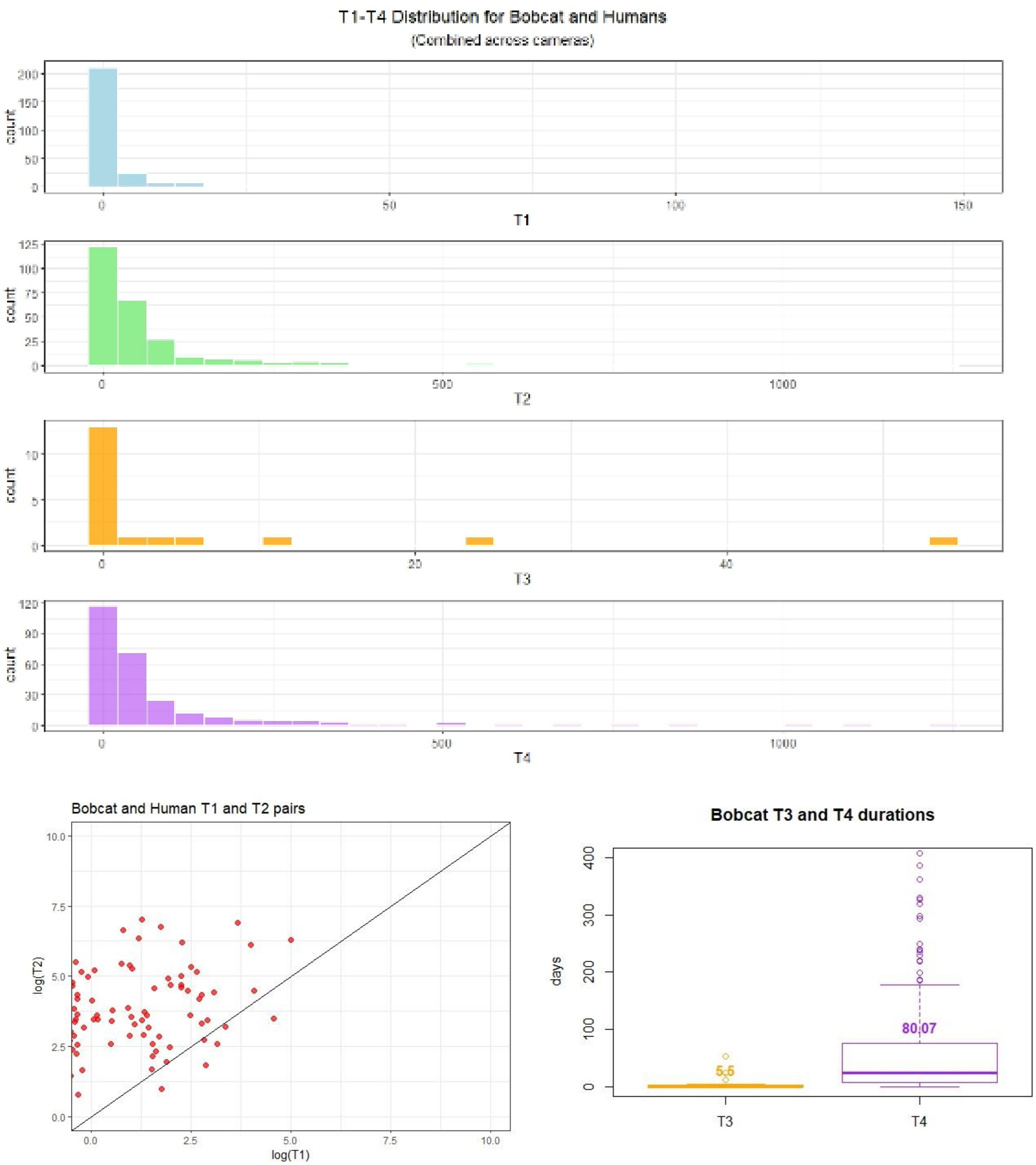


Figure 22: Bobcat AAR plots, including histograms of T1–T4 time durations, scatterplot of T1/T2 pairs with line of equality (black line) and boxplot of T3 (bobcat to bobcat) and T4 (bobcat to human/s to bobcat) durations.

We separated the 31 cameras into high and low human activity based on mean (2349) human detections per camera. We found differences in peak diel activity for bobcats between low and high human activity cameras. On cameras with high human activity, bobcats were less active during peak human activity 10:00 am – 5:00 pm, and exhibit an activity peak slightly later on cameras with lower human detections from 8:00 pm – 11:00 pm and with more activity during the night. The overlap model indicates a low overlap index (0.21) between bobcats on high human activity cameras and human activity (Figure 23).

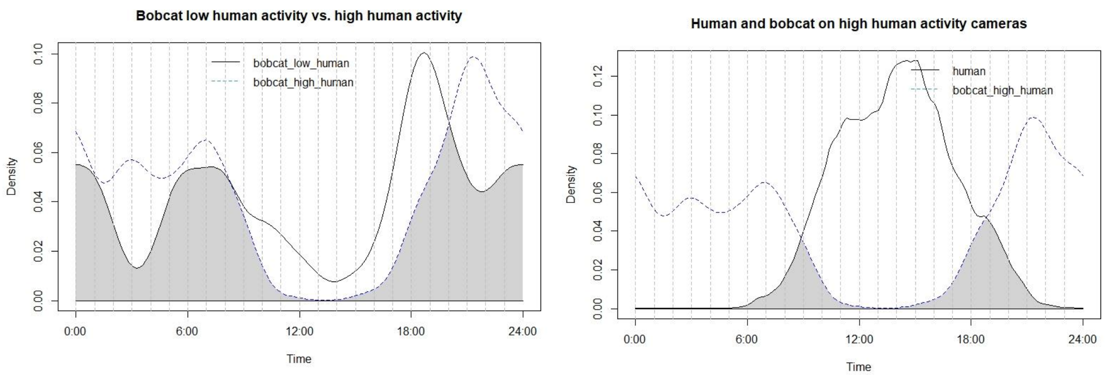


Figure 23: Overlap diel activity patterns for bobcat on high and low human detection cameras (left panel), and bobcat detections on high human detection cameras and human activity (right panel). Time of daily overlap is shaded in grey.

Red Fox

A plot of human and red fox detections per camera across the study duration (Figure 24) indicates 28 cameras had a least one red fox detection, with 14 cameras having more than one red fox detection. These 14 cameras were used to generate time intervals per camera to assess the temporal interaction between species. A scatter plot of T1 and T2 duration pairs for red fox indicates T2 durations are longer than T1. In addition, the AAR ratio for T2/T1 using mean T1 and T2 values across all cameras for red fox is 32.6. Finally, the T4 duration mean (based on days) is longer than T3 duration, indicating red fox avoid human activity. In summary, results indicate red fox are significantly avoiding camera sites with higher human detections (Figure 25). Due to the low number of red fox detections, we did not separate the data into high and low human activity classes.

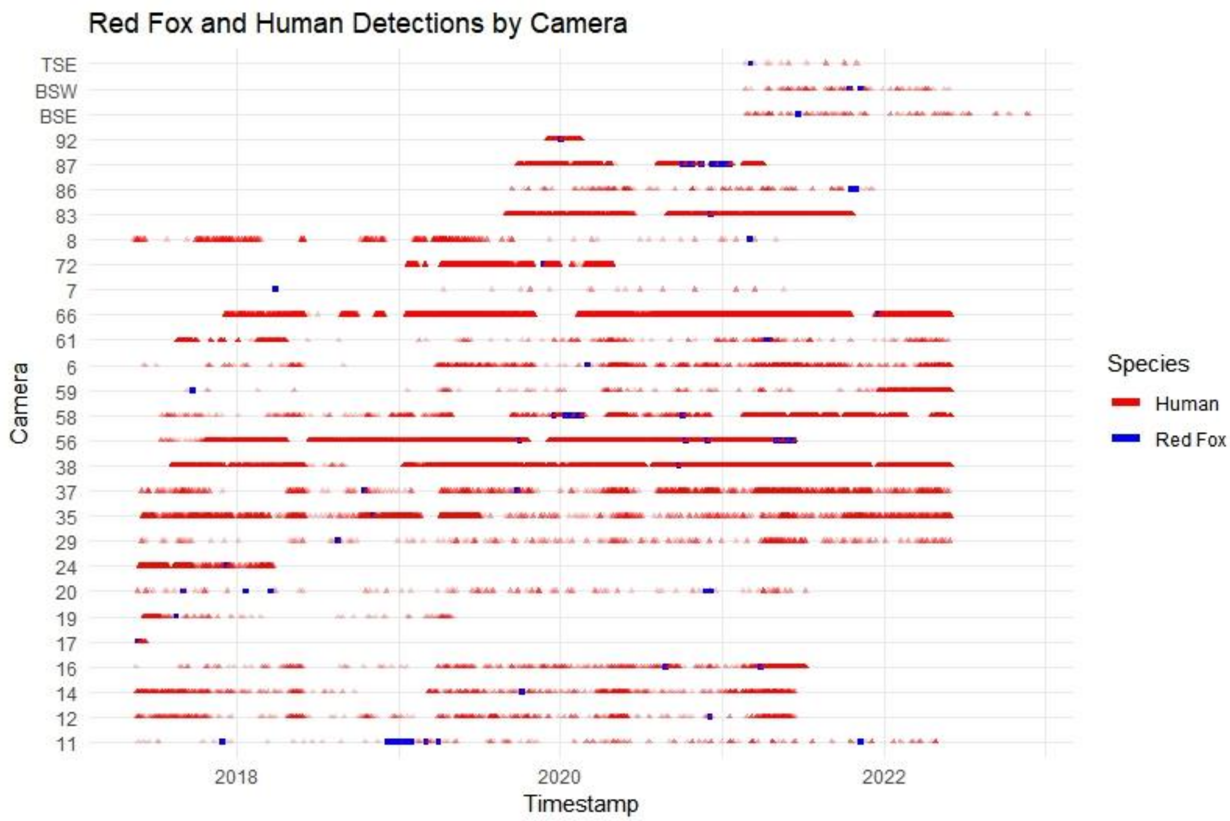


Figure 24: Human and red fox detections by camera across study duration

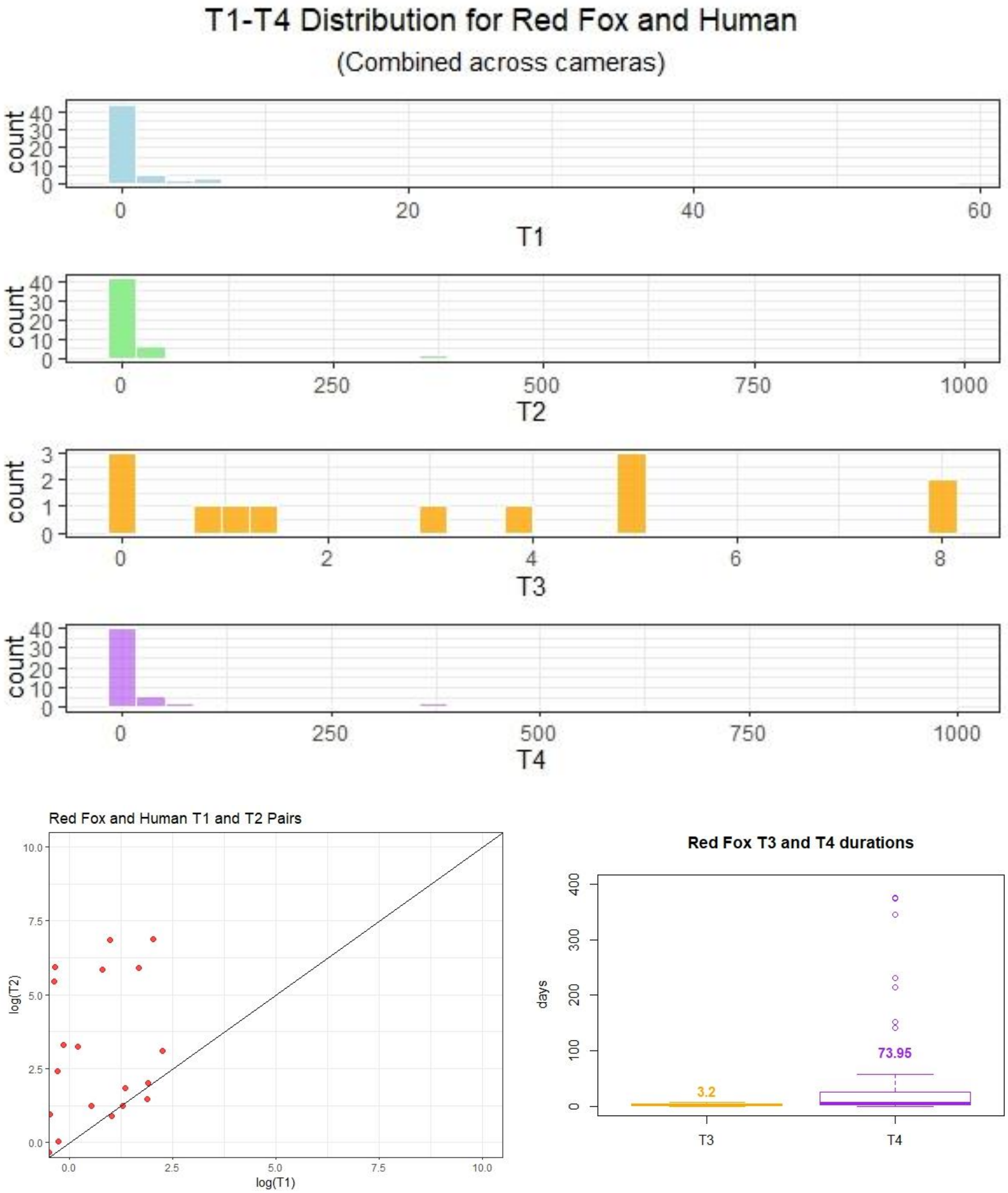


Figure 25: Red fox AAR plots, including histograms of T1–T4 time durations, scatterplot of T1/T2 pairs with line of equality (black line) and boxplot of T3 (red fox to red fox) and T4 (red fox to human/s to red fox) durations.

Mule deer

A plot of human and mule deer detections per camera across the study duration (Figure 26) indicates 102 cameras had a least one mule deer detection, with 93 cameras having more than one mule deer detection. These 93 cameras were used to generate time intervals per camera to assess the temporal interaction between species. A scatter plot of T1 and T2 duration pairs for mule deer indicates T2 durations are longer than T1. In addition, the AAR ratio for T2/T1 using mean T1 and T2 values across all cameras for mule deer is 6.96. Lastly, the T4 duration mean (based on days) is longer than T3 duration, indicating mule deer avoid human activity. In summary, results indicate mule deer (with statistical significance) are avoiding camera sites with higher human detections. (Figure 27).

