



miistakis institute
APPLIED CONSERVATION RESEARCH

Biodiversity Monitoring at Pronghorn Enhancement Sites along TransCanada Highway



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

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Enhancement Sites along the TransCanada
Highway**

Prepared by Tracy S. Lee, Sara Jordan-McLachlan
and Ken Sanderson
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Miistakis Institute
EB3013, Mount Royal University
4825 Mount Royal Gate SW
Calgary, Alberta T3E 6K6

Phone: (403) 440-8444
Email: institute@rockies.ca
Web: www.rockies.ca

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Executive Summary

Pronghorn (*Antilocapra americana*) are a uniquely adapted ungulate of North America's open prairie ecosystems. In Canada, their range is restricted to the Northern Sagebrush Steppe (NSS) of Alberta and Saskatchewan, where habitat fragmentation from roads, agriculture, and development increasingly threatens their persistence. The Trans-Canada Highway (TCH), a high-volume transportation corridor bisecting the NSS, presents both a movement barrier and a mortality risk through animal-vehicle collisions. Building on previous connectivity modelling, collar data, and collision analyses, this project supports implementation of the *Pronghorn Conservation Action Plan* by assessing biodiversity at priority mitigation sites identified along a 340 km section of the TCH between Brooks, Alberta, and Swift Current, Saskatchewan.

Over 2024–2025, we monitored six proposed road enhancement sites using autonomous recording units (ARUs) and remote cameras to assess multi-species use. ARUs detected multiple grassland bird species at risk, including Chestnut-collared Longspur (*Calcarius ornatus*) (Endangered), Sprague's Pipit (*Anthus spragueii*) (Threatened), Thick-billed Longspur (*Rhynchophanes mccownii*) (Threatened), Long-billed Curlew (*Numenius americanus*) (Special Concern), and Ferruginous Hawk (*Buteo regalis*) (Threatened). Several sites supported multiple at-risk species during peak breeding months (May–July). These results indicate that the priority enhancement sites support not only movement across the landscape, but also breeding and foraging habitat for prairie obligate birds. Their repeated detection highlights the broader ecological significance of these sites and the importance of minimizing additional habitat fragmentation around future road mitigation works.

Remote camera results demonstrate that these locations are used by a diverse grassland community beyond pronghorn. Remote cameras documented pronghorn (18% of detections), coyote (*Canis latrans*) (16%), white-tailed deer (*Odocoileus virginianus*) (11%), mule deer (*Odocoileus hemionus*), American badger (*Taxidea taxus taxus*), red fox (*Vulpes vulpes*), and other native mammals. This confirms that the proposed enhancement sites are used by a broad mammal community and suggests that mitigation designed to improve pronghorn permeability may also generate wider multi-species benefits.

Seasonal and diel activity patterns further support the importance of these sites. Mammal detections were highest in spring and fall, aligning with known migration and transitional movement periods for ungulates. Pronghorn activity peaked during documented spring and fall migration windows and was largely diurnal, while white-tailed deer, red fox, and coyote maintained primarily crepuscular to nocturnal activity patterns. Comparisons between control and highway-adjacent cameras showed strong similarity in 24-hour activity distributions, providing little evidence that highway proximity was shifting the timing of daily activity. Instead, the results suggest that the highway is more likely affecting where animals are willing to use habitat than when they are active.

Overall, the findings indicate that these sites retain high ecological value despite being adjacent to a major transportation corridor. In the absence of the highway, the habitats surrounding these sites would likely provide suitable summer and breeding-season habitat for a range of species. Current patterns suggest that some ungulates, especially pronghorn, concentrate their use of highway-adjacent areas mainly during movement periods such as migration, implying that the road may reduce broader seasonal use of otherwise suitable habitat. Improving safe permeability across the highway may therefore have benefits beyond crossing alone by increasing functional access to habitat on both sides of the road.

Although pronghorn remain the primary target for mitigation planning, crossing structure design should account for the wider range of species documented at these sites. Large ungulates such as mule deer and white-tailed deer are likely to benefit from relatively open, wider crossing structures, while medium-sized carnivores such as coyote and red fox may also use structures depending on openness, substrate, and surrounding habitat context. Birds may not use the structures directly, but the repeated occurrence of species at risk underscores the need to maintain open prairie conditions and avoid further fragmentation around structure approaches. Taken together, the results support a multi-species approach to road mitigation that improves pronghorn connectivity while also enhancing habitat function and landscape permeability for the broader prairie wildlife community.

Introduction

Pronghorn are the second fastest land animal in the world and a unique ungulate in North America having coevolved to run across the open prairie during the Pleistocene epoch to avoid predators including the now extinct North American Cheetah (*Miracinonyx trumani*) (Higgins et al., 2022). Today their range in Canada is restricted to the open Northern Sagebrush Steppe (NSS) ecosystem in Alberta and Saskatchewan (Jakes et al., 2018). Adapted to travelling across an expansive landscape, their persistence is threatened by habitat fragmentation resulting from roads, agriculture, residential and industrial development (Jones et al., 2022). While all roads can present a barrier to the movement of wildlife, higher volume roads like the Trans-Canada Highway (TCH) can cause wildlife to avoid an area or present a mortality risk through animal vehicle collisions (AVCs) (Lee & Sanderson, 2024. Lee et al. 2023). This project aims to build on previous research, and support conservation efforts outlined in a *Pronghorn Conservation Action Plan*¹ for the Canadian portion of the Northern Sagebrush Steppe (Lee et al. 2024). Data obtained from collared pronghorn, analysis of AVCs and connectivity modelling were used to identify vital movement areas across the TCH for pronghorn. Connectivity modelling has also detected potential areas of connectivity overlap for other grassland species of concern including American badger, prairie rattlesnake (*Crotalus viridis*) and mule deer.

Our objective was to monitor proposed pronghorn crossing mitigation sites for grassland mammal and bird species presence. Over two years (2024–2025) we monitored six sites using remote cameras and autonomous recording units (ARUs). Monitoring results will help guide crossing structure design that accommodates myriad grassland species using the landscape near the TCH.

Methods

The study area is part of a larger region known as the Northern Sagebrush Steppe (NSS) which covers ~315,000 km² of the Northern Great Plains including portions of Alberta and Saskatchewan in Canada, and Montana in the USA. The landscape is characterized by flat, open prairie and rolling hills, remnants of glacial recession and deposits with prevalent badlands and deep coulees throughout the region (Mitchell, 1980). Human settlements are sparsely distributed with few urban population centers. Cattle grazing is the predominant land use as the soils, terrain, and precipitation are poorly suited for row crop agriculture. The region is considered semi-arid and receives an annual mean of 39.2 cm of precipitation, with approximately 70% as rainfall (Jones et al., 2022).

Our monitoring focuses on the TCH that bisects the NSS. This study monitored six priority road enhancement sites along a 340 km section of the TCH between Brooks, Alberta and Swift Current, Saskatchewan (Figure 1). Traffic volumes range from a low of 4520 vehicles per day near Tompkins, Saskatchewan to a high of 16240 average vehicles per day near Medicine Hat, Alberta². At each site we set up two ARUs per site, on each side of the TCH where noise from the TCH was recorded as less than 65 decibels (mean distance from TCH was 433 m). We also set up four remote cameras, two adjacent

¹ https://www.rockies.ca/files/reports/Pronghorn_Connectivity_Conservation_Plan_July_2024.pdf

² <https://www.transportation.alberta.ca/mapping/>

to the TCH on both its north and south sides, and two control cameras placed within 500 m of the TCH (mean distance from TCH was 467 m), one north and one south of the highway.

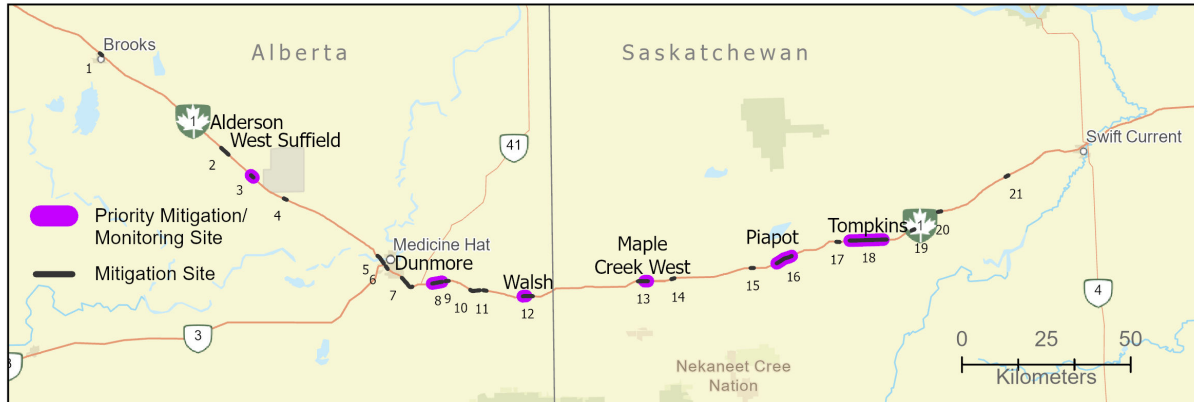


Figure 1: Twenty-one road enhancement sites with six priority locations recommended for crossing infrastructure on the TCH in Alberta and Saskatchewan.