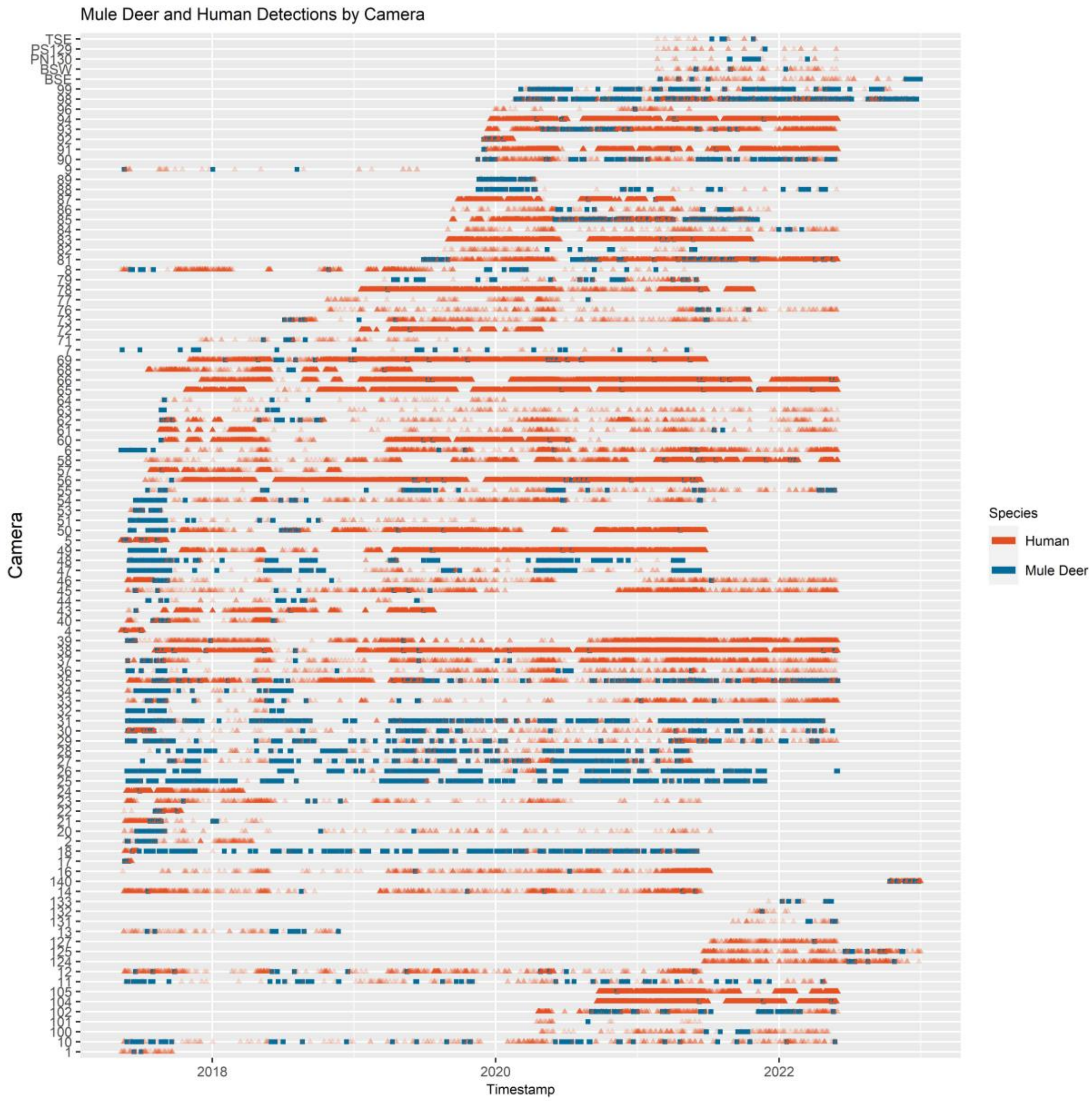


Figure 26: Human and mule deer detections by camera across study duration

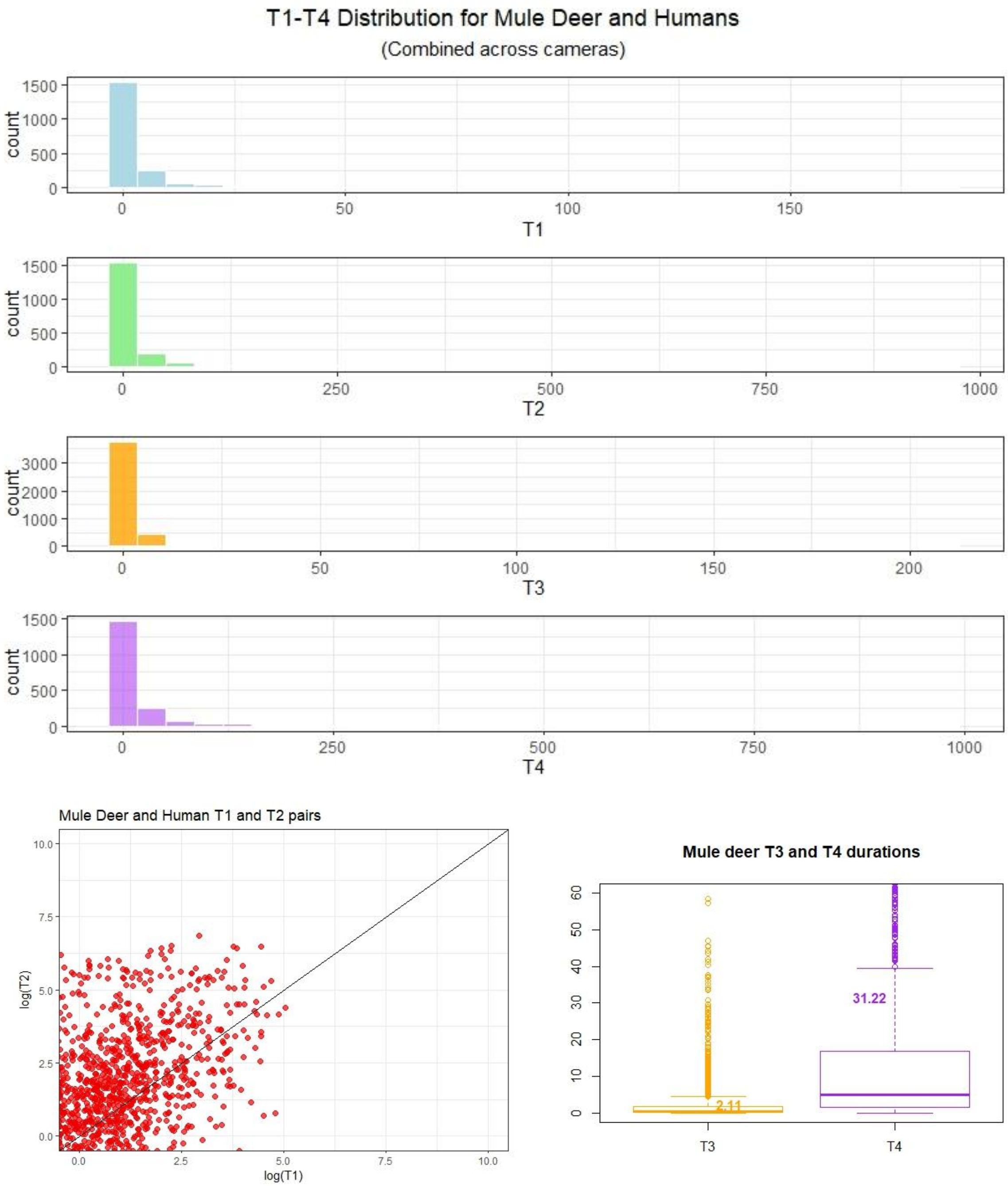


Figure 27: Mule deer AAR plots, including histograms of T1-T4 time durations, scatterplot of T1/T2 pairs with line of equality (black line) and boxplot of T3 (mule deer to mule deer) and T4 (mule deer to human/s to mule deer) durations.

We separated the 93 cameras into high and low human activity, dividing at the mean human detections per camera (1614). We found minor differences in peak diel activity for mule deer between low and high human activity cameras, but not a statistically significant change in mule deer daily activity between low and high human detection cameras with both high and low cameras indicating a low overlap index of 0.46 (Figure 28).

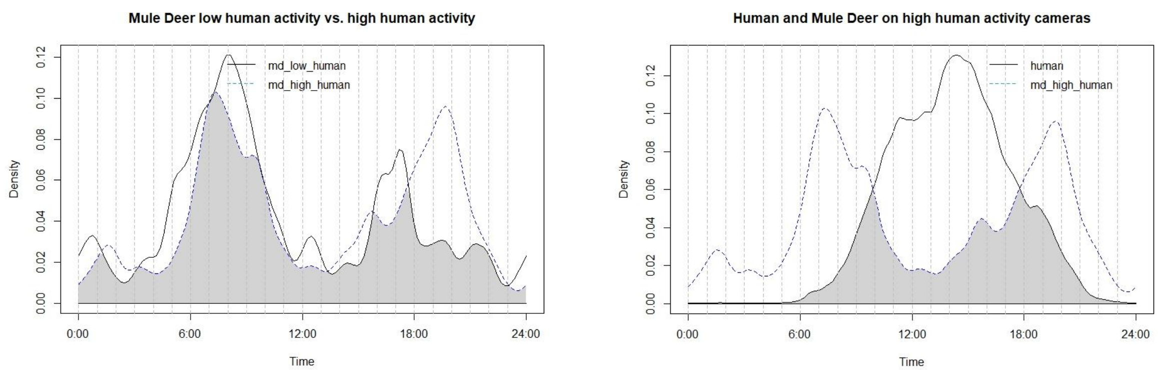


Figure 28: Overlap diel activity patterns for mule deer on high and low human detection cameras (left panel), and mule deer detections on high human detection cameras and human activity (right panel). Time of daily overlap is shaded in grey.

Domestic dog leashing in parks and wildlife corridors

There were 68,928 detections of domestic dogs (representing 32% of all events over five years). We detected 50,247 off-leash dog detections accounting for 24% of all events in the study while 18,681 were on-leash detections, accounting for 9% of all events in the study. Twelve cameras were placed in (or within 50m of) a designated off-leash area including Tom Campbell, Winchester Heights, Nose Hill and Bowmont. When these twelve cameras were excluded from analysis, there were 17,493 detections of on-leash dogs and 45,344 of off-leash dogs. A key finding is 72% of dogs off-leash were in designated on-leash areas.

Weaselhead/Glenmore and Fish Creek Provincial Park have no designated off-leash areas but both parks detected significant numbers of humans with off-leash dogs. In parks where both on-leash and off-leash areas are present, including Nose Hill, Bowmont, and Edworthy, off-leash dogs were also detected in designated on-leash areas (Figure 29).

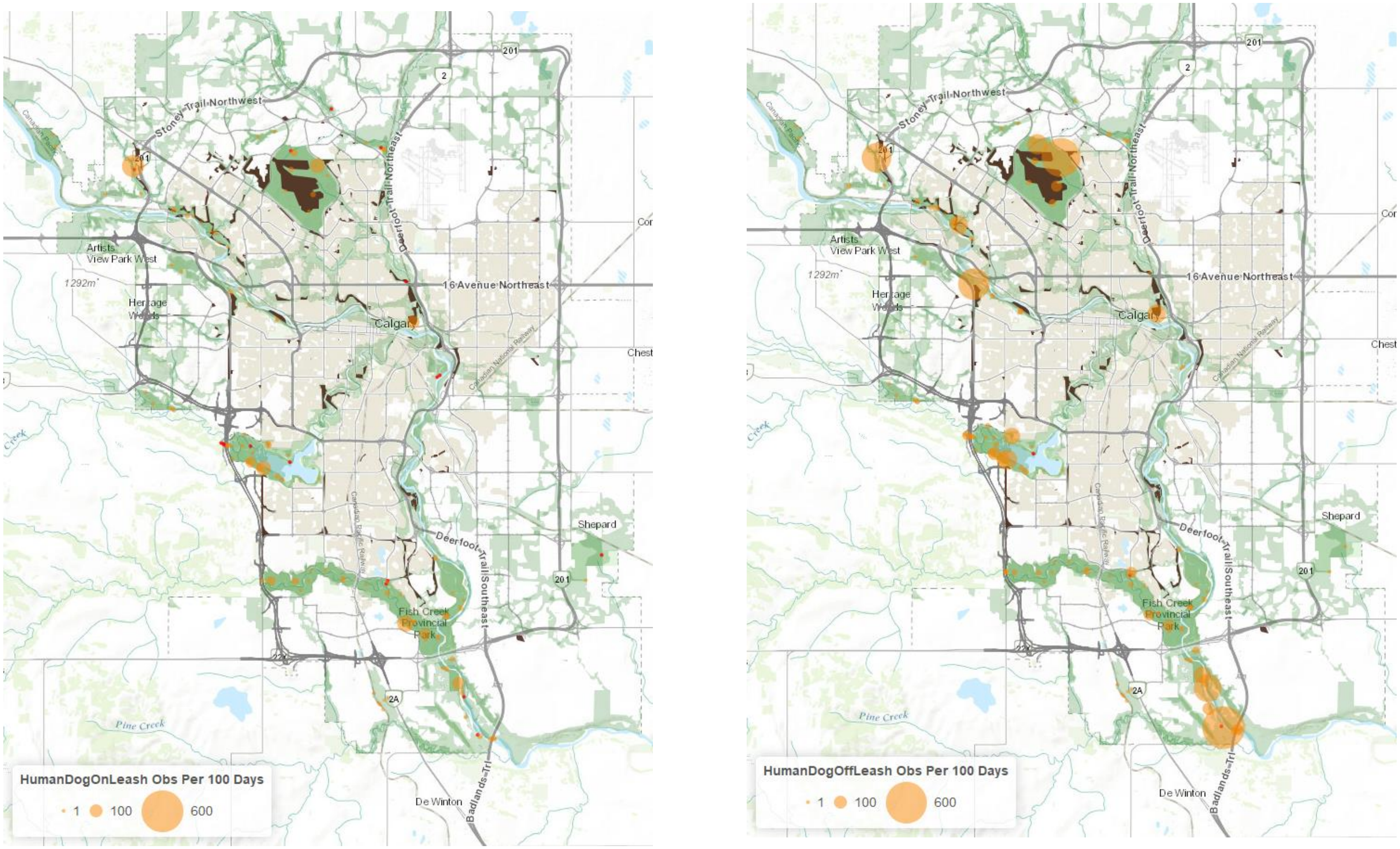


Figure 29: On-leash dog activity (left panel) and off-leash dog activity (right panel) per 100 camera trap days. Designated off-leash areas are displayed in brown. Ecological network displayed in green in background.

What species are detected in the ecological corridors?

We plotted total ungulates (Figure 31) and carnivores (Figure 32) detected in each ecological (wildlife) corridor: Weaselhead-Griffith Woods Corridor (WGC), Haskayne-Bowmont Corridor (HBC), and Fish Creek Corridor (FRC) (Figure 30).

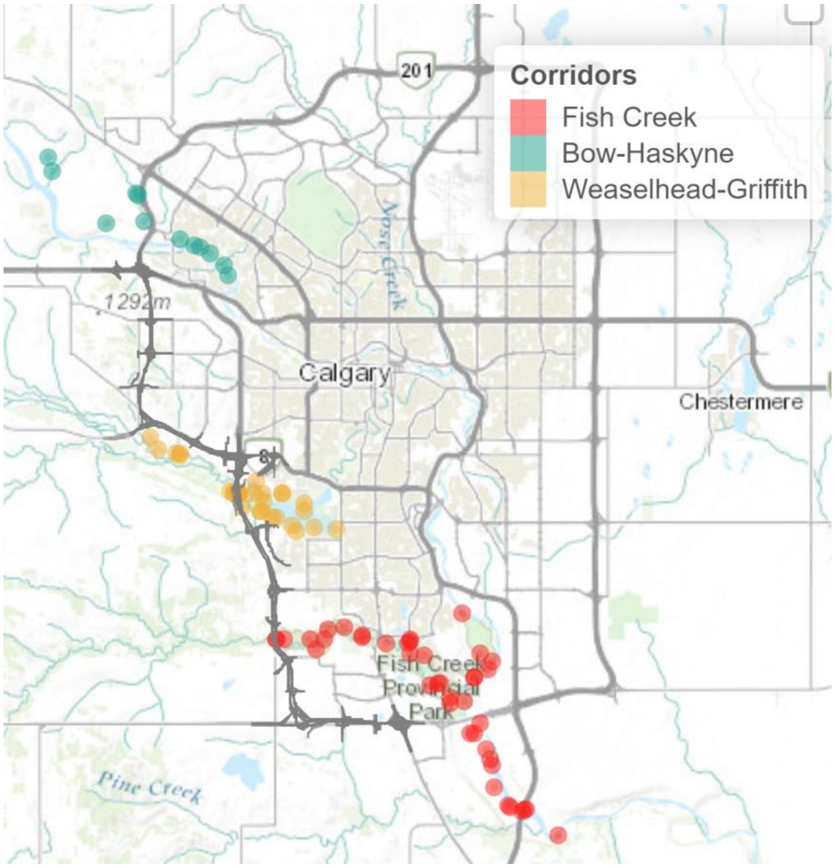


Figure 30: Camera locations for three ecological corridors in the Calgary Ecological Network.

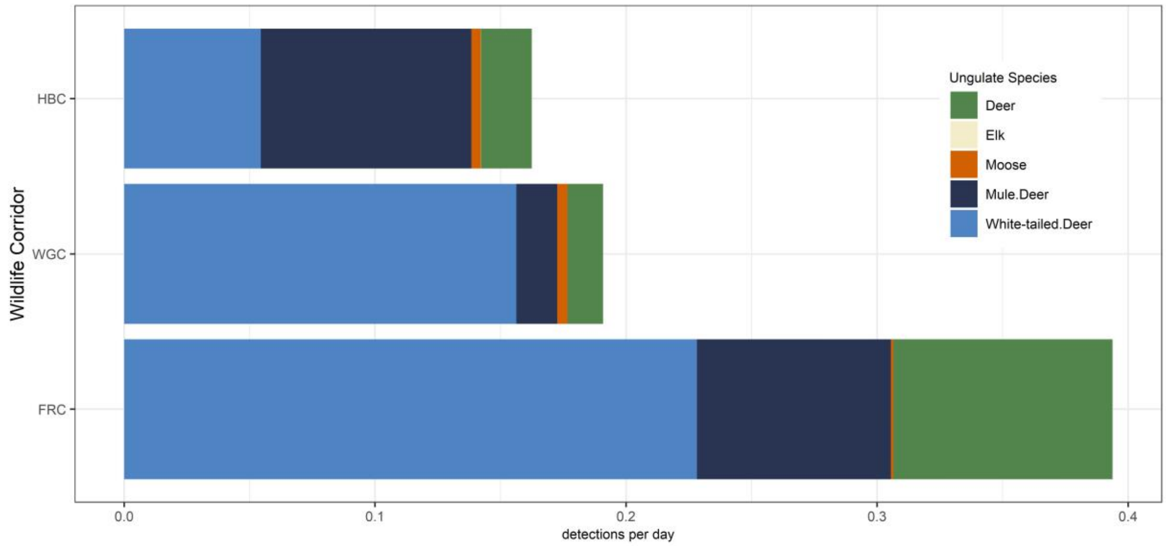


Figure 31: Ungulate species detections per day by ecological corridor.

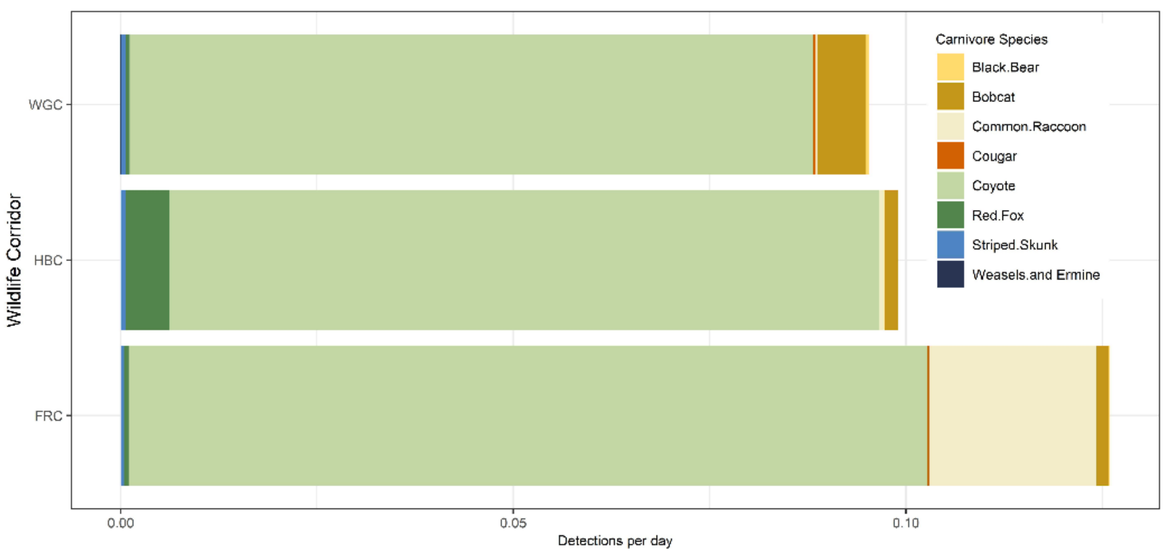


Figure 32: Carnivore species detections per day by ecological corridor.

Weaselhead-Griffith Woods Corridor

The Weaselhead- Griffith Woods Corridor includes cameras from North and South Glenmore Park, Weaselhead, and Griffith Woods. Here we present the yearly detections per 100 trap days of ungulate (Figure 33) and carnivore species (Figure 34). Elk were not recorded in the Weaselhead-Griffith Woods Corridor during five-year period, but have been recorded recently in 2023.

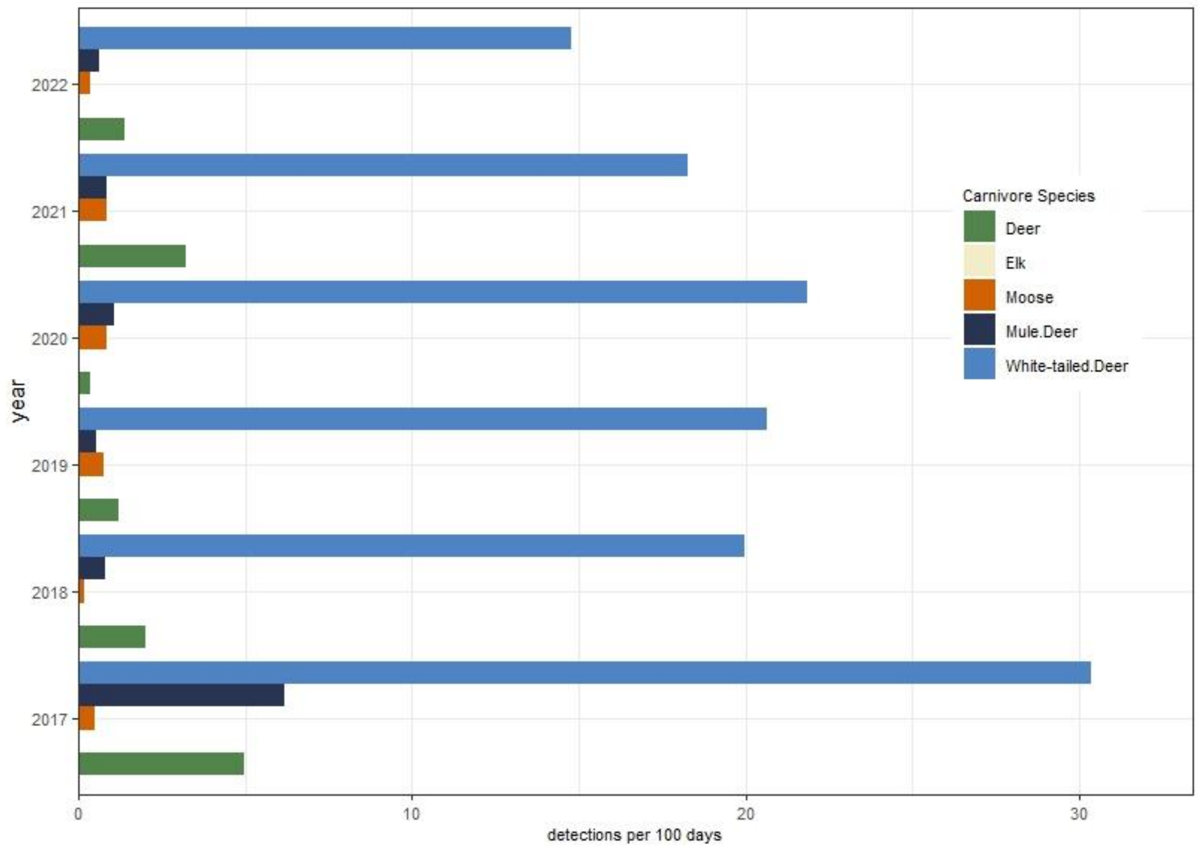


Figure 33: Ungulate detections per 100 camera trap days in the Weaselhead-Griffith Woods Corridor per year.

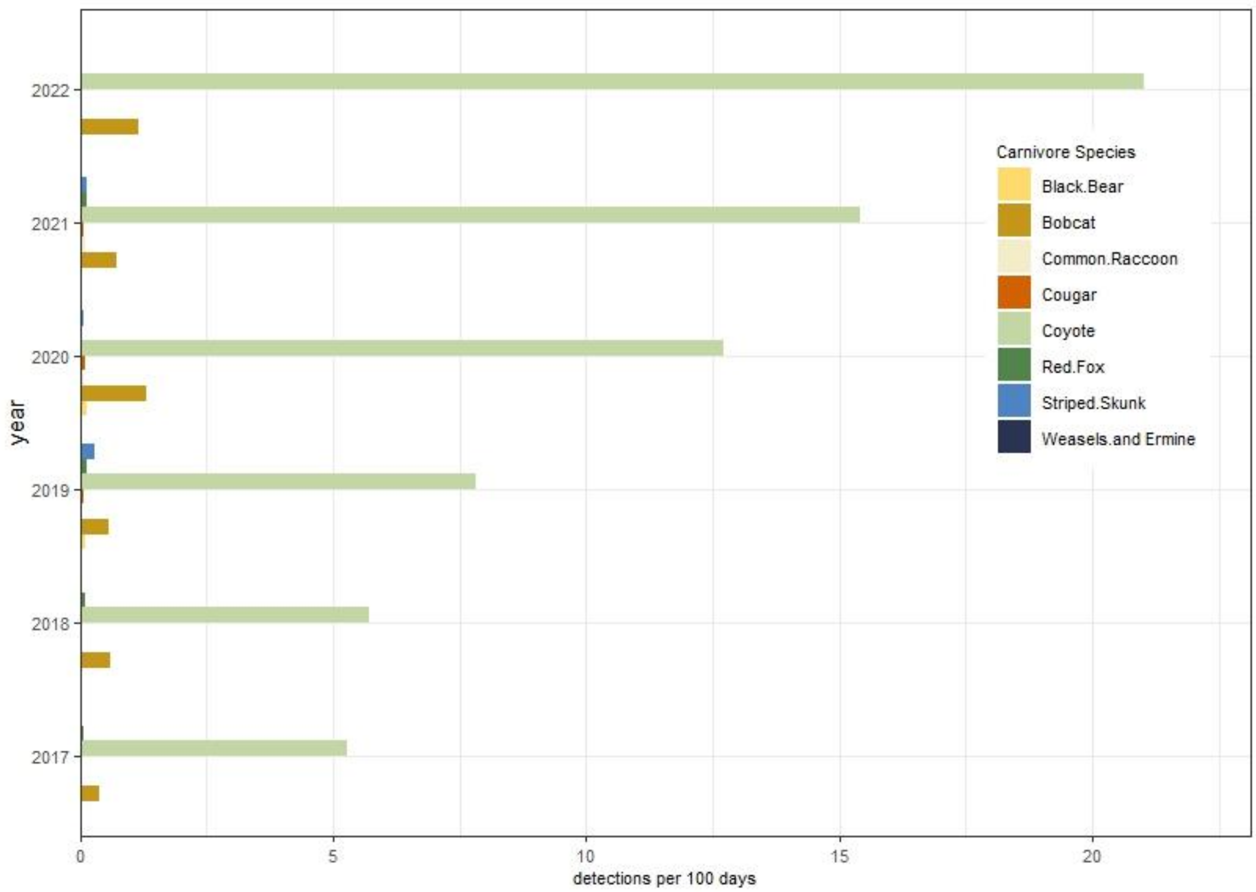


Figure 34: Carnivore detections per 100 camera trap days in the Weaselhead-Griffith Woods Corridor per year.

To determine if there were changes in detection rates along an ecological corridor from inside to outside the city we plotted mule deer (Figure 35), moose (Weaselhead- Griffith Woods Corridor.

Figure 36), bobcat (Figure 37), red fox (Figure 38) and cougar (Figure 39) detection rates per 100 trap days for the Weaselhead- Griffith Woods Corridor. Detection rates for mule deer are similar throughout the corridor with a hotspot of activity occurring in South Glenmore Park. Moose occur at similar activity patterns in portions of the corridor, except in North and South Glenmore Parks where they are rarely detected along the western edge. Bobcat occur in most of the corridor, except in North and South Glenmore Parks where there are no detections to the east, but activity hotspots on the western edge. Red fox occur sporadically within the corridor at low detection rates. Cougar occur with similar activity patterns in portions of the corridor, except for no detections in North and South Glenmore Parks.

Figure 35: Mule deer detection rates per 100 camera trap days (ranging from 0.12 to 17.2) in the Weaselhead- Griffith Woods Corridor.

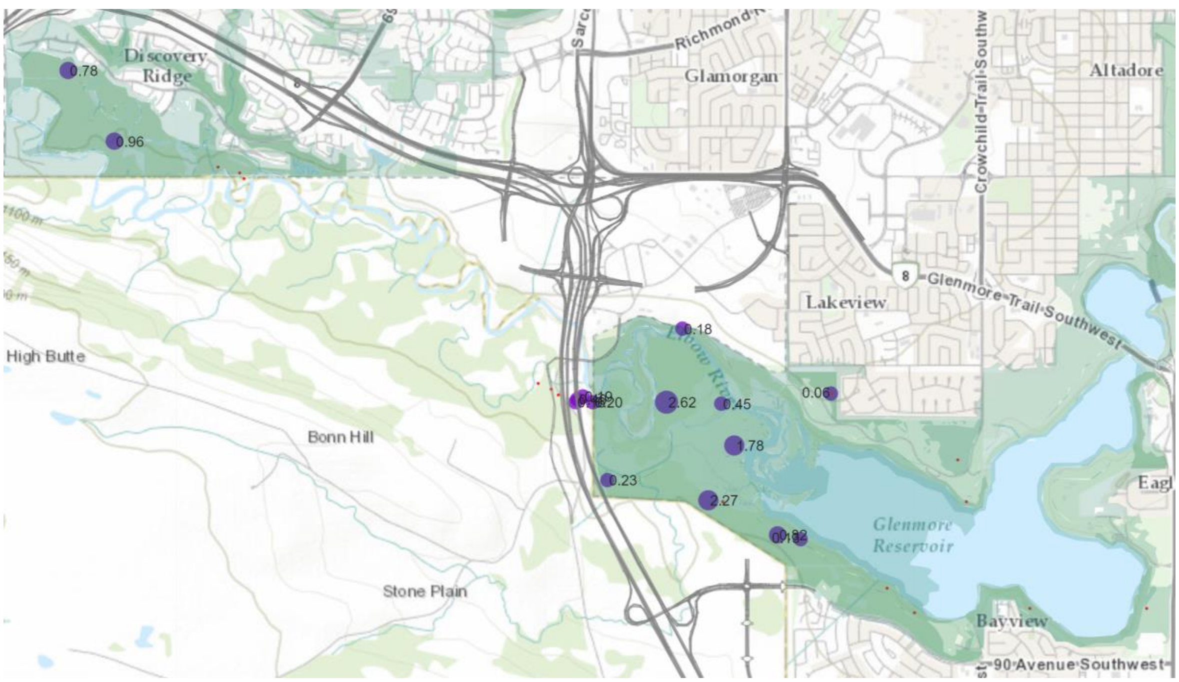


Figure 36: Moose detection rates per 100 camera trap days (ranging from 0.06 to 2.62) in the Weaselhead-Griffith Woods Corridor.

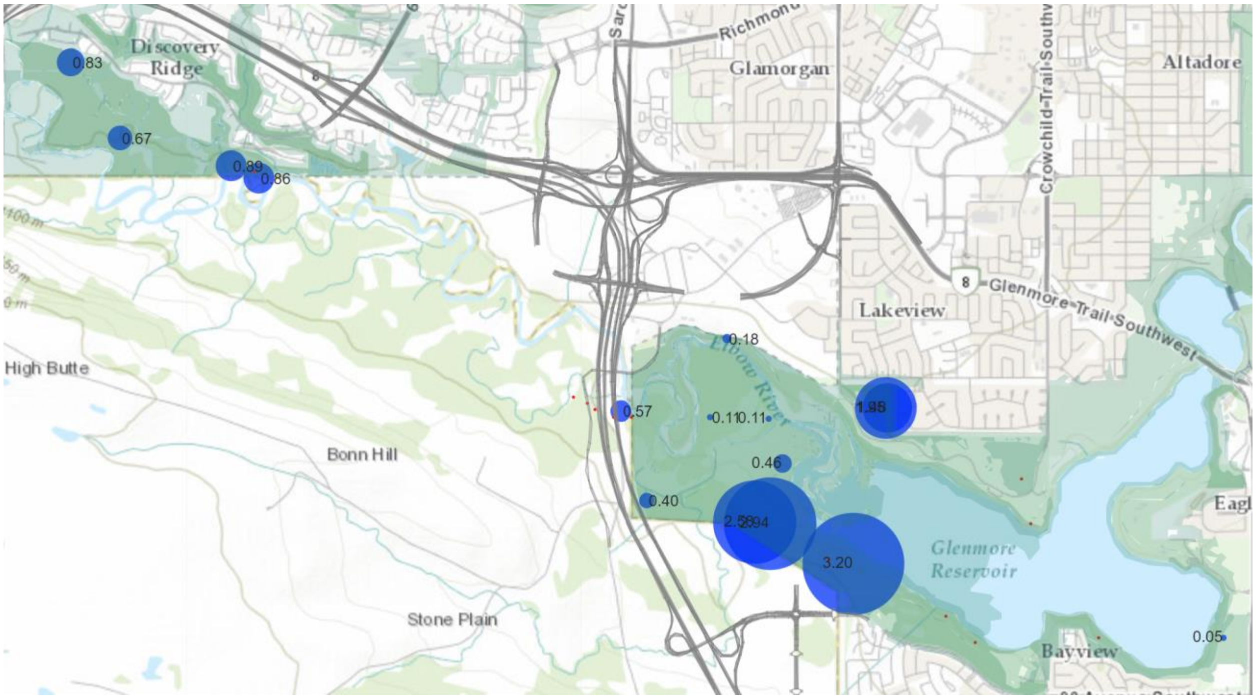


Figure 37: Bobcat detection rates per 100 camera trap days (ranging from 0.10 to 3.20) in the Weaselhead-Griffith Woods Corridor.

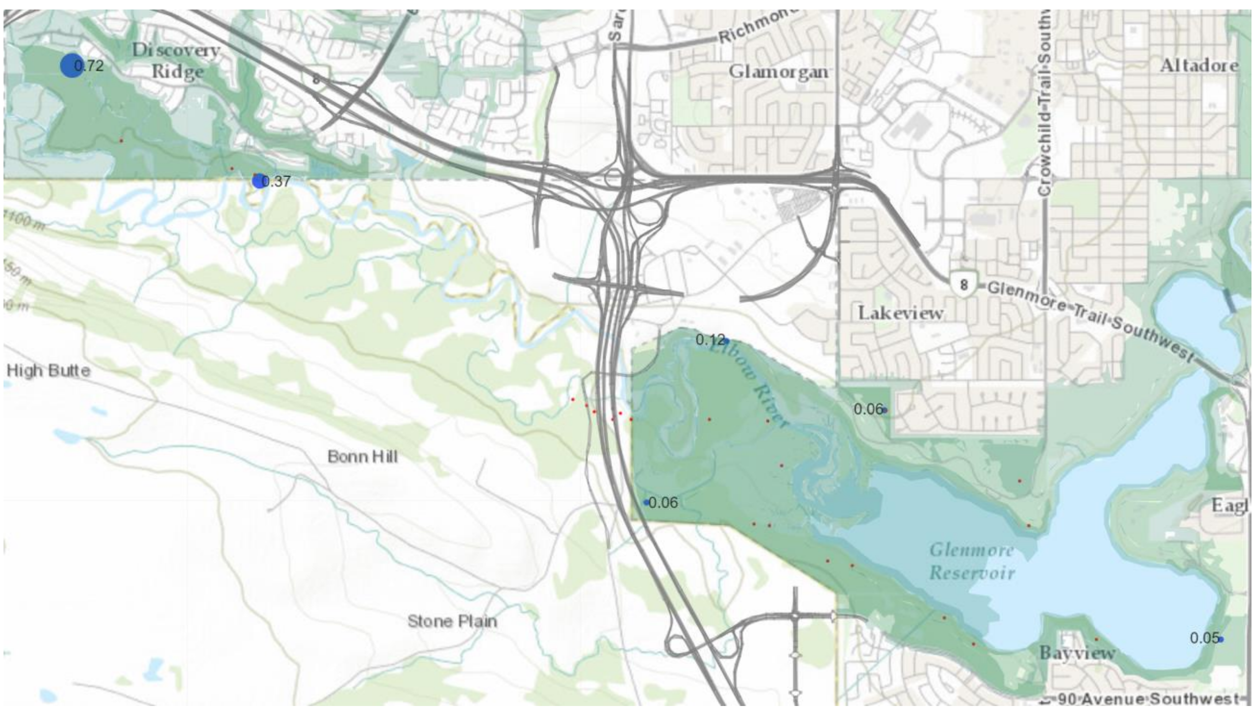


Figure 38: Red fox detection rates per 100 camera trap days (ranging from 0.05 to 0.72) in the Weaselhead-Griffith Woods Corridor.

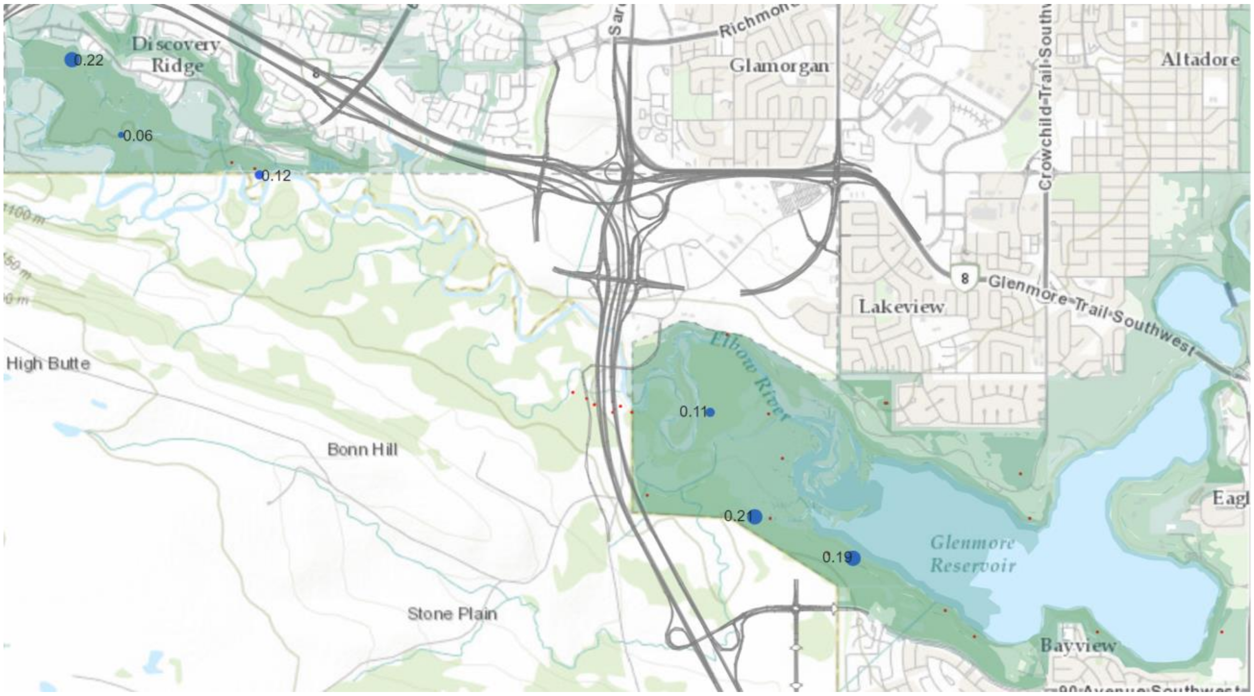


Figure 39: Cougar detection rates per 100 camera trap days (ranging from 0.06 to 0.22) in the Weaselhead-Griffith Woods Corridor.