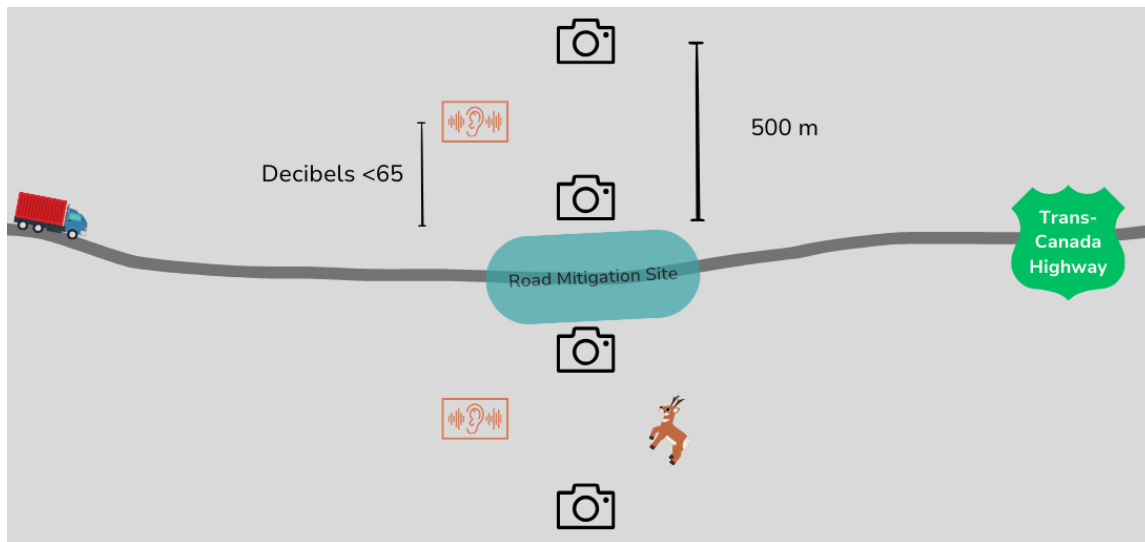


Figure 2: Remote camera (camera icons) and Autonomous Recording Unit (ear icons) placement at 6 priority/monitoring sites along the TCH in Alberta and Saskatchewan.

Sites include predominantly tame pasture, with some native grasslands, crop and trees areas. In Table 1 we outline the dominant community reported during field visits where cameras and ARU's were placed in and note if any wetland was in the vicinity (within 2 km radius). A review of crop inventory for Alberta indicates native grasslands further off the TCH at all the sites in Alberta.

Table 1: Priority enhancement site vegetation community

Site	Direction	Dominant community
West Suffield	North	Tame Pasture, wetland
West Suffield	South	Tame Pasture, wetland
Dunmore	North	Tame pasture, native grassland, deciduous trees, wetland
Dunmore	South	Tame Pasture

Walsh	North	Tame pasture
Walsh	South	Tame pasture, native grassland, wetland
West Maple Creek	North	Tame pasture, wetland
West Maple Creek	South	Tame pasture, wetland
Piapot	North	Tame pasture, wetland
Piapot	South	Tame pasture, wetland
Tompkins	North	Tame pasture, wetland
Tompkins	South	Crop, tame pasture, deciduous trees, wetland

Autonomous Recording Units (ARU)

ARUs were set up from August 7, 2024 to November 6, 2024 and from April 7, 2025 to October 22, 2025 on both sides of the TCH at 6 priority enhancement sites. ARUs recorded for 10 min on the top of every hour. ARU data were grouped per site.

To analyze the months of acoustic data, we selected an even number of recordings from each site, then ran the sampled hours through BirdNET to parse avian species. To narrow the list of tags BirdNet can apply when analyzing acoustic data, we compile a list of local birds using citizen science data (e.g., eBird, iNaturalist), species-specific range information (e.g., All About Birds, Birds of the World), and official local resources (e.g., Royal Alberta Museum, Alberta Fish and Wildlife Management Information System). This is transformed into a custom species list for BirdNET-Analyzer and is applied during batch analysis.

The model's batch results were reviewed manually by an expert bioacoustician until each of the model's species tags by site were positively confirmed or ruled out. During the process of species verification, recorded samples of known species that are publicly available through sound libraries (e.g., Macaulay Library, Xeno-canto) were used for a visual and auditory match to the experimentally recorded data. After BirdNET analysis and verification was complete, a smaller subset of data were manually reviewed for sounds that could not be identified by BirdNET (e.g., amphibians, mammals, data-deficient birds, very quiet vocalizations).

Bird species status follow The *Species at Risk Act* (SARA) Schedule 1, as the official list of wildlife species at risk in Canada. This database classifies those species as being either extirpated, endangered, threatened, or a special concern.

To aid in data analysis, we identified the following bird identification methods, Validated BirdNET ID, Incidental BirdNET Observation or Manual ID from KPro Cluster. To identify species presence at each site and for species richness measures we used all three bird identification methods; to calculate presence per month for species at risk we used only the Manual ID kPro Cluster identification method as this validation process considered even sampling over the course of the study.

Bird species were classified into functional guilds representing ecologically similar niches. Groups were defined based on shared habitat associations, primary foraging strategies, and life history characteristics relevant to prairie and wetland systems. The six guilds were: (1) grassland obligates, (2) shorebirds and cranes, (3) waterfowl, (4) raptors, (5) aerial insectivores, and (6) generalists/edge-associated species.

Remote Cameras

Remote cameras were deployed from August 2024 to November 2025, a period of 15 months at six sites along TCH (Figures 1 and 2). Images were uploaded and classified using WildTrax and downloaded for analysis. We used a 10-minute independent event gap to create events for species to use in analysis. To address inconsistencies in camera effort (number of days active) we calculated events per 100 camera trap days. This dataset was then used to determine species events at each proposed priority crossing site, and between treatment types (control and highway cameras). Independent detection events were defined using a 10-minute threshold, such that consecutive photographs of the same species at the same camera were considered part of a single event unless at least 10 minutes had elapsed between detections. Additionally, events represent one occurrence but could include larger group sizes.

We used the R package “*overlap*” to create a kernel density estimate of diel activity detected by remote cameras for control and highway locations within a species (coyote, pronghorn, and white-tailed deer) using the D_{hat4} ($\Delta 4$ estimator), which is appropriate for moderate to large sample sizes. The resulting delta value is an index from 0 (no overlap of a species daily temporal activity on control and highway cameras) to 1 (complete overlap) (Ridout and Linkie 2009). This analysis will help interpret if and how the highway is affecting daily movement of animals captured on the remote cameras.

Results

Bird Species

We detected 138 unique bird species from 12 ARUs at six priority road enhancement sites during our study (Figure 3). Species per functional group are displayed per priority road enhancement site in Appendix A.

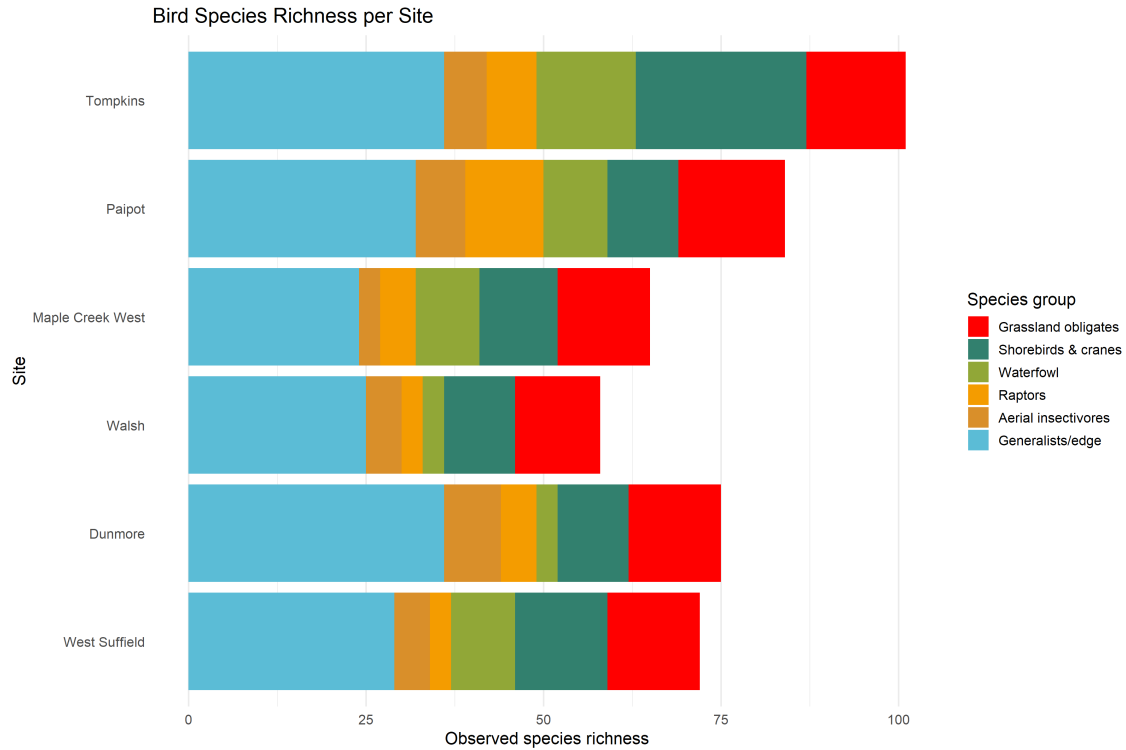


Figure 3: Bird richness per species functional groups per priority road enhancement site. The westernmost site is West Suffield, Alberta to the easternmost site, Tompkins, Saskatchewan.

We detected 12 species at risk, including one endangered, six threatened and five of special concern at the 6 priority road enhancement sites (Figure 4). We detected one non-bird species, the Great Plains Toad (*Anaxyrus cognatus*). Monthly activity of the bird species at risk activity at each site show expected patterns for migratory, grassland breeding birds that require native grassland habitat for nesting and chick rearing (Figure 5).

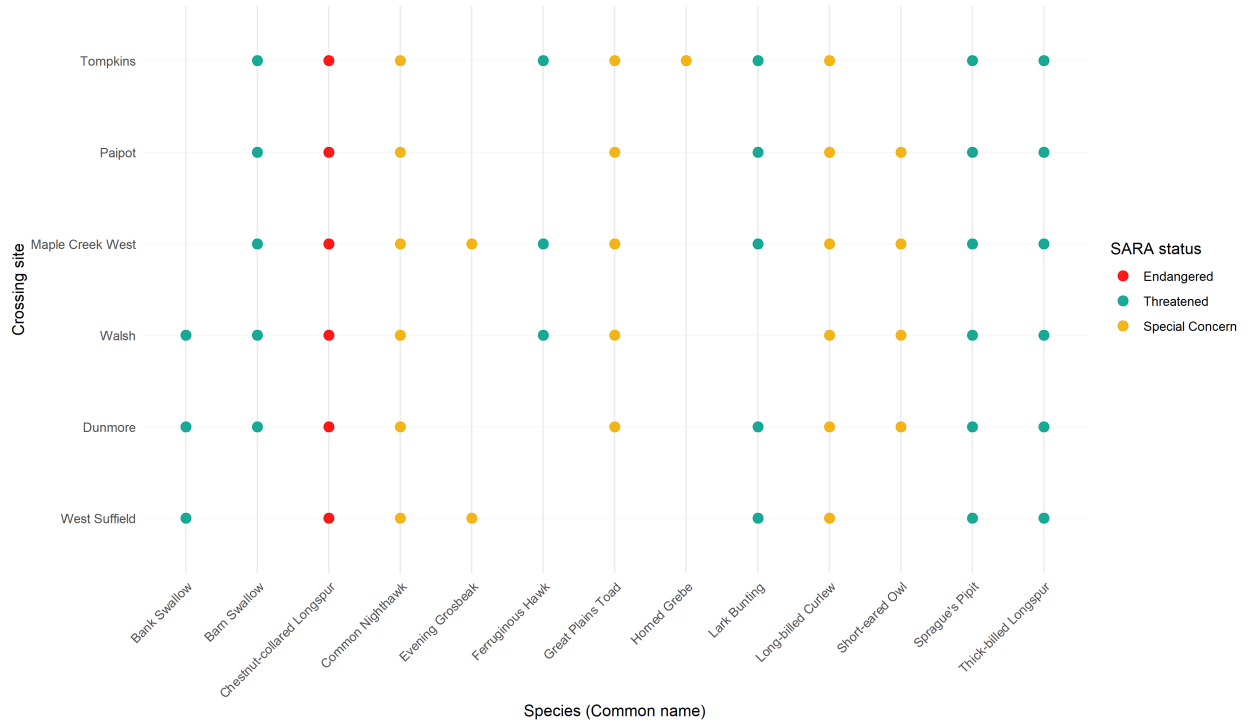
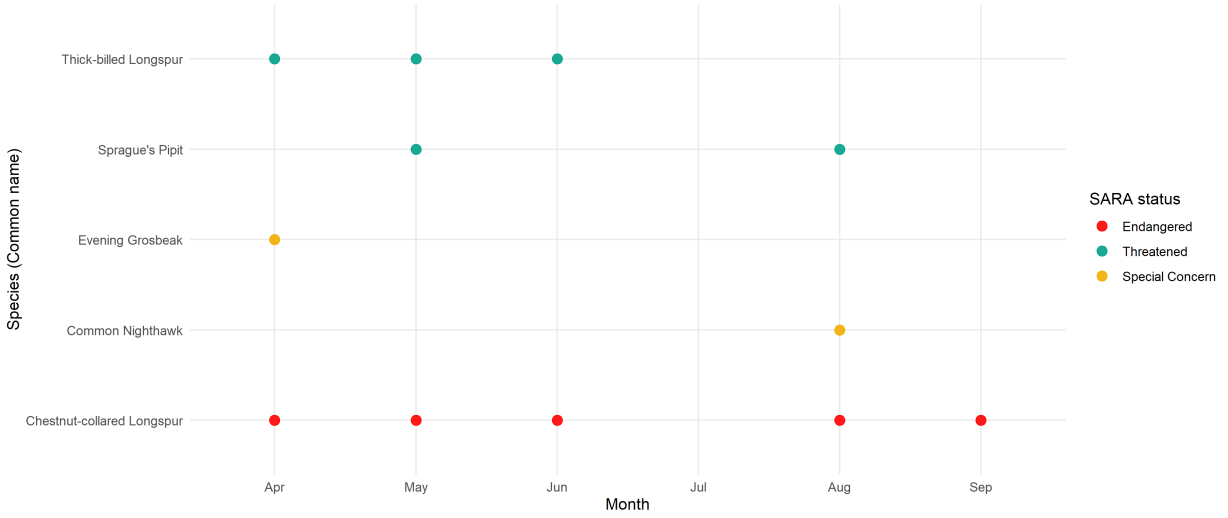
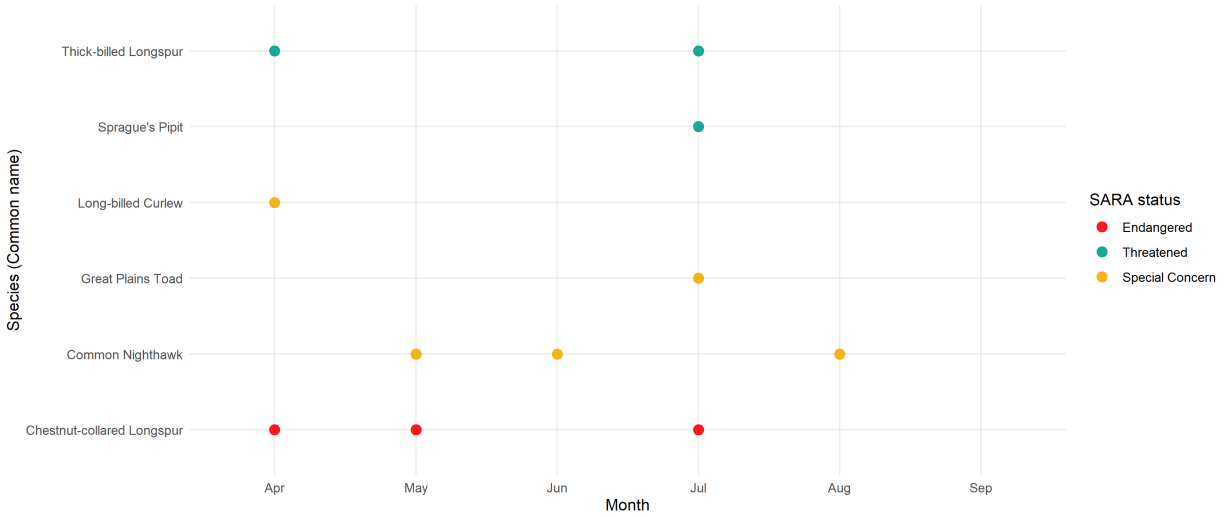