Road mitigation sites

To understand wildlife use of road mitigation sites (displayed in Figure 40), we examined species detections from cameras placed at road mitigation sites as well as a reference camera located on a trail within 500 m of the road mitigation (Table 3). Coyote, human, domestic dog, mule deer, moose, and white-tailed deer were detected at all three mitigation sites and the reference cameras. All species detected at the Bow South at Deerfoot Trail reference camera were also detected on the associated underpass camera. Bobcat and domestic cat were detected at the Fish Creek at Tsuut'ina Trail reference camera, but not on the associated underpass camera. Bobcat and striped skunk were detected on the Weaselhead/Glenmore at Tsuut'ina Trail reference camera, but not on the underpass camera. We plotted the species detections per 100 camera days at each road mitigation site (Figure 41), removing all species with, on average, fewer than 0.005 detections across all road mitigation sites. We plotted detections of deer (unidentified species), moose, coyote, white-tailed deer, mule deer, and humans per 100 camera-trap days at the three road mitigation sites (Figure 42 – Figure 44). The following species were not detected at any of the road mitigation sites or within 500 m of each site: cougar (although cougar were detected in 2023), badger, black bear, elk, long-tailed weasel, marten, and mink.

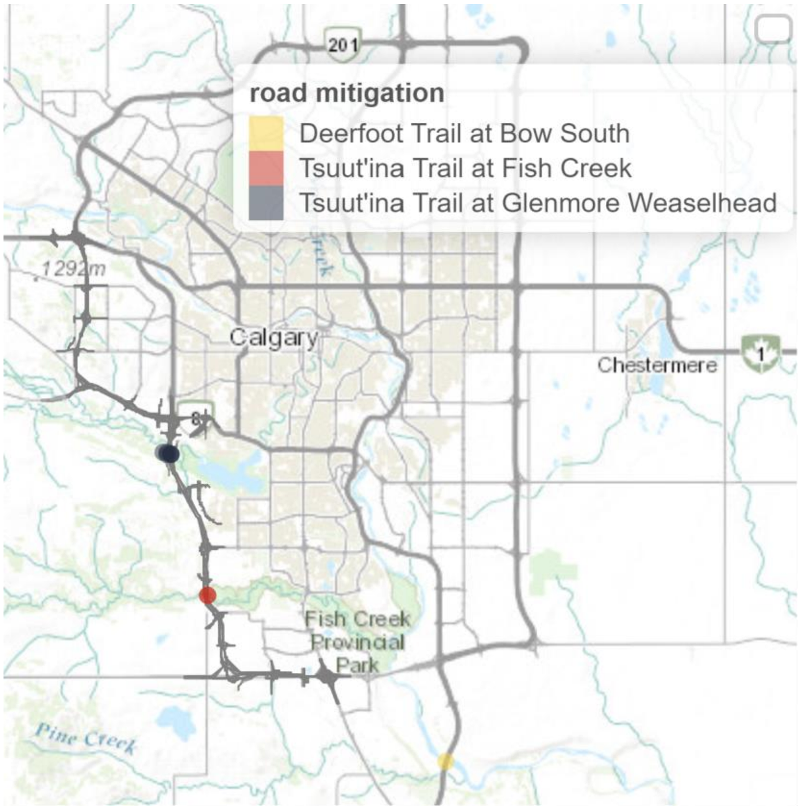


Figure 40: Road mitigation sites in Calgary

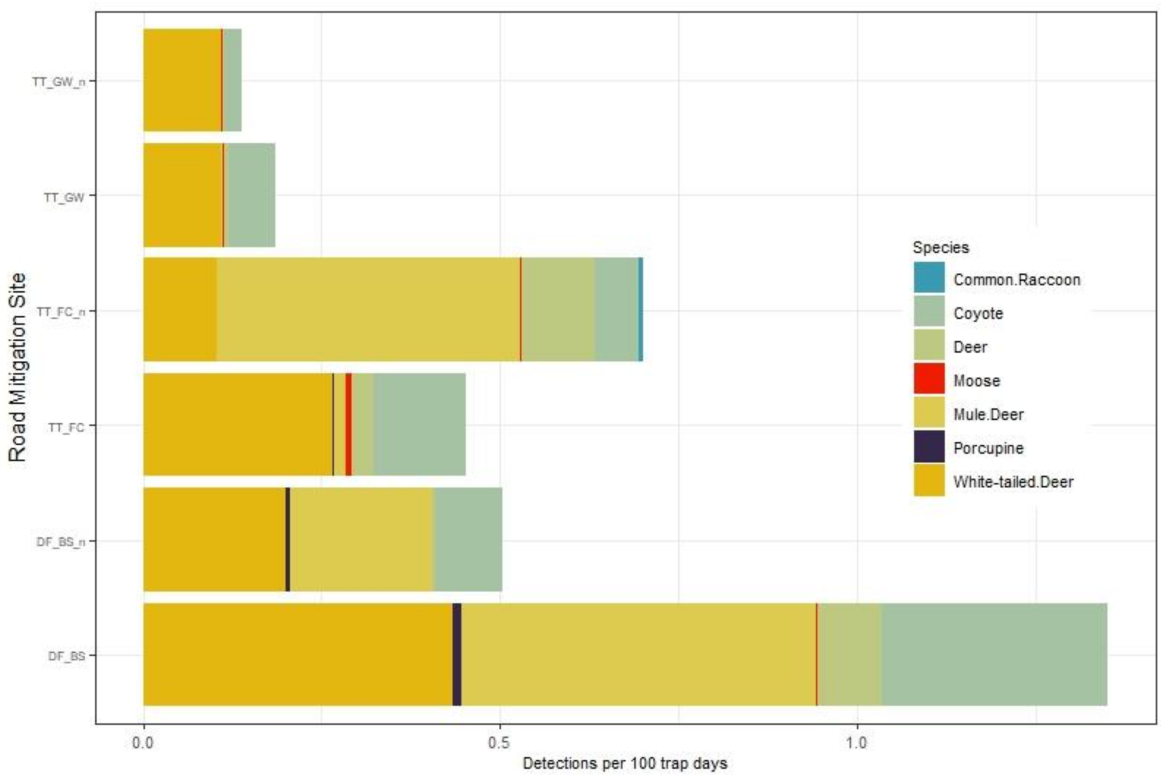


Figure 41: Species detections per 100 camera-trap days at road mitigation sites: Weaselhead/Glenmore at Tsuut'ina (TT_GW), Fish Creek at Tsuut'ina (TT_FC) and Bow South at Deerfoot Trail (DF_BS). "n" represents cameras on trails

within 500 m of a road mitigation camera. Only species with >0.005 detections averaged across sites were included in the plot.

Table 3: Species detections per 100 camera trap days at road mitigation sites and reference trail camera within 500 m.

Species	Bow South at Deer Foot Trail underpass	Bow South at Deer Foot Trail (500m)	Fish Creek at Tsuut'ina Trail underpass	Fish Creek at Tsuut'ina Trail (500m)	Weaselhead Glenmore at Tsuut'ina Trail underpass	Weaselhead Glenmore at Tsuut'ina Trail (500m)
Badger	0	0	0	0	0	0
Beaver	0	0	0	0	0.003	0.005
Black Bear	0	0	0	0	0	0
Bobcat	0	0	0	0.003	0	0.003
Common Raccoon	0.001	0.001	0	0.007	0	0
Cougar	0	0	0	0	0	0
Coyote	0.316	0.093	0.129	0.062	0.066	0.025
Deer	0.091	0.005	0.030	0.102	0.007	0.002
Domestic Cat	0	0	0	0.004	0	0
Domestic Cow	0.002	0.001	0.007	0	0	0
Domestic Horse	0	0	0.002	0.000	0	0
Elk	0	0	0	0	0	0
Human	1.069	1.149	0.699	2.541	0.377	0.224
HumanDogOffLeash	0.554	0.630	0.134	0.256	0.170	0.041
HumanDogOnLeash	0.171	0.119	0.032	0.693	0.004	0.012
HumanNoDog	0.344	0.399	0.533	1.591	0.204	0.172
Long-tailed Weasel	0	0	0	0	0	0
Marten	0	0	0	0	0	0
Mink	0	0	0	0	0.001	0
Moose	0.001	0.001	0.009	0.002	0.001	0.002
Mule Deer	0.497	0.199	0.017	0.425	0.002	0.001
Porcupine	0.013	0.006	0.001	0	0	0
Red Fox	0	0	0	0	0	0
Striped Skunk	0	0	0	0	0	0.0009
Weasels and Ermine	0	0	0	0	0	0
White-tailed Deer	0.434	0.199	0.266	0.103	0.110	0.109

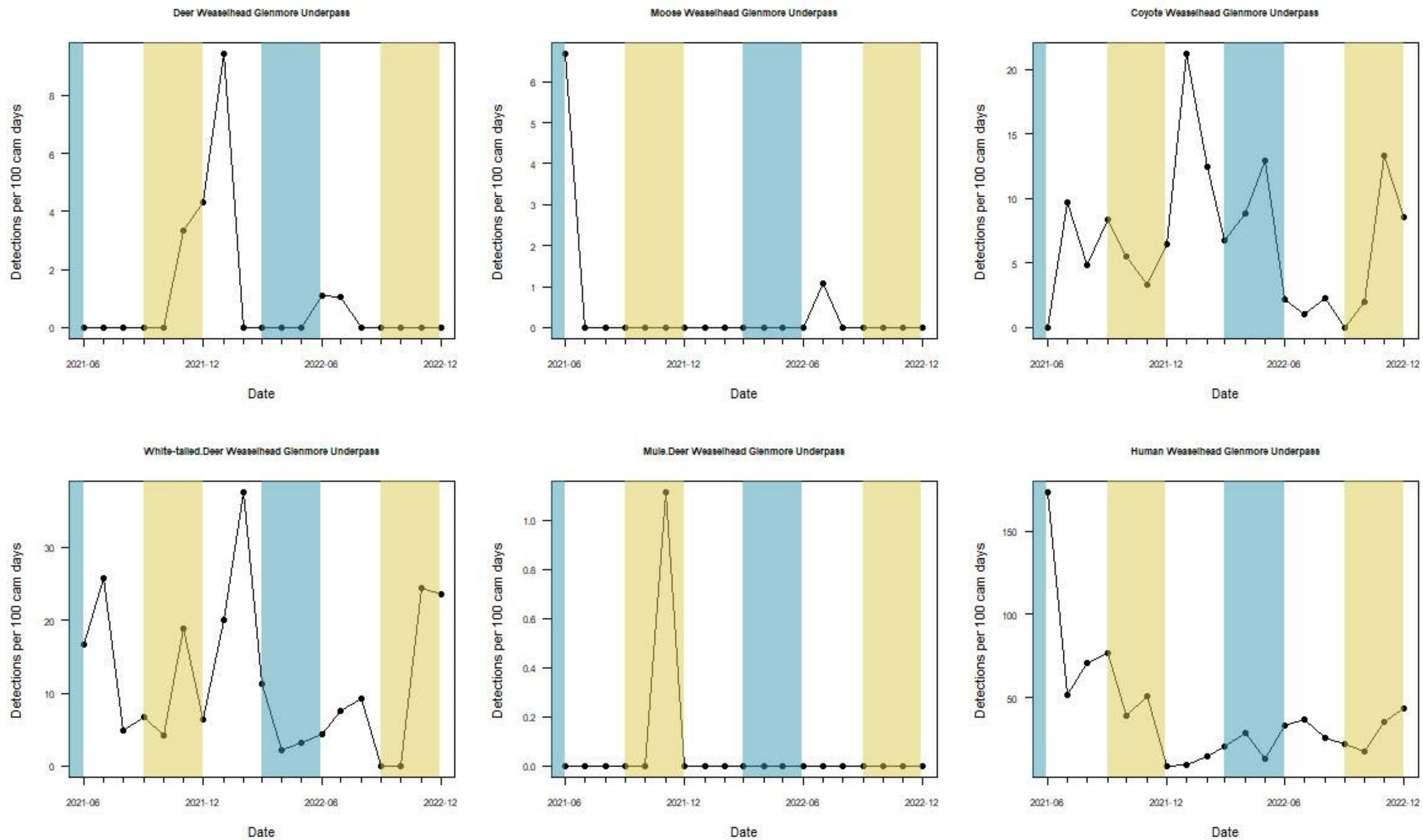


Figure 42: Temporal plots of deer (of unidentified species), moose, coyote, white-tailed deer, mule deer, and human detections per 100 camera-trap days at Weaselhead/Glenmore at Tsuut'ina Trail underpass. Spring months are highlighted in blue and fall months are highlighted in yellow.

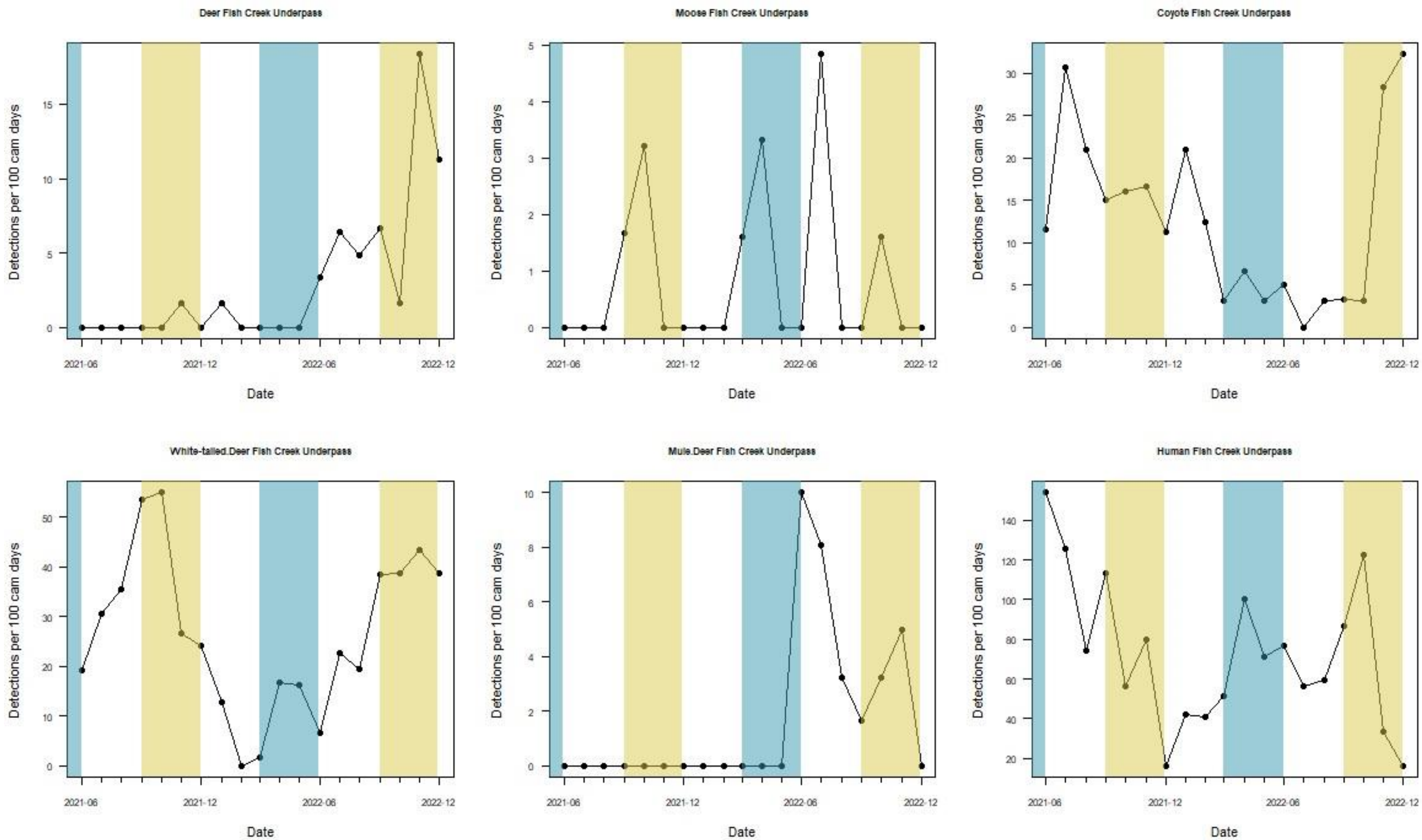


Figure 43: Temporal plots of deer (of unidentified species), moose, coyote, white-tailed deer, mule deer, and human detections per 100 camera-trap days at Fish Creek Tsuut'ina underpass. Spring months are highlighted in blue and fall months are highlighted in yellow.