Figure 4: Species at Risk detected on ARUs per priority road enhancement site

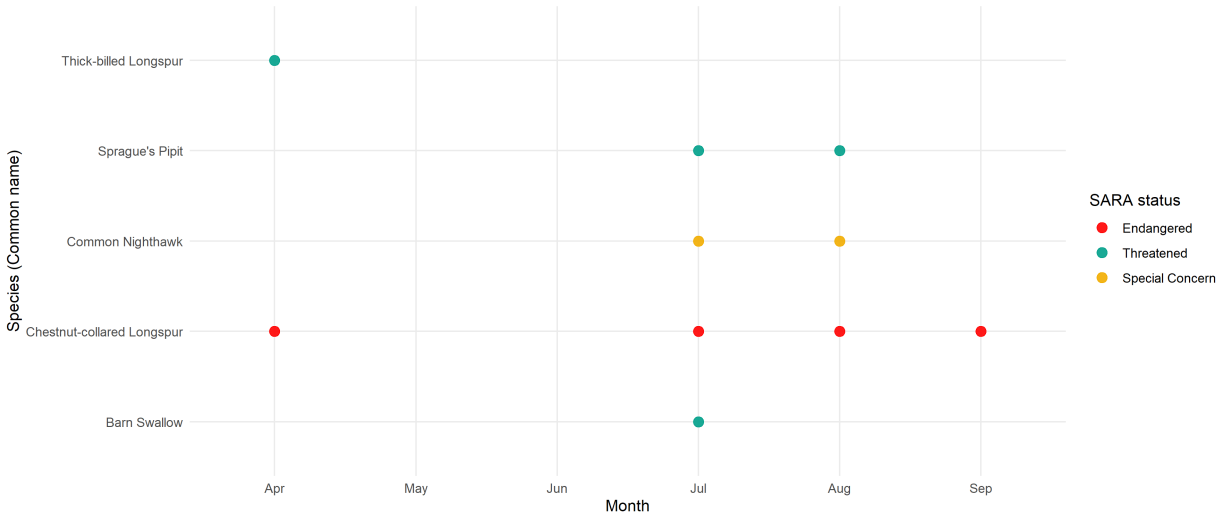
Species at Risk by Month — West Suffield



Species at Risk by Month — Dunmore



Species at Risk by Month — Walsh



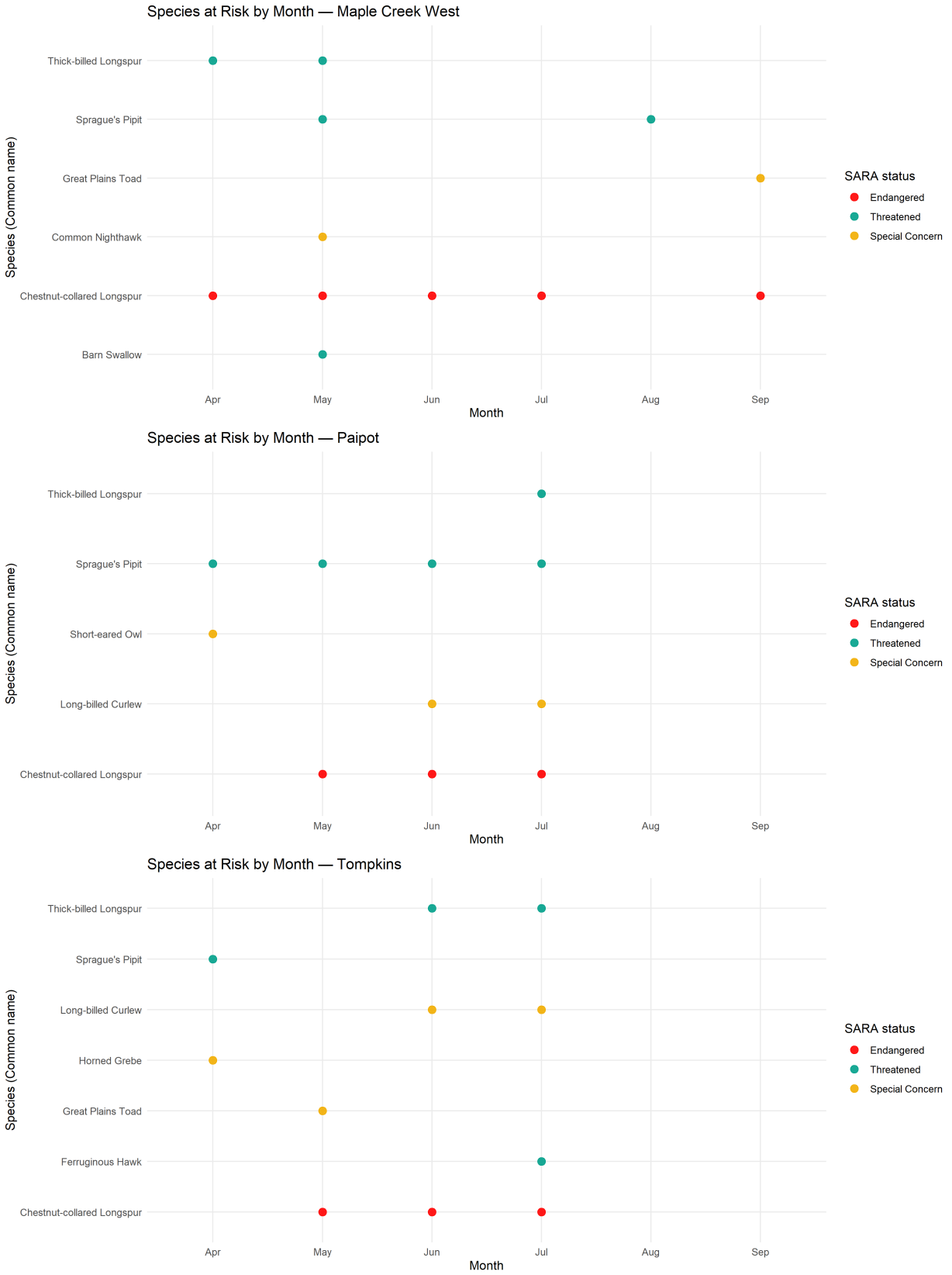


Figure 5: Bird species at risk per priority road enhancement site per month

Mammal species

We detected 3054 medium to large mammal events (including human and domestic animal) during our study (Table 2). For a complete list of species detected including birds and smaller mammals see Appendix B.

Table 2: Species events across remote cameras along Trans-Canada Highway in Alberta and Saskatchewan.

Species	Events	%
Domestic Cow	1631	44.03
Pronghorn	670	18.09
Coyote	596	16.09
White-tailed Deer	413	11.15
Human	181	4.89
Red Fox	106	2.86
American Badger	47	1.27
Mule Deer	19	0.51
Striped Skunk	7	0.19
Common Raccoon	6	0.16
Domestic Donkey	6	0.16
Domestic Dog	5	0.13
Unidentified Mammal	5	0.13
Long-tailed Weasel	4	0.11
Porcupine	4	0.11
Domestic Horse	3	0.08
Moose	1	0.03

Pronghorn, white-tailed deer, red fox and American badger were more common on wildlife cameras away from the TCH (control sites) when compared to cameras placed along the highway. While the opposite occurred for coyote and mule deer with more events on cameras placed close to the TCH (Figure 6).