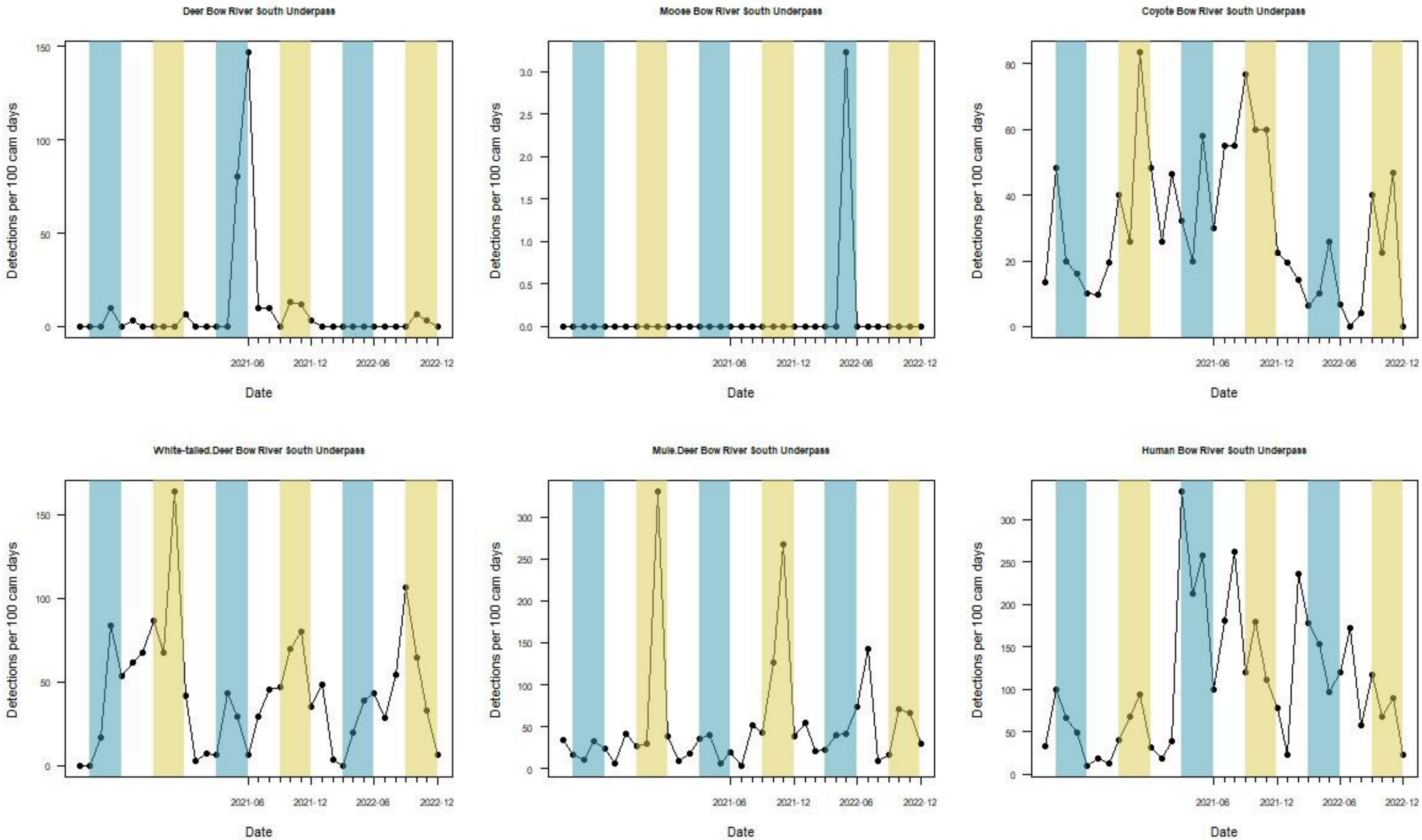


Figure 44: Temporal plots of deer (of unidentified species), moose, coyote, white-tailed deer, mule deer and human detections per 100 camera-trap days at Bow River South underpass. Spring months are highlighted in blue and fall months are highlighted in yellow.

Discussion

What mammals use parks in Calgary?

Parks, and Calgary's ecological network, support a diversity wildlife, including many medium- to large-sized mammals. Unsurprisingly, as recreational areas for urban residents, the most common visitors to these sites are people and their pet dogs; people outnumber wildlife in Calgary's ecological network by a factor of four. Nevertheless, this unbalance is notable given that it was detected by cameras set up on lower human-use and game trails. Managing these areas for the successful coexistence of people and wildlife is a key to their success.

The distribution of wildlife in Calgary can be described along a continuum from species that normally avoid urban areas, to utilizers, all the way to dwellers (Fischer et al., 2015). Fischer et al. (2015) describes urban avoiders as species that rarely occur in urban areas. Avoiders may persist in natural areas embedded in urban landscapes depending on the size, shape, number, configuration, quality, and connectivity of natural areas in the urban matrix. Urban utilizers are those wildlife species that tend to be more tolerant of urbanization and people, and formally defined as species that are nonbreeding or breeding where persistence is tied to dispersal from embedded natural areas[1]. Urban dwellers persist independently of natural areas, such as squirrels or mice that maintain robust and growing populations entirely within an urban setting.

In Calgary, cougar, black bear, and elk are urban avoiders. These species were not detected in all five years of the study and detections for all these species were associated with larger natural areas that are connected to the non-urbanized landscape, such as Fish Creek Provincial Park, Griffith Woods, Weaselhead Glenmore or Haskayne Park. Moose were detected in low numbers compared to deer on the western edge of the city where natural areas are connected to neighbouring, less urbanized, jurisdictions. Moose are situated on the gradient between avoider to utilizer.

White-tailed deer, coyote and mule deer were the most common wildlife species detected on cameras and were detected at all sites. These species are urban utilizers and are tied to natural areas. Bobcat, red fox, porcupine, striped skunk, and racoon could also be considered urban utilizers with detections in smaller parks closer to the city center without connected to the non-urbanized jurisdictions. Some of these species, such as racoon and striped skunk, could be situated on the gradient between utilizer to dweller.

When do mammals use the Parks?

Daily activity patterns indicate humans are most active from noon to 5:00 pm. All wildlife species had lower activity during peak human activity. Both deer species were active at dusk and dawn, while moose had higher levels of activity before noon, and from 6:00 pm to dusk. All carnivore species exhibited crepuscular to nocturnal activity. Coyote were also active during the day but with lower activity during peak human activity.

Does human activity affect wildlife activity?

To better understand species specific reactions to human activity, we focused on temporal displacement by running an overlap analysis that measured the diel overlap in activity between a

[1] Natural areas are defined broadly as open spaces such as parks, golf courses, and environmental reserves.

specific wildlife species and humans. We also calculated avoidance attraction ratios to assess wildlife responses to human presence as time (days) between detections.

We found moose to have the highest levels of overlap with human activity compared to all other species, with 49% of their daily activity overlapping with people. An overlap model of diel patterns for moose based on low and high human detections indicated moose are altering diel activity patterns during peak human activity in urban natural areas. In areas with higher human activity, moose are less active during daylight hours and shift activity to evening and nighttime hours (7:00 pm –2:00 am), and in the morning (6:00 am – 9:00 am). Moose are shifting their activity to avoid peak human activity in areas that experience ahigh human visitation.

Furthermore, avoidance attraction analyses determined that moose are temporally avoiding human activity, with a longer time interval between moose detections when people are detected in between. We found that moose activity can be displaced by days due to human activity. This highlights that even if the habitat is appropriate and moose are able to move to natural areas, they can be displaced by people. Moose are likely using two strategies to avoid human activity — shifting diel patterns and/or shifting away from the camera site for a period of time (days).

Bobcat experience moderate levels of overlap with human activity compared to other species, with 30% of their daily activity overlapping with people. Bobcat are detected more commonly on cameras away from the edge of the city but to the east of Deetfoot Trail. Bobcat are urban adapters, and may be able to use areas with higher human activity because they are shifting their diel patterns to avoid peak human activity. In areas with higher human activity, bobcats are less active during peak human activity and shift activity to evening and nighttime hours (8:00 pm – 8:00 am). Furthermore, avoidance attraction analysis determined that bobcat are temporally avoiding areas with high levels of human activity, with a longer time interval (days) between bobcat detections when human visits are frequent. However, there are likely other interactions with cougar and coyote that are influencing bobcat distribution that we have not analyzed.

Red fox have low level of overlap with people compared to other species with only 12% of their daily activity overlapping with humans. Red fox are considered urban adapters, perhaps due to their crepuscular and nocturnal activity patterns enabling them to avoid peak human activity. In addition, red fox had the strongest avoidance attraction ratio, indicating human detections on cameras result in temporal avoidance of the area for a number of days.

Mule deer, one of the most common wildlife species in Calgary, spend 46% of their daily activity in overlap with human activities. We did not detect a significant difference in mule deer daily activity between low and high human-use cameras. Despite this, mule deer did exhibit avoidance of activity after a human detection on the landscape.

These findings demonstrate that wildlife are avoiding areas (days at a time when humans are most active) or are adjusting daily temporal patterns to use parks when humans are less active.

Which areas have high off-leash dog events?

People with domestic dogs are prevalent throughout Calgary's parks, with the exception of Inglewood. A key finding was that 72% of domestic dog detections occur off-leash in on-leash areas. Weaselhead/Glenmore and Fish Creek Provincial Park have no designated off-leash areas but we detected significant numbers of people with off-leash dogs in both of these areas. In parks where both on-leash and off-leash areas are available (Nose Hill, Bowmont, and Edworthy) off-leash dogs were detected in designated on-leash areas. These findings, along with the sensitivity of wildlife to dogs (as indicated by overlap results), highlight management and educational outreach are needed to improve compliance with off-leash dogs.

Are wildlife using ecological corridors?

Five years of camera analysis demonstrates that a variety of wildlife is using Calgary's ecological corridors. Medium- to large-sized mammals were found in all three corridors with species including mule deer, white-tailed deer, moose, coyote, and bobcat being found in all corridors across all years. Other species including striped skunk, porcupine, raccoon, red fox, and cougar are detected in multiple years but not across all corridors. While wildlife can be found in all corridors, their movement is significantly affected by the presence of human activity. Species such as moose and coyote have more overlap with humans than other species (e.g., cougar, red fox) but all species are temporally and/or spatially separating themselves from humans, with higher human use having a more significant effect. Nevertheless, human presence in parks is not the only anthropogenic activity affecting the movement of wildlife in Calgary; large roads (Deerfoot Trail, Stoney Trail) present barriers for wildlife movement in and out of the city.

Is the road mitigation working?

Wildlife were detected on cameras in all three road mitigation sites indicating that the underpasses at these sites are facilitating some wildlife movement. Several species were detected at all mitigation sites as well as reference cameras 500 m from the road. These included mule deer, white-tailed deer, moose, and coyote. Common raccoon, porcupine, and mink were all detected using at least one of the mitigation sites. While this is promising for wildlife movement generally, some species like bobcat and striped skunk, were detected on the reference cameras but not at the mitigation sites. Mitigations may not be equally effective for all species. While we cannot compare activity rates across the three mitigation sites due to differing lengths of monitoring, the Bow River South at Deerfoot Trail site has the same species present on the reference cameras and the underpass cameras suggesting that these species are using the underpass like nearby habitat.

Recommendations

Data collected from five years of camera monitoring in Calgary parks and ecological corridors have helped inform which wildlife are present in the city, where wildlife move through natural areas and how wildlife respond to human activity. The results presented in this report lead to the following recommendations:

- City Council and Administration support the maintenance of the ecological network published in the Municipal Development Plan with particular emphasis on retaining corridors that connect the City of Calgary to the surrounding area. Supporting these corridors for wildlife movement will require collaboration with neighbouring jurisdictions.
- While the inclusion of the ecological network in the Municipal Development Plan is a positive step towards acknowledging ecological connectivity in the urban environment, it needs to be integrated into development decisions. Prior final development plan approvals, a review of affects to the ecological network should be considered.
- Road mitigation sites around large volume roads support wildlife movement in and out of the city; however, their benefit and use can be improved. Suggestions for increasing their use include:
    - Add and maintain vegetative cover to create a more seamless habitat corridor across roadways.

    - Manage human and domestic dog use around mitigation sites. Fish Creek at Stoney Trail and Bow River South at Deerfoot Trail both had more humans and humans with dogs than wildlife.
    - Mitigate wildlife movement along corridors that they currently use. Stoney Trail currently has mitigation sites at two wildlife corridors on the west end of the city: along Fish Creek and the Elbow River in the Weaselhead. However, there are no wildlife mitigation sites currently along Stoney Trail in the northwest corridor, nor on more central roads such as Crowchild Trail or Glenmore Trail.
- Our results can be used to inform management and for public education to foster human-wildlife coexistence. Effective messaging regarding bear, coyote, bobcat, moose, and cougar can keep humans, their dogs, and wildlife safe.

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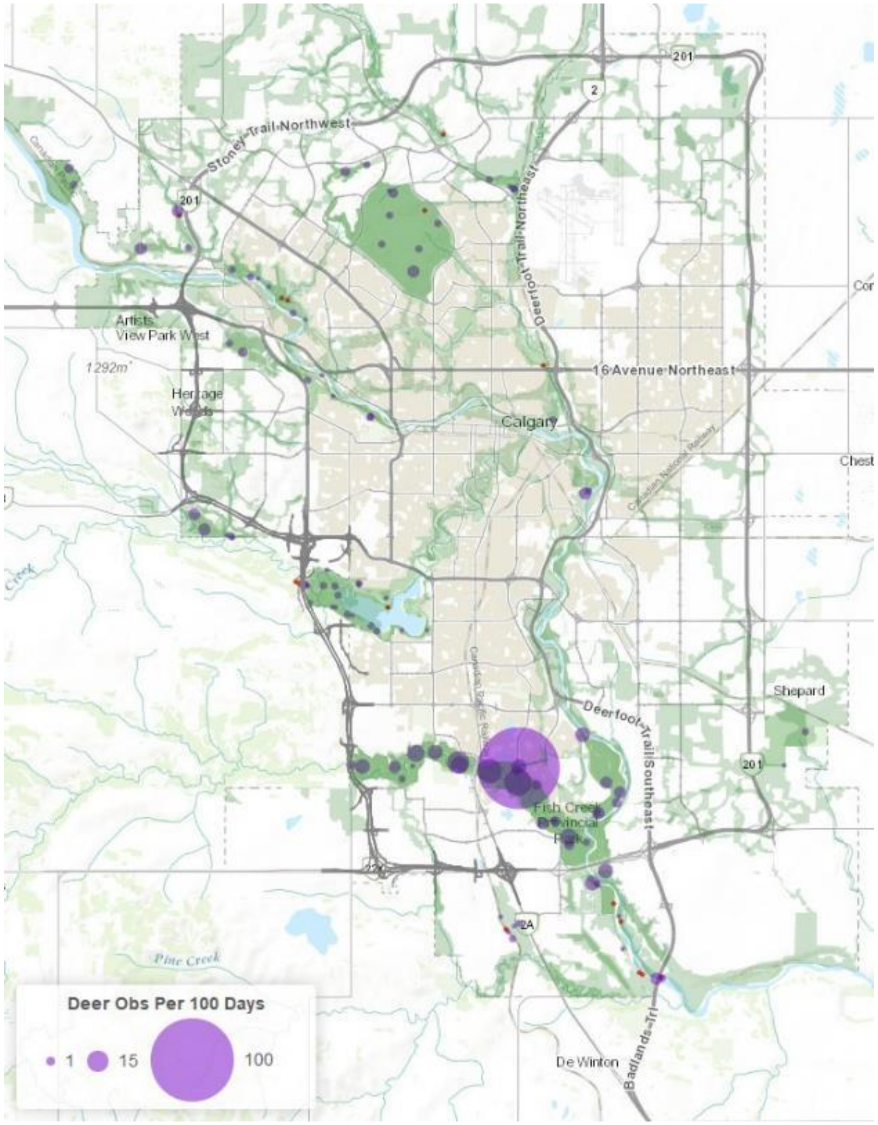
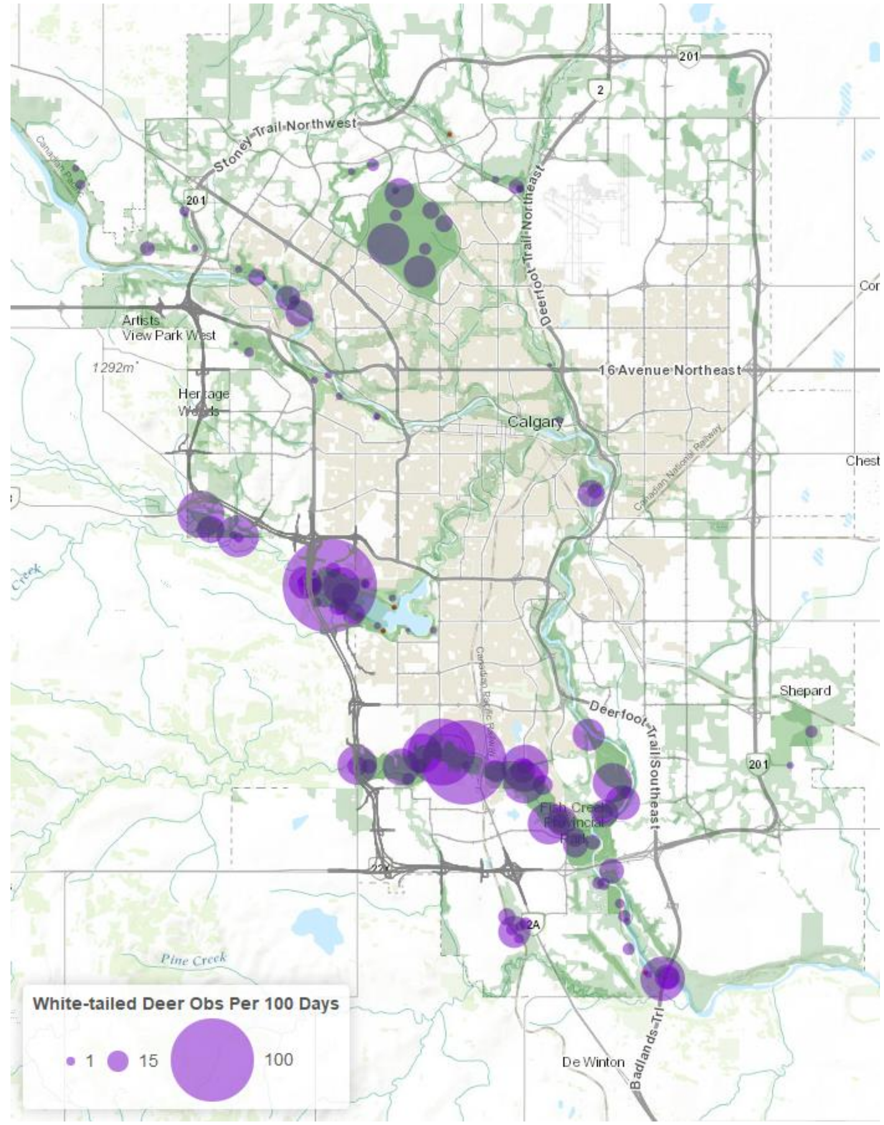
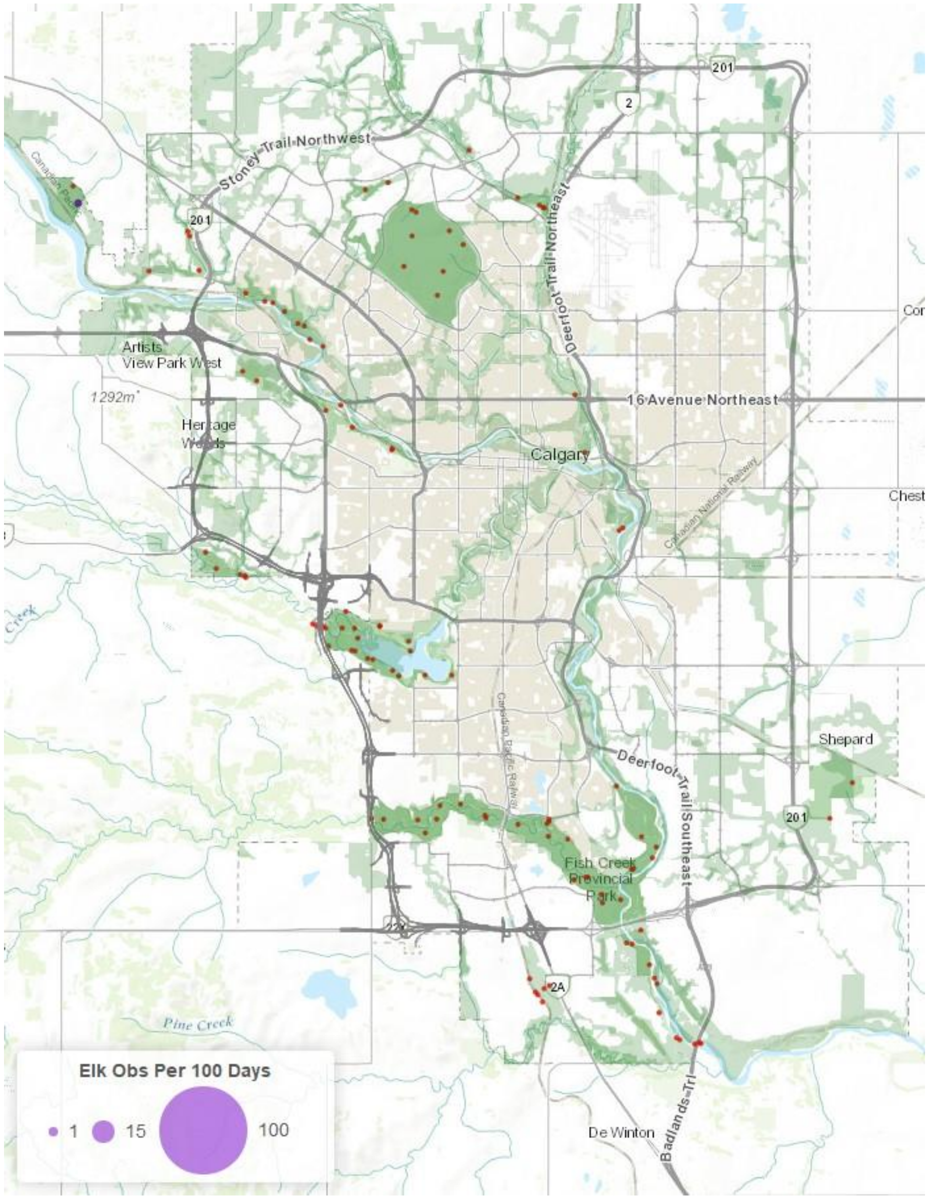
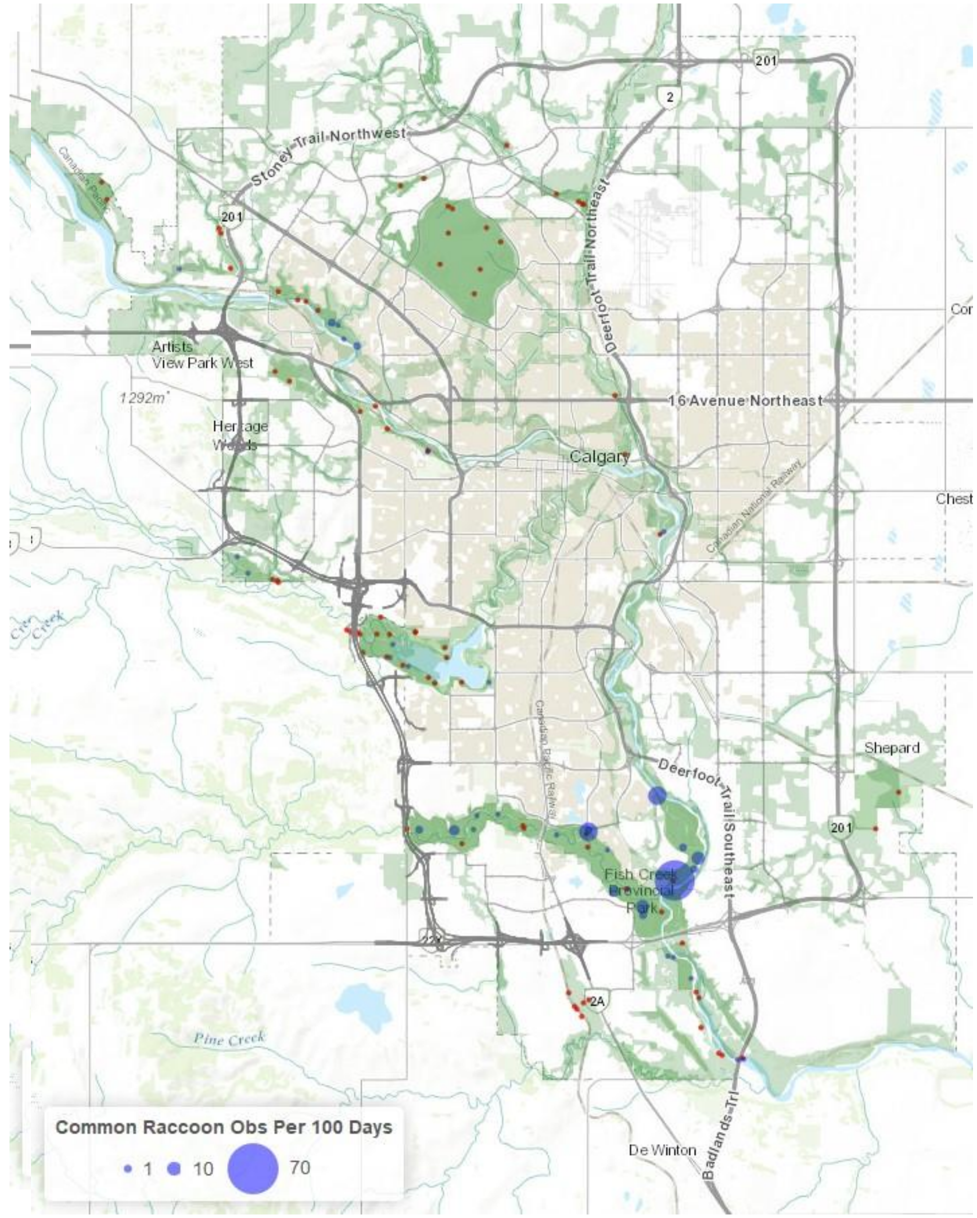
Appendix A: Spatial Activity Maps by Species

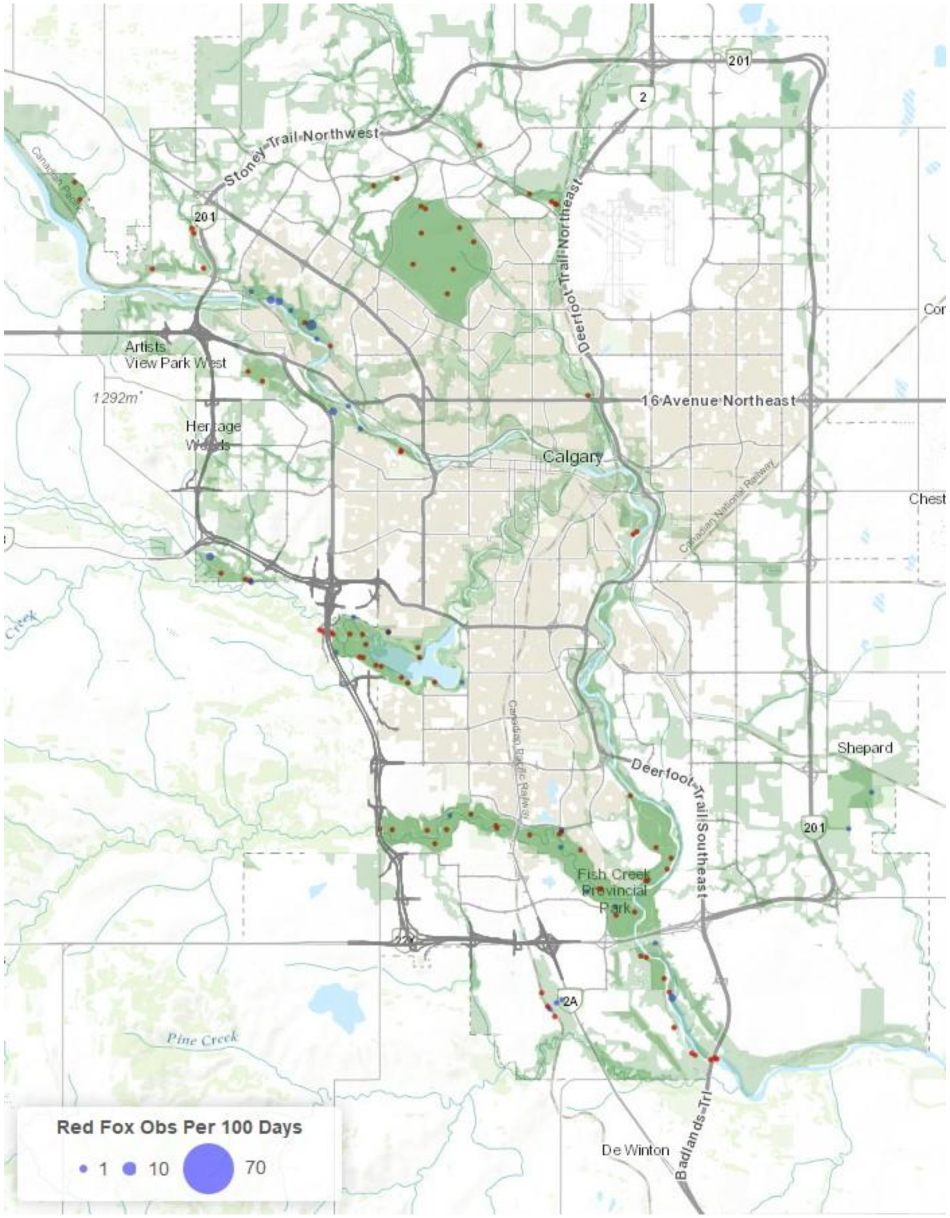
The following spatial activity maps plot the dot pattern of daily events per 100 camera trap days. Red dots indicate no detection of the species. The ecological network is displayed in green. Maps were scaled based on maximum daily events within the carnivore/rodent species (blue) and ungulate (purple) species groups to enable comparison of species in each category.

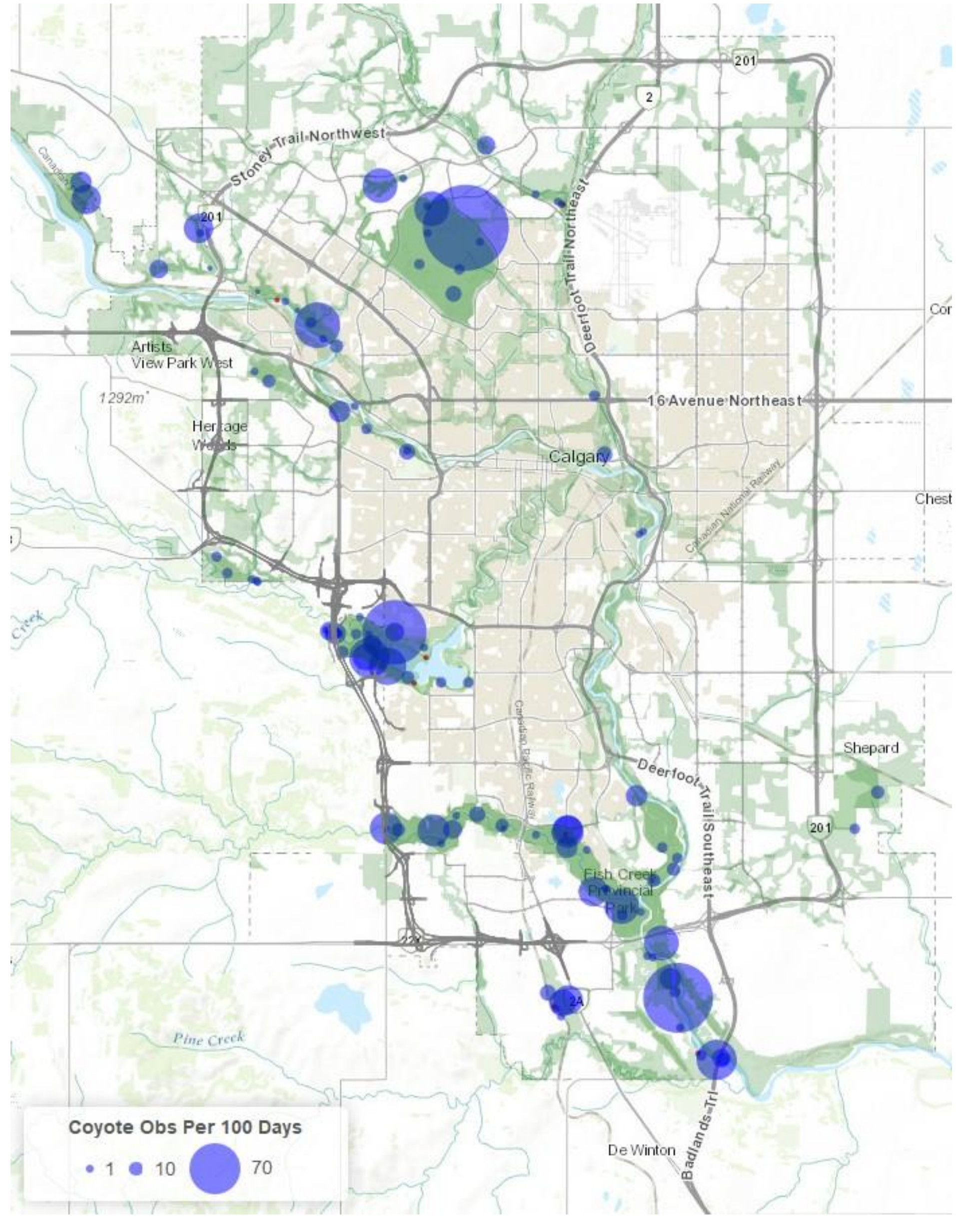


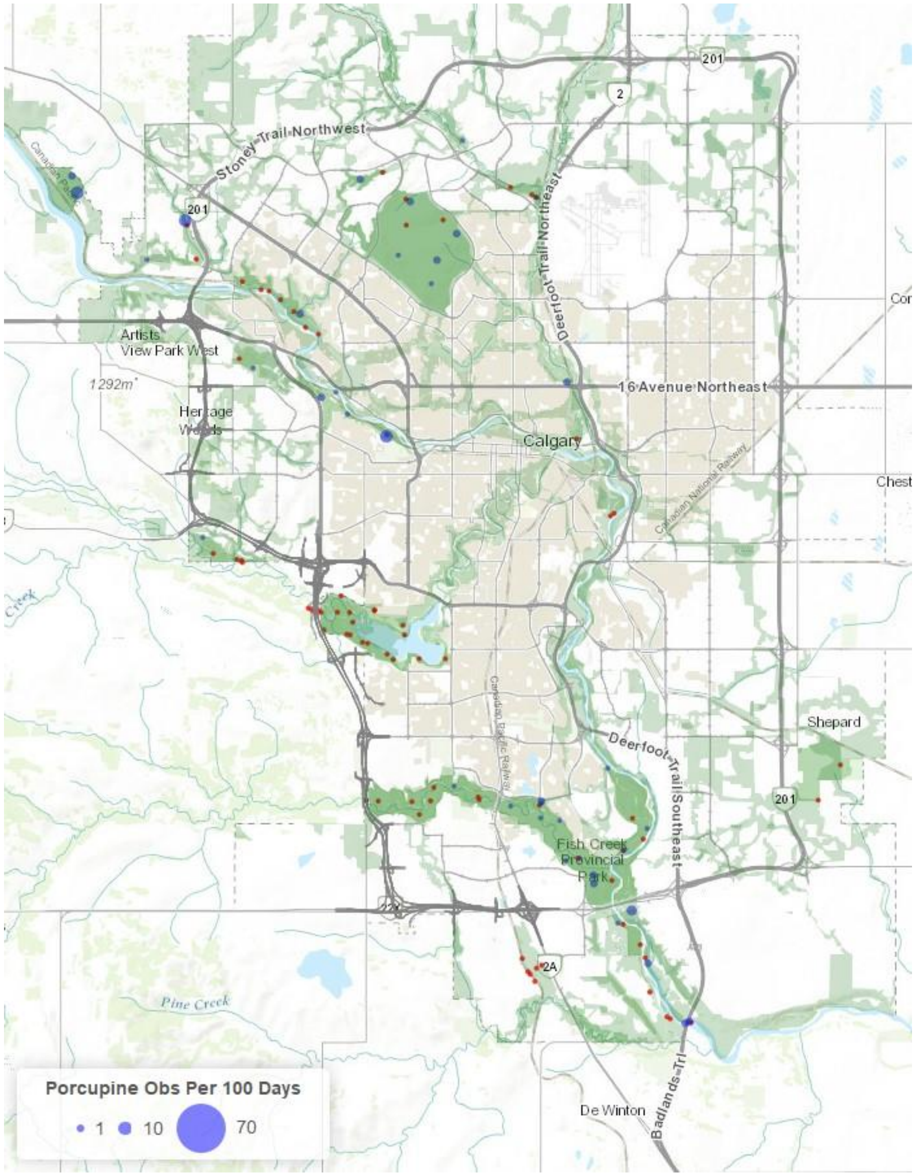



Elk Obs Per 100 Days
1
15
100
Stoney Trail Northwest
Deerfoot Trail Northeast
16 Avenue Northeast
Calgary
Artists View Park West
Heritage Woods
Shepard
Fish Creek Provincial Park
Deerfoot Trail Southeast
Badlands Trl
De Winton
Pine Creek
1292m
201
2
2A