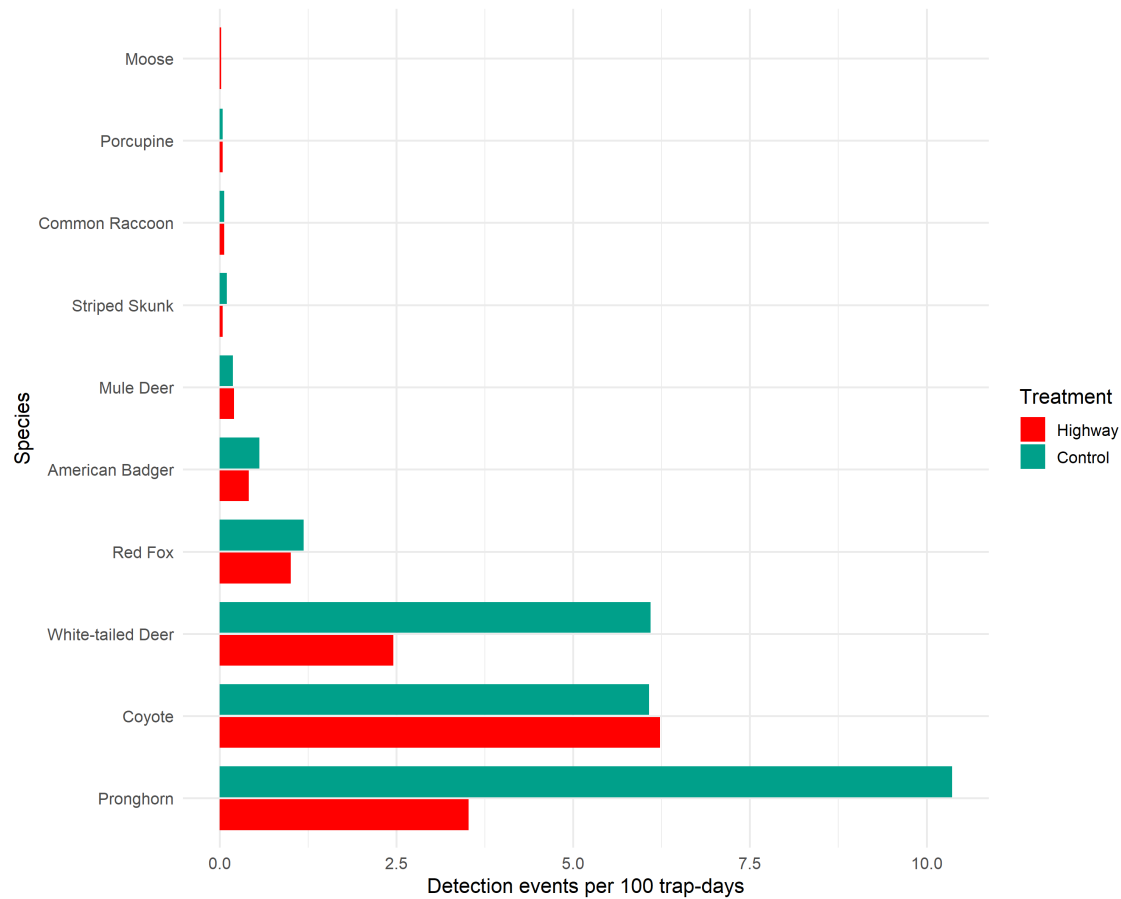
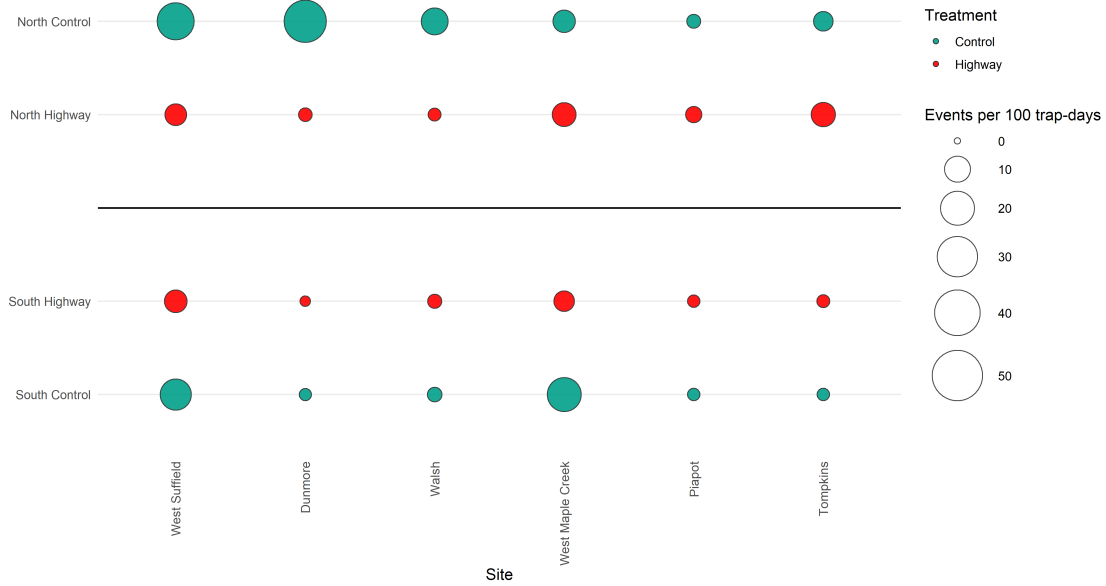


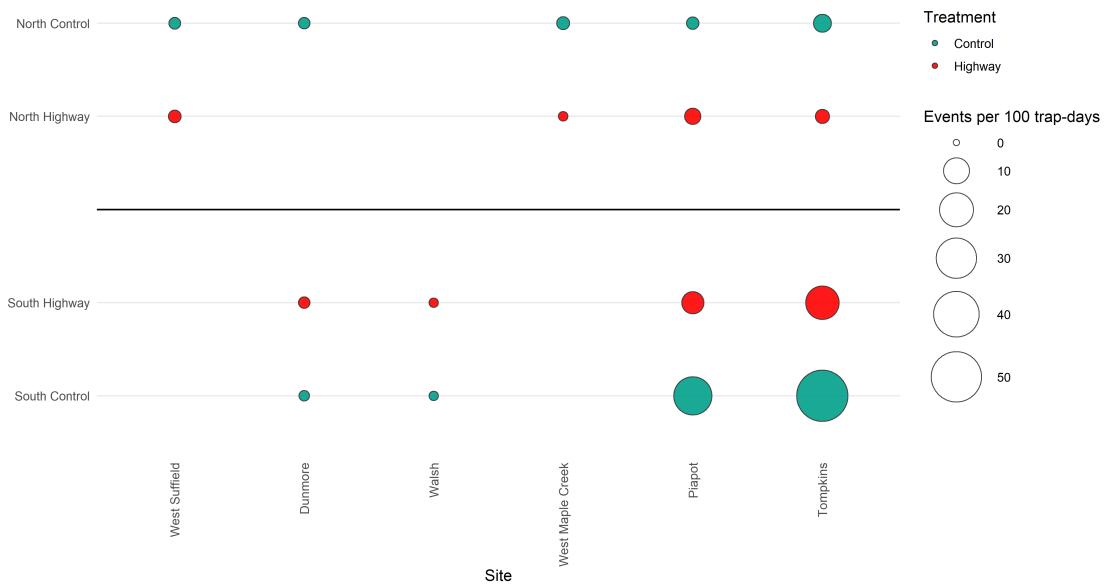
Figure 6: Species events per 100 camera trap days at control (sites distant from the TCH) and highway cameras summed across sites.

Total ungulate events per 100 camera trap days per site per treatment (Figure 7) shows the differences among that group in detections relative to distance from highway and along the TCH. Generally, pronghorn were detected 56% less on highway cameras over control cameras placed away from the TCH, although the effect was not statistically significant at $\alpha = 0.05$ ($p = 0.068$). There were more ambiguous patterns for the other ungulates and samples sizes were too low to compare statistically. Mesocarnivore (America badger, raccoon, coyote, red fox, and skunk) and rodent (porcupine) total events per 100 camera trap days per site per treatment varied strongly among sites, species, and distance from highway (Figure 8). Badgers, red fox, and porcupines were more commonly detected south of the highway with the latter two species more easterly and badger more common in the west. Coyotes were the most commonly detected species in this group (Figure 8).

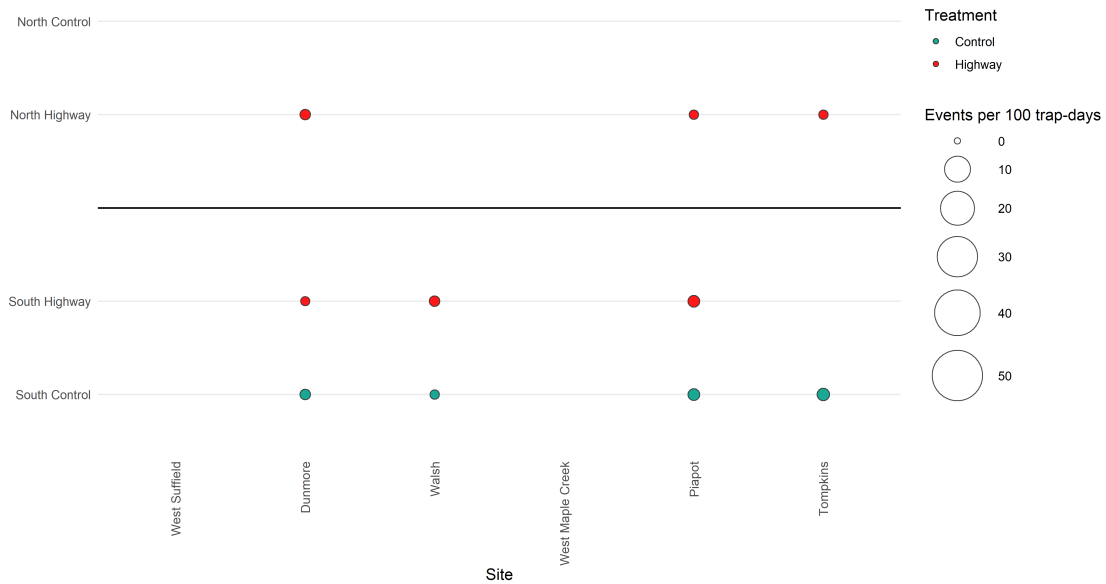
Pronghorn Activity by Site and Treatment