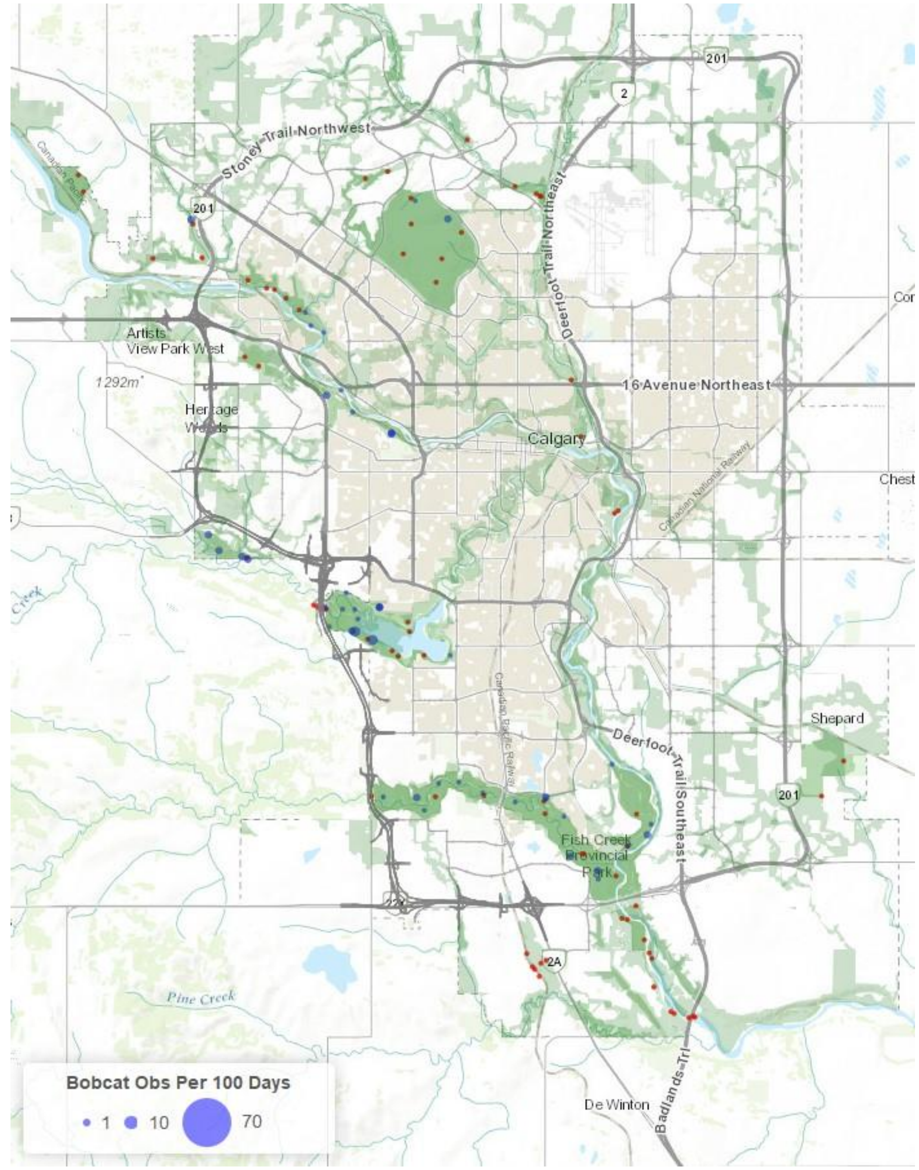

Common Raccoon Obs Per 100 Days
1
10
70
Stoney Trail Northwest
Deerfoot Trail Northeast
16 Avenue Northeast
Calgary
Artists View Park West
Heritage Woods
Shepard
Fish Creek Provincial Park
Deerfoot Trail Southeast
Badlands Trl
De Winton
Pine Creek
1292m
201
2
2A


Stoney Trail Northwest
201
2
Deerfoot Trail Northeast
Artists View Park West
1292m
Heritage Woods
16 Avenue Northeast
Calgary
Canadian National Railway
Chest
Shepard
Deerfoot Trail Southeast
Fish Creek Provincial Park
201
22X
2A
Pine Creek
De Winton
Badlands Trl
Red Fox Obs Per 100 Days
1
10
70

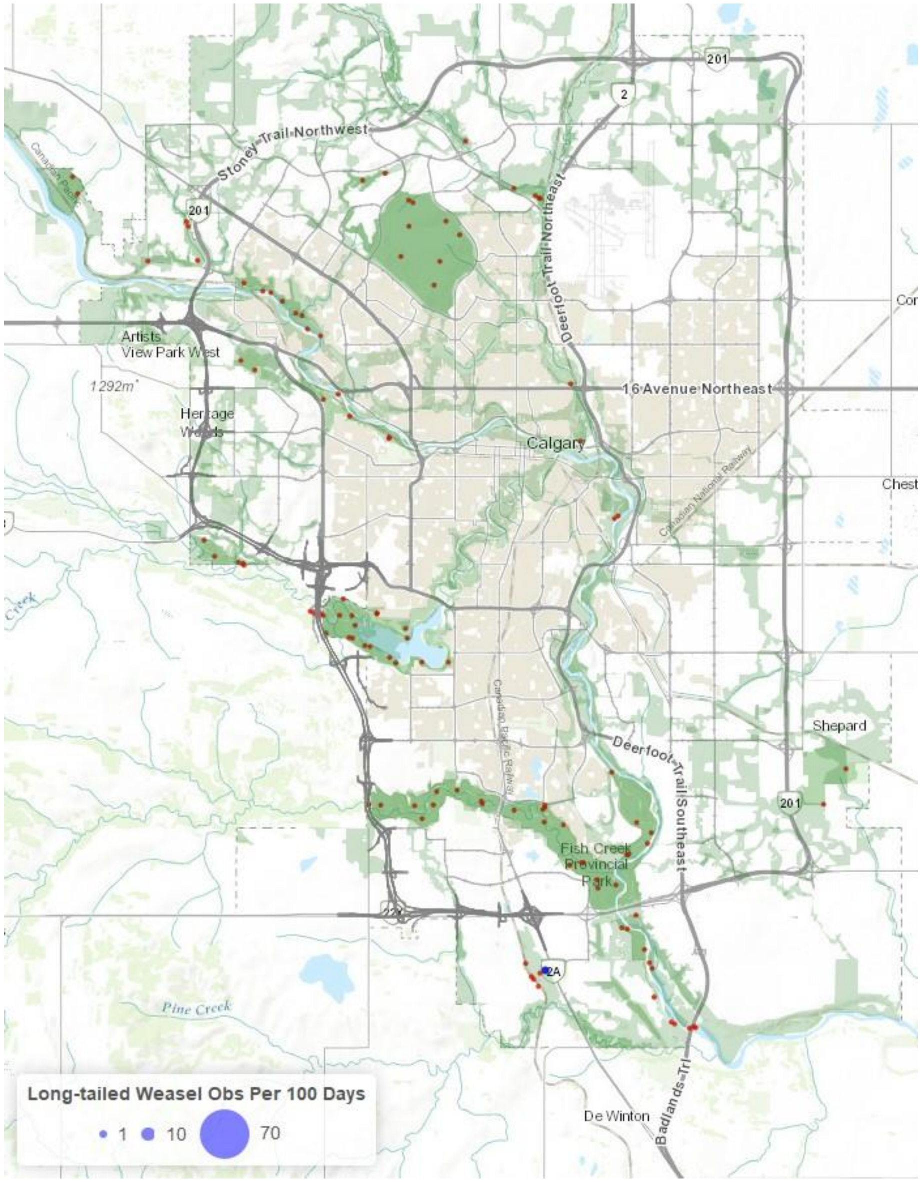

Stoney Trail Northwest
201
2
Deerfoot Trail Northeast
Artists View Park West
1292m
Heritage Woods
16 Avenue Northeast
Calgary
Canadian National Railway
Chest
Shepard
Deerfoot Trail Southeast
Fish Creek Provincial Park
201
22X
2A
Pine Creek
De Winton
Badlands Trl
Coyote Obs Per 100 Days
1
10
70

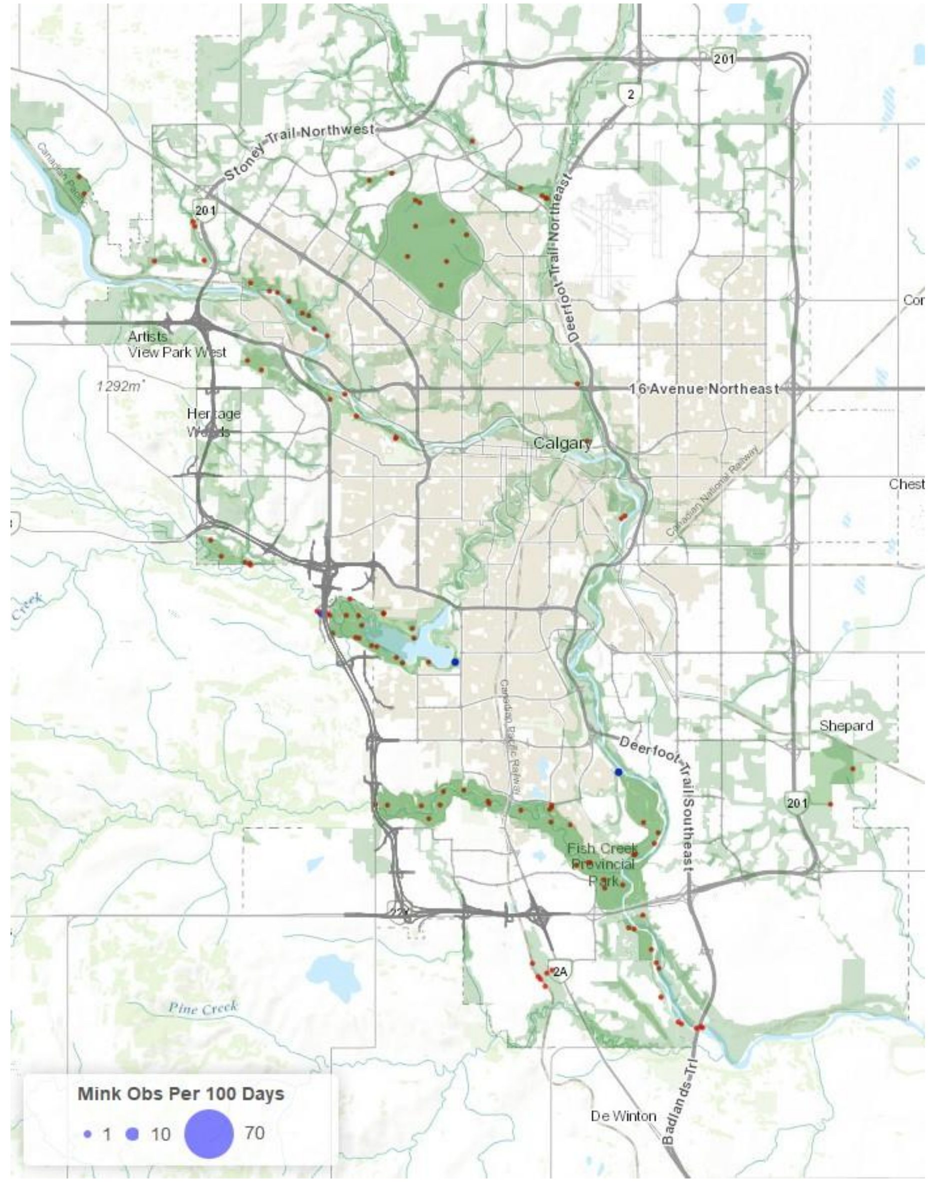


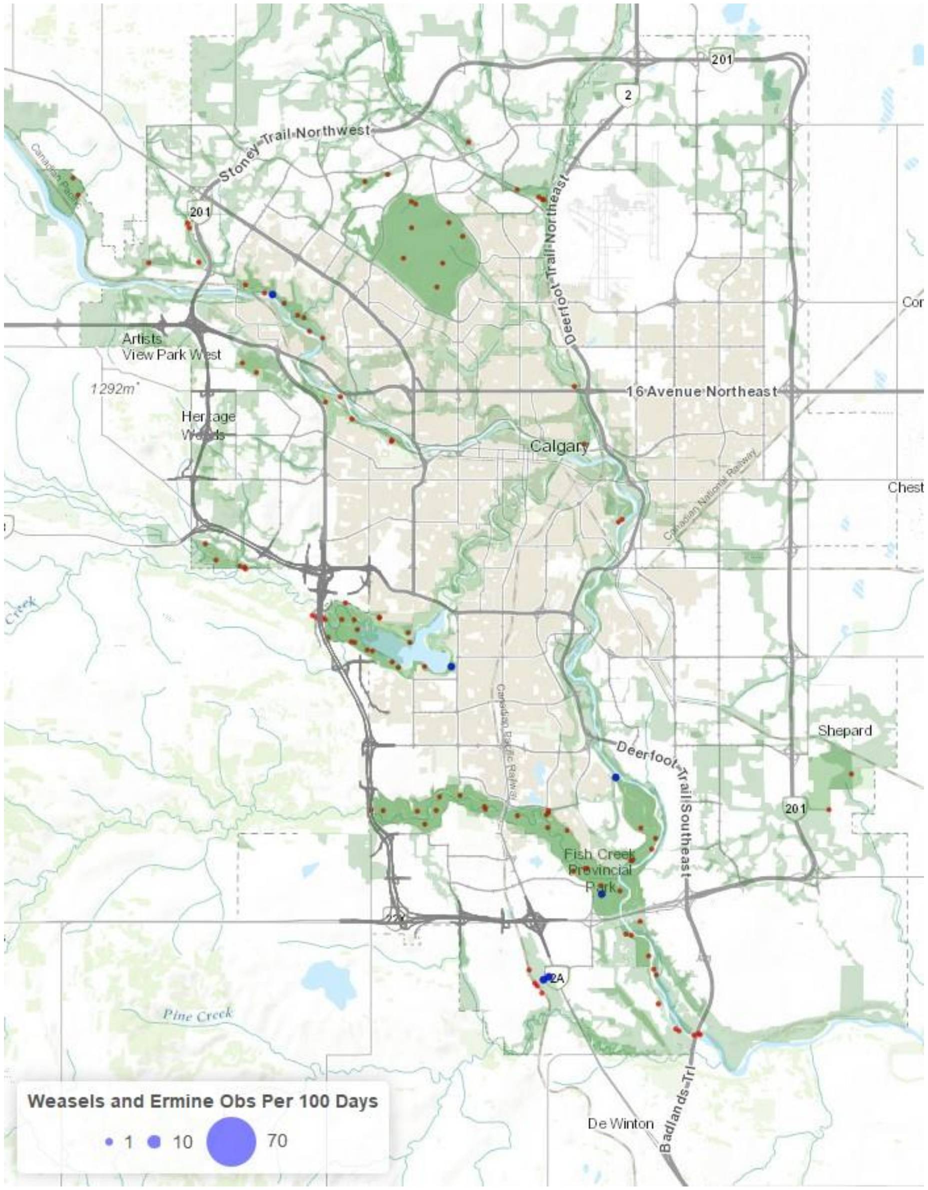
Stoney Trail Northwest
201
2
Deerfoot Trail Northeast
Artists View Park West
1292m
Heritage Woods
16 Avenue Northeast
Calgary
Canadian National Railway
Chest
Shepard
Deerfoot Trail Southeast
201
Fish Creek Provincial Park
2A
Pine Creek
De Winton
Badlands Trl
Porcupine Obs Per 100 Days
1
10
70



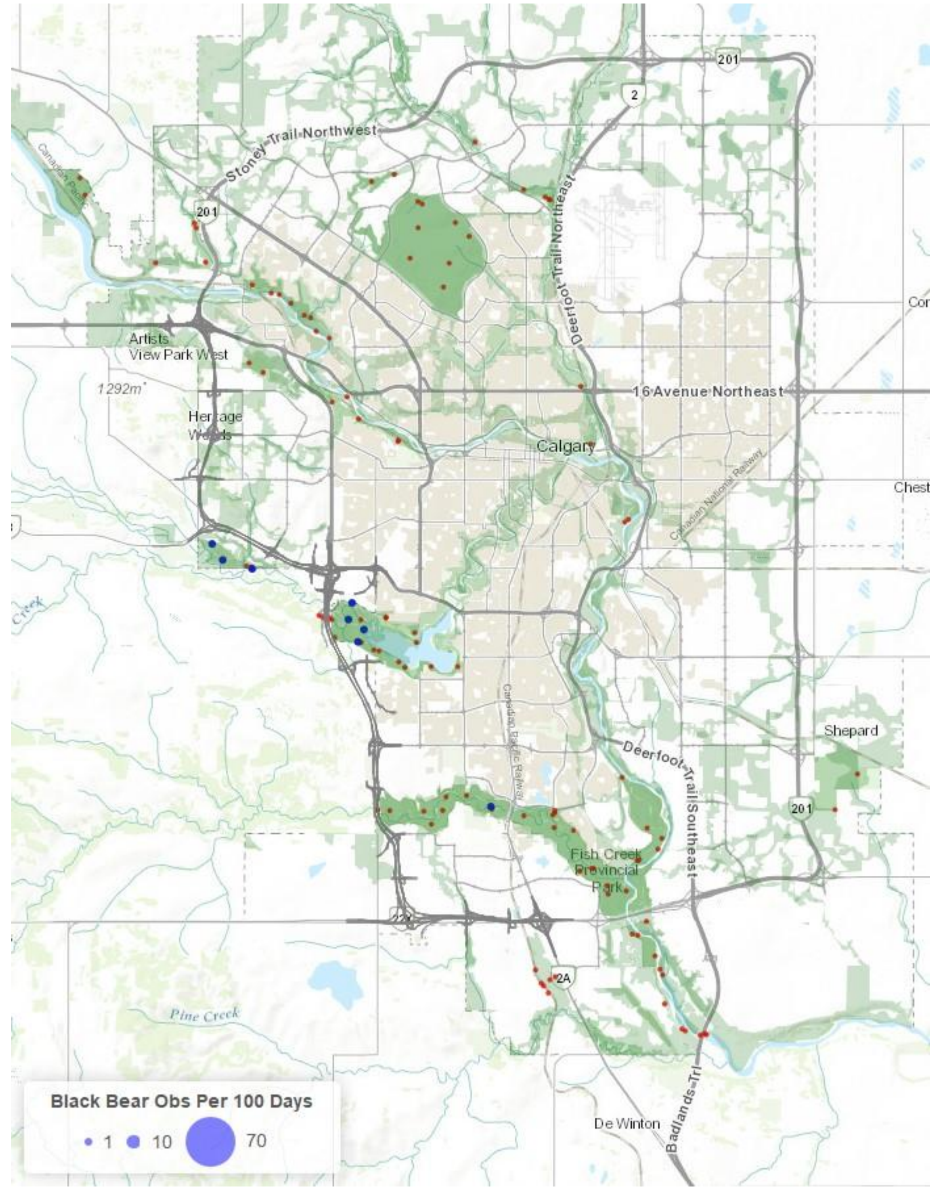
Stoney Trail Northwest
201
2
Deerfoot Trail Northeast
Artists View Park West
1292m
Heritage Woods
16 Avenue Northeast
Calgary
Canadian National Railway
Chest
Shepard
Deerfoot Trail Southeast
201
Fish Creek Provincial Park
2A
Pine Creek
De Winton
Badlands Trl
Bobcat Obs Per 100 Days
1
10
70