White-tailed Deer Activity by Site and Treatment



Mule Deer Activity by Site and Treatment



Moose Activity by Site and Treatment

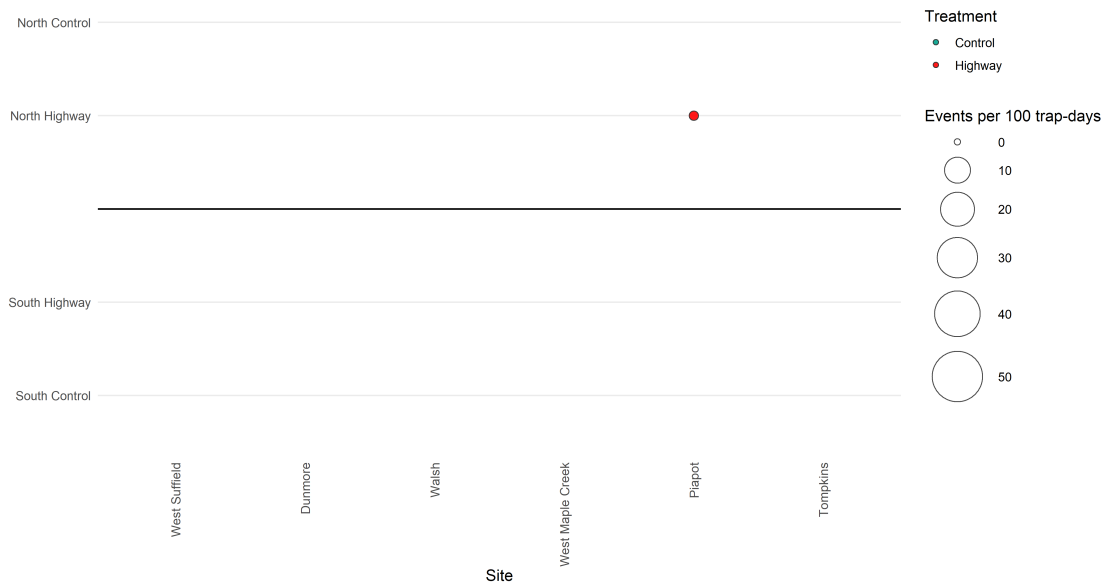
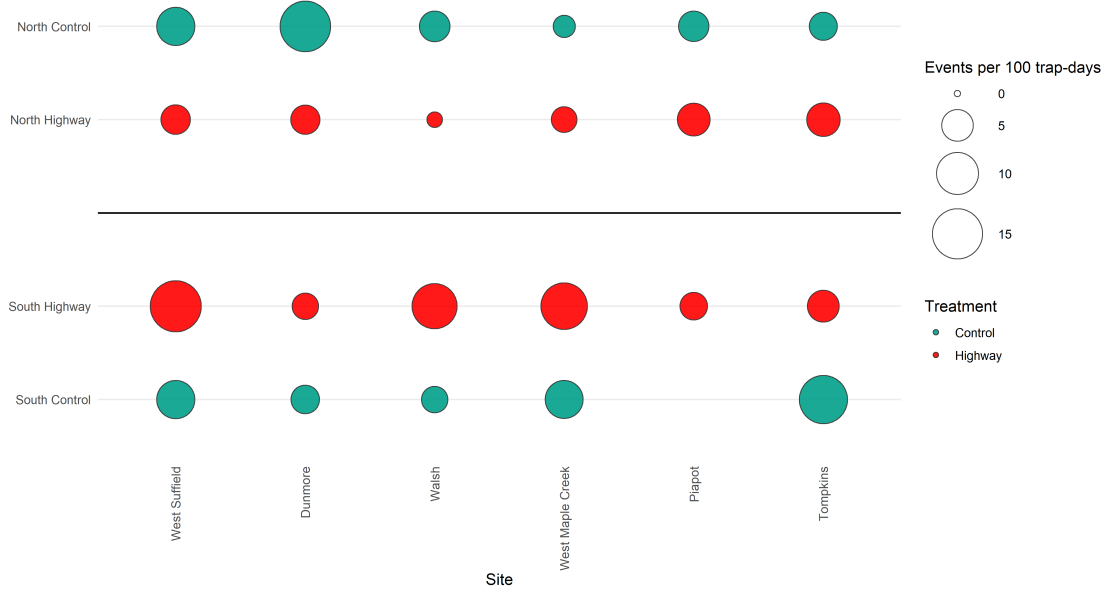
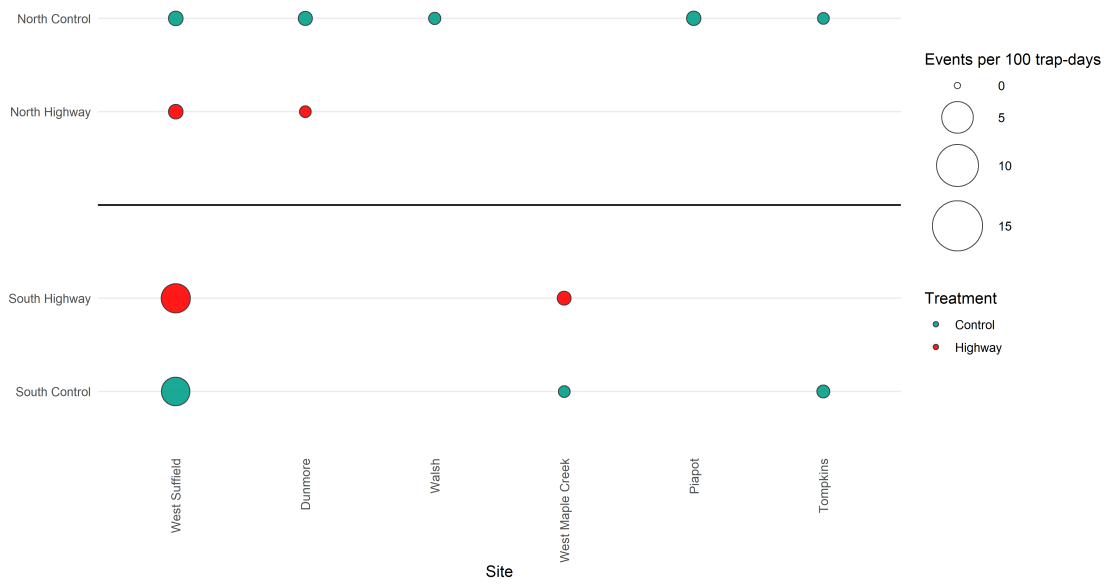


Figure 7: Ungulate species events per 100 camera trap days per treatment type. Cameras adjacent to the highway are in red and control cameras (approximately 500 m from the TCH) are in green. Plots are divided by side of the TCH (north or south), represented as a black horizontal line. The size of the circle represents species activity level on a camera whereby larger circles represent higher activity.