Long-tailed Weasel Obs Per 100 Days
1
10
70
Stoney Trail Northwest
Deerfoot Trail Northeast
16 Avenue Northeast
Calgary
Artists View Park West
Heritage Woods
Shepard
Fish Creek Provincial Park
Deerfoot Trail Southeast
Pine Creek
De Winton
Badlands Trl
Chest

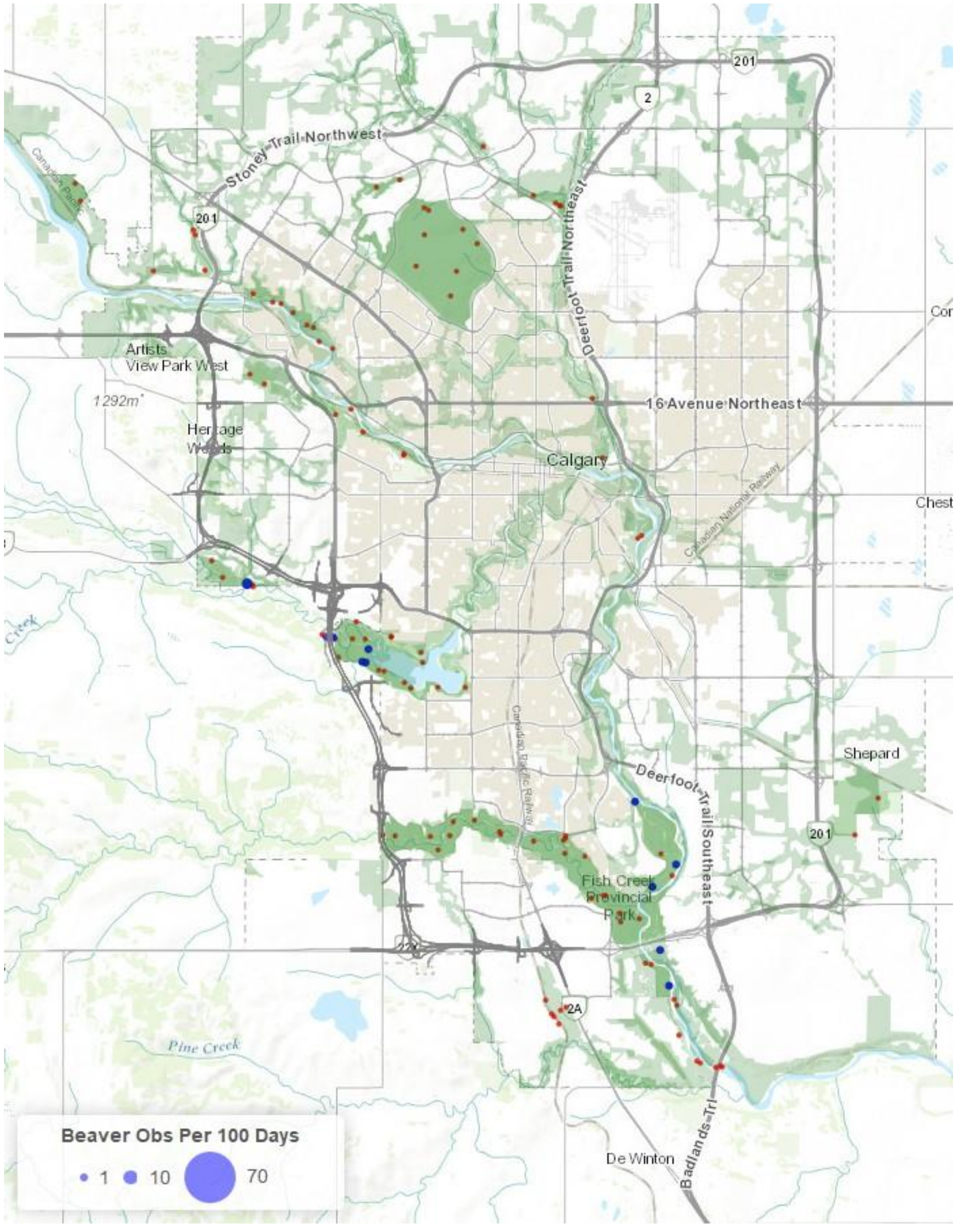

Mink Obs Per 100 Days
1
10
70
Stoney Trail Northwest
Deerfoot Trail Northeast
16 Avenue Northeast
Calgary
Artists View Park West
Heritage Woods
Shepard
Fish Creek Provincial Park
Deerfoot Trail Southeast
Pine Creek
De Winton
Badlands Trl
Chest

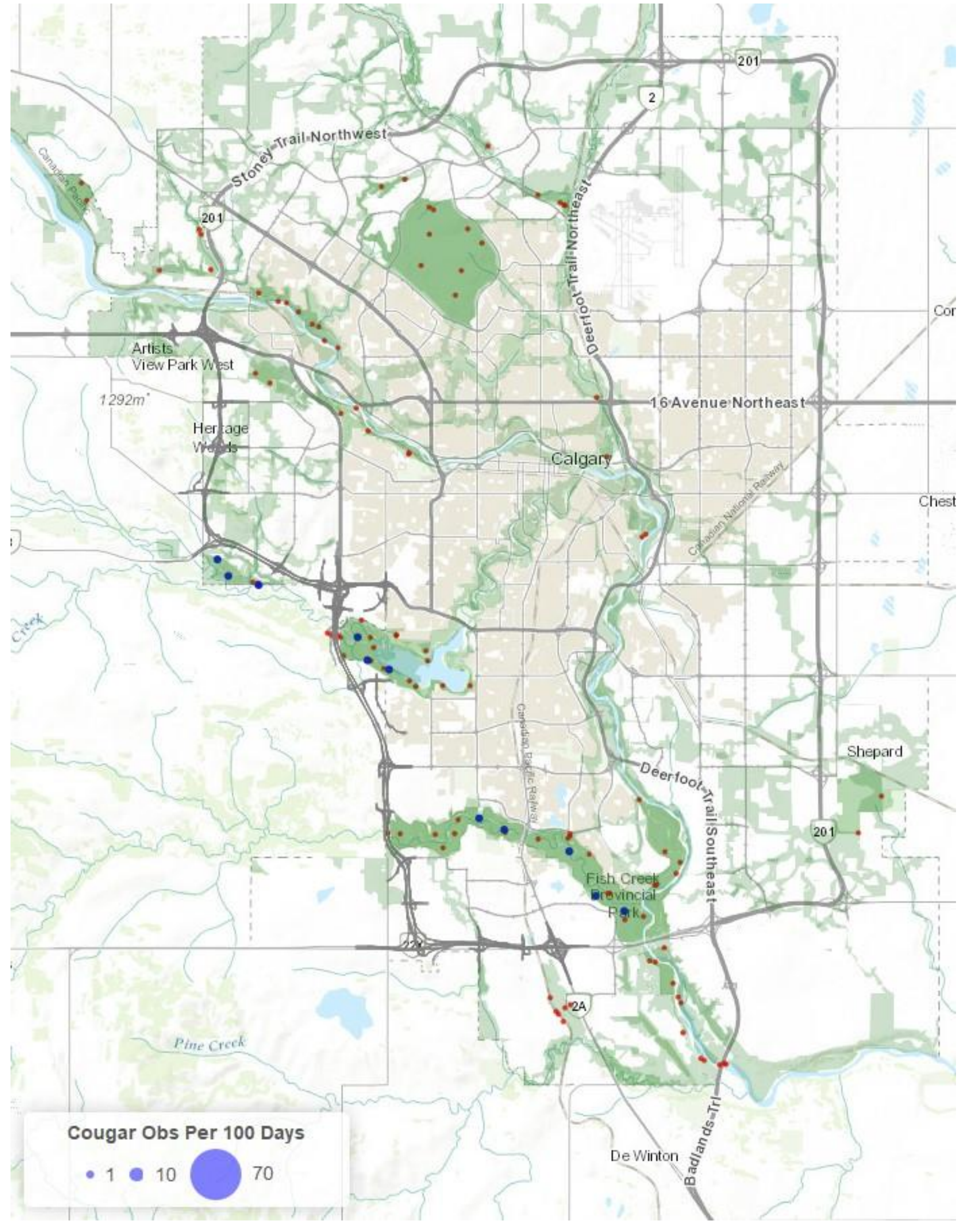


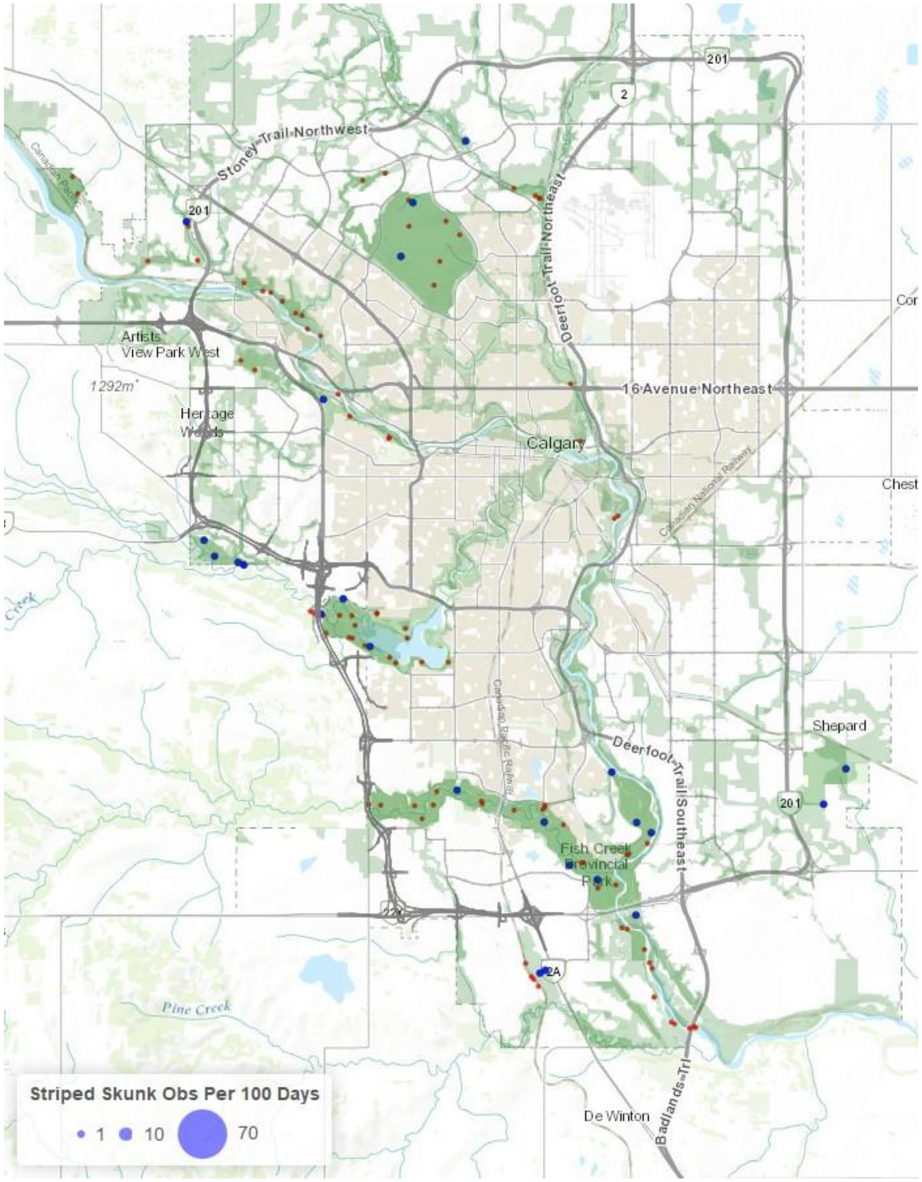
Weasels and Ermine Obs Per 100 Days
1
10
70
Stoney Trail Northwest
Deerfoot Trail Northeast
16 Avenue Northeast
Calgary
Artists View Park West
Heritage Woods
1292m
Shepard
Deerfoot Trail Southeast
Fish Creek Provincial Park
Pine Creek
De Winton
Badlands Trl
201
2
2A



Black Bear Obs Per 100 Days
1
10
70
Stoney Trail Northwest
Deerfoot Trail Northeast
16 Avenue Northeast
Calgary
Artists View Park West
Heritage Woods
1292m
Shepard
Deerfoot Trail Southeast
Fish Creek Provincial Park
Pine Creek
De Winton
Badlands Trl
201
2
2A


Stoney Trail Northwest
Deerfoot Trail Northeast
16 Avenue Northeast
Artists View Park West
Heritage Woods
Calgary
Shepard
Fish Creek Provincial Park
Deerfoot Trail Southeast
Pine Creek
De Winton
Badlands Trl
Beaver Obs Per 100 Days
1
10
70


Stoney Trail Northwest
Deerfoot Trail Northeast
16 Avenue Northeast
Artists View Park West
Heritage Woods
Calgary
Shepard
Fish Creek Provincial Park
Deerfoot Trail Southeast
Pine Creek
De Winton
Badlands Trl
Cougar Obs Per 100 Days
1
10
70


Striped Skunk Obs Per 100 Days
1
10
70
Stoney Trail Northwest
Deerfoot Trail Northeast
16 Avenue Northeast
Calgary
Artists View Park West
Heritage Woods
1292m
Shepard
Deerfoot Trail Southeast
Fish Creek Provincial Park
Pine Creek
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Badlands Trl
201
2
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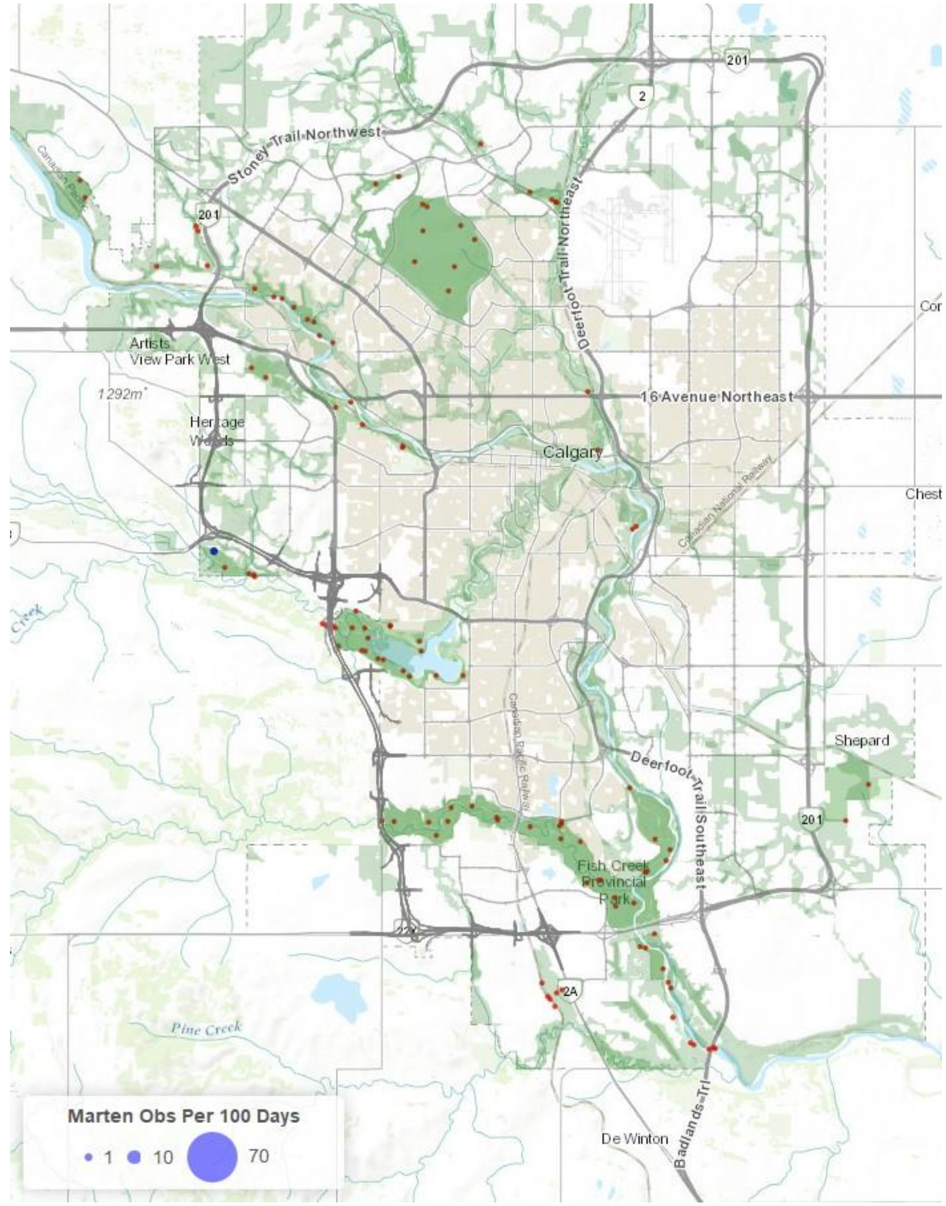
Chest


Marten Obs Per 100 Days
1
10
70
Stoney Trail Northwest
Deerfoot Trail Northeast
16 Avenue Northeast
Calgary
Artists View Park West
Heritage Woods
1292m
Shepard
Deerfoot Trail Southeast
Fish Creek Provincial Park
Pine Creek
De Winton
Badlands Trl
201
2
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