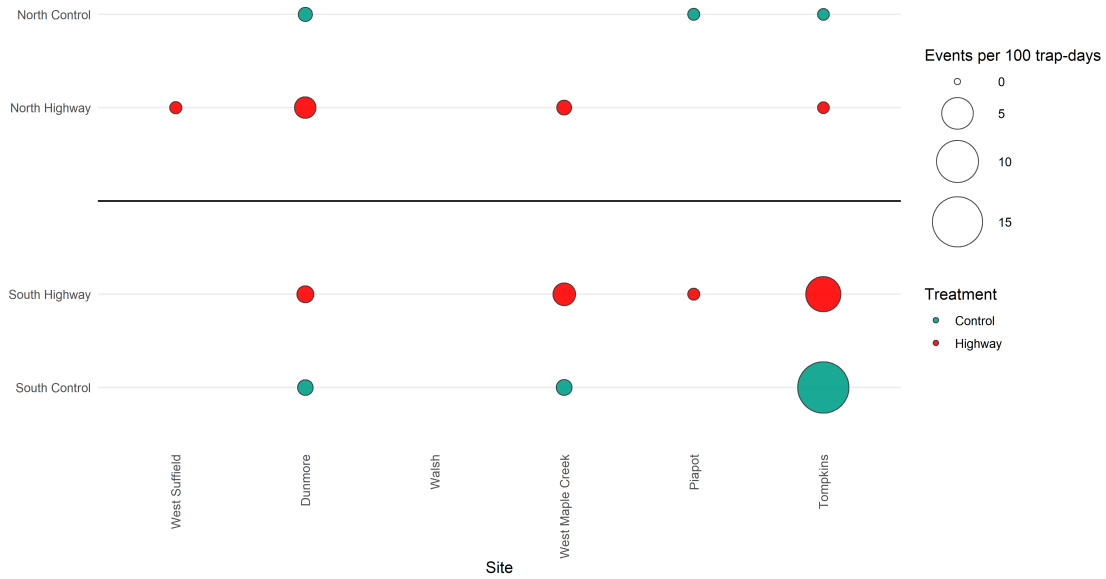
Coyote Activity by Site and Treatment



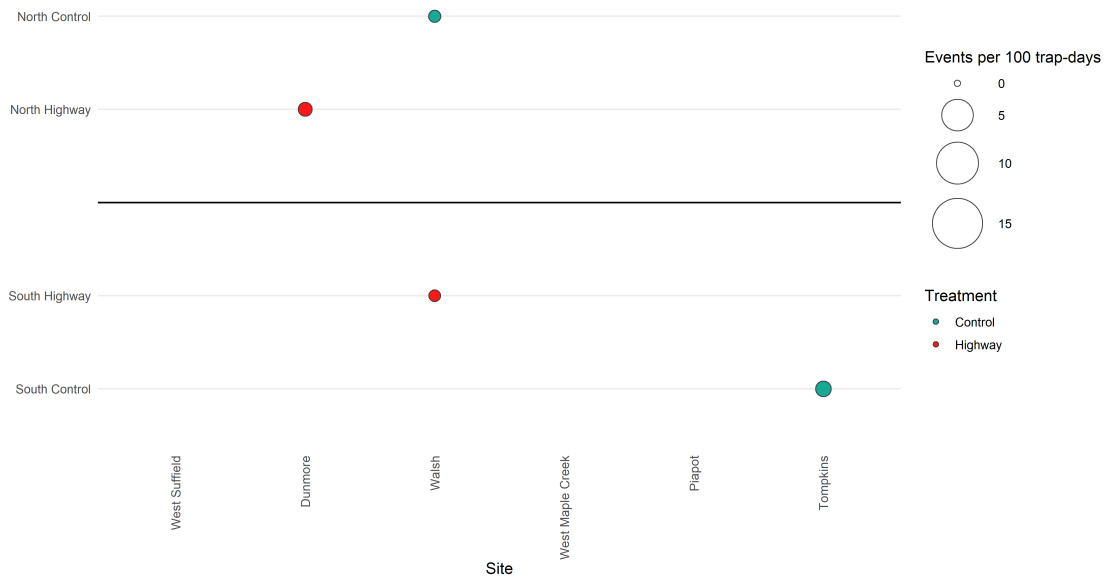
American Badger Activity by Site and Treatment



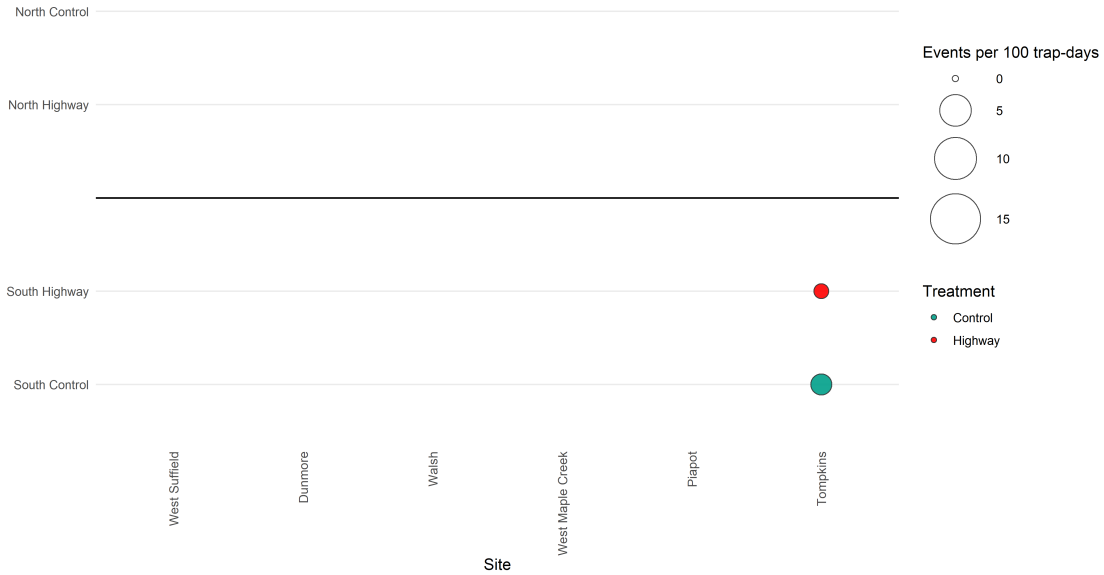
Red Fox Activity by Site and Treatment



Common Raccoon Activity by Site and Treatment



Striped Skunk Activity by Site and Treatment



Porcupine Activity by Site and Treatment

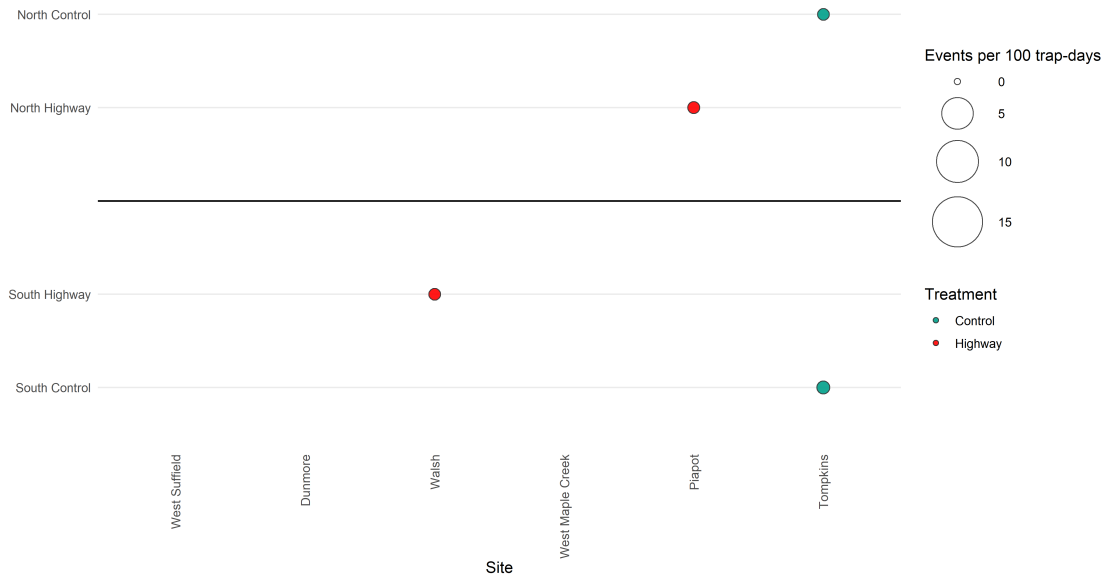
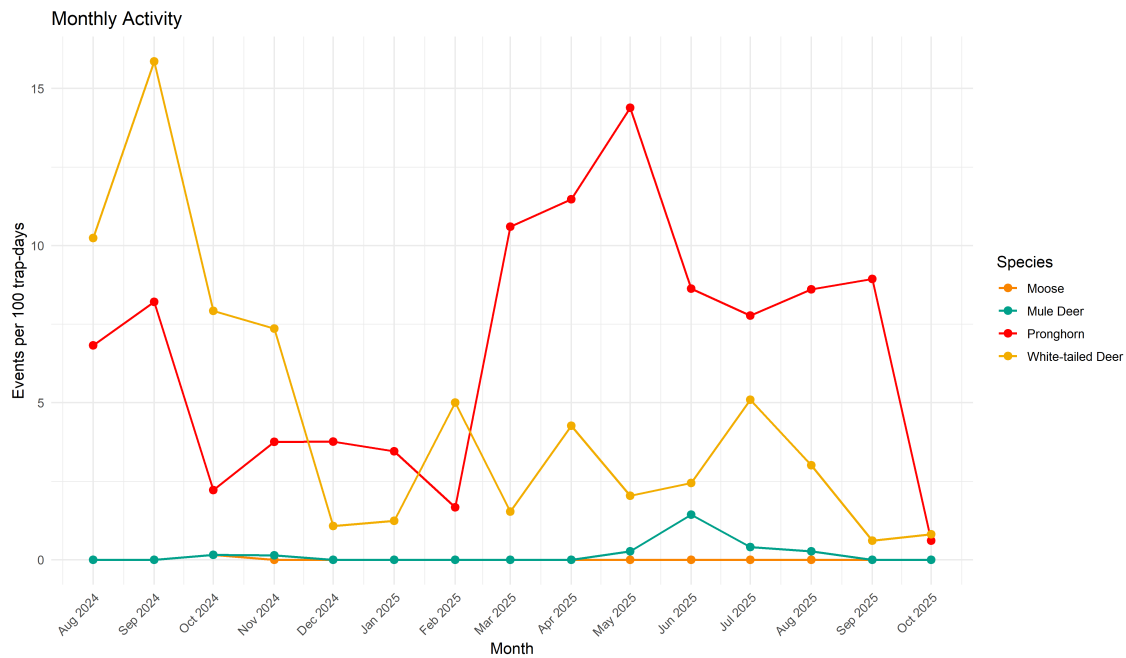


Figure 8: Mesocarnivore or rodent species events per 100 camera trap days per treatment type (highway cameras in red and control cameras in green) and direction (north or south) on the Trans-Canada Highway (black horizontal line). Plots are divided by side of the TCH (north or south), represented as a black horizontal line. The size of the circle represents species activity level on a camera whereby larger circles represent higher activity.

We identified temporal activity using events per 100 camera trap days per species across sites for ungulates (Figure 9, upper panel), and the smaller mammals (mesocarnivores, and one rodent; figure 9, lower panel). In addition to noteworthy differences in abundance, we found distinct seasonal patterns for white-tailed deer and pronghorn that confirm high pronghorn activity in the late-winter through spring, while high late-summer and fall white-tailed deer activity. Such strong seasonality was absent from the smaller mammal data, although coyotes appeared to be less active around the TCH in late winter through spring. We also show pronghorn per month per 100 camera trap days per site and identify spring and fall migration periods based on existing movement data (Figure10; Jakes, 2015). These data show clear site and temporal differences; we generally detected greater activity at West Suffield and West Maple Creek than the other sites except for Dunmore during the spring and summer. Piapot, Tompkins, and Walsh showed generally less activity, with some seasonal pulses.



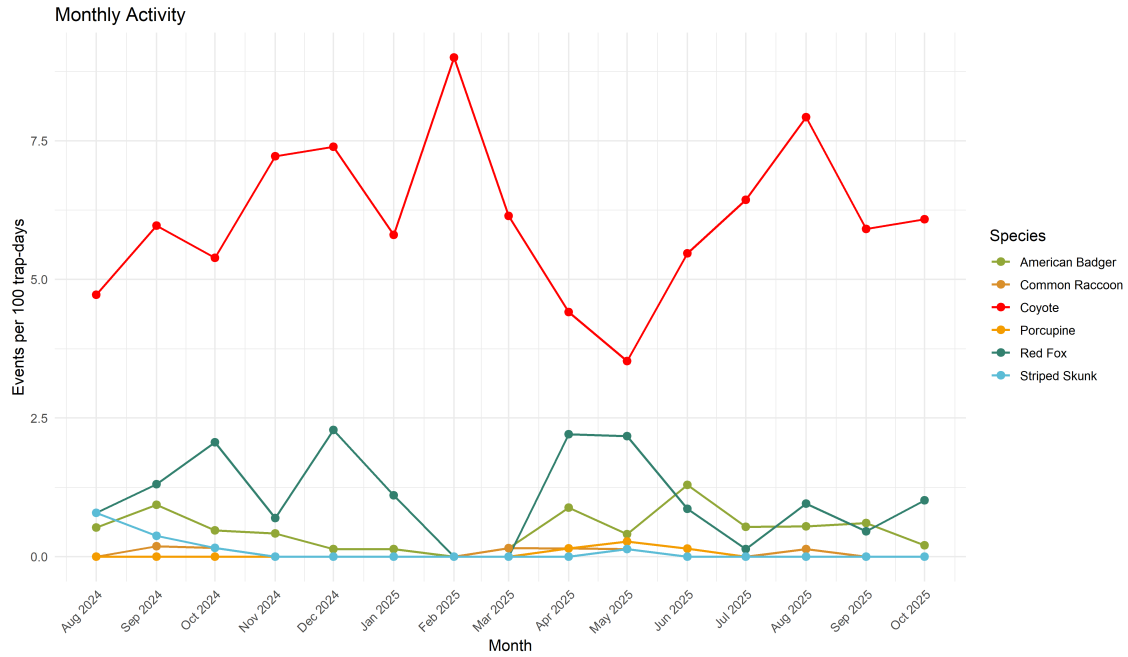


Figure 9: Events per month per 100 camera trap days per species during study period from August 2024 to October 2025 across all sites.

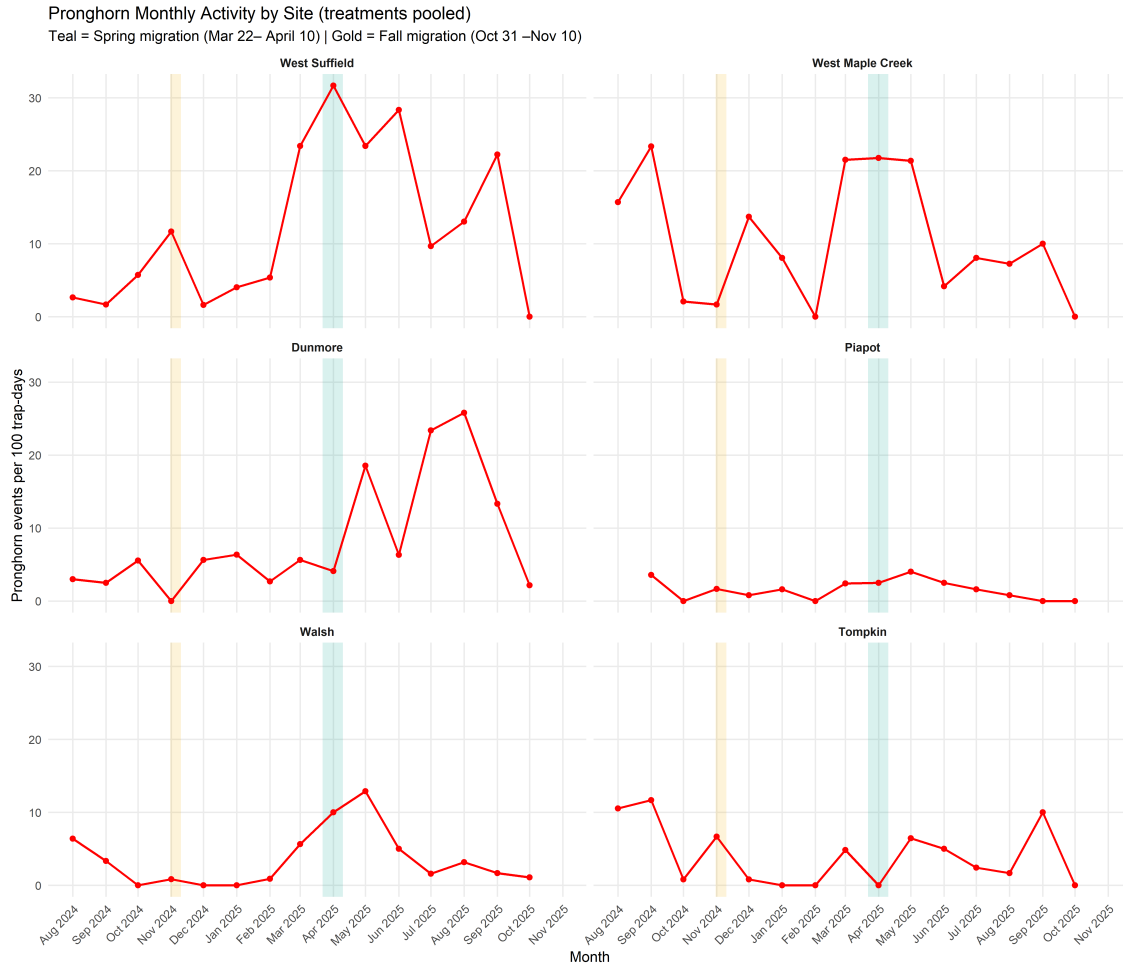


Figure 10: Pronghorn monthly events per 100 camera trap days per site during study period, whereby fall (October 31 to November 10) is represented in gold and spring (March 22 to April 10) is represented in teal. Dates based on Jakes et al 2015.

Finally, we show 24-hour temporal activity for pronghorn, white-tailed deer, red fox and coyote (other species did not have enough events to accurately calculate temporal use) across sites (Figure 11). For three species (greater than 75 detections) we tested overlap between treatment and highway events. Overlap coefficients ($\Delta = 0.83\text{--}0.92$) indicate strong similarity in *diel* activity patterns between control and highway camera sites, suggesting limited evidence for temporal displacement associated with highway proximity (Table 3).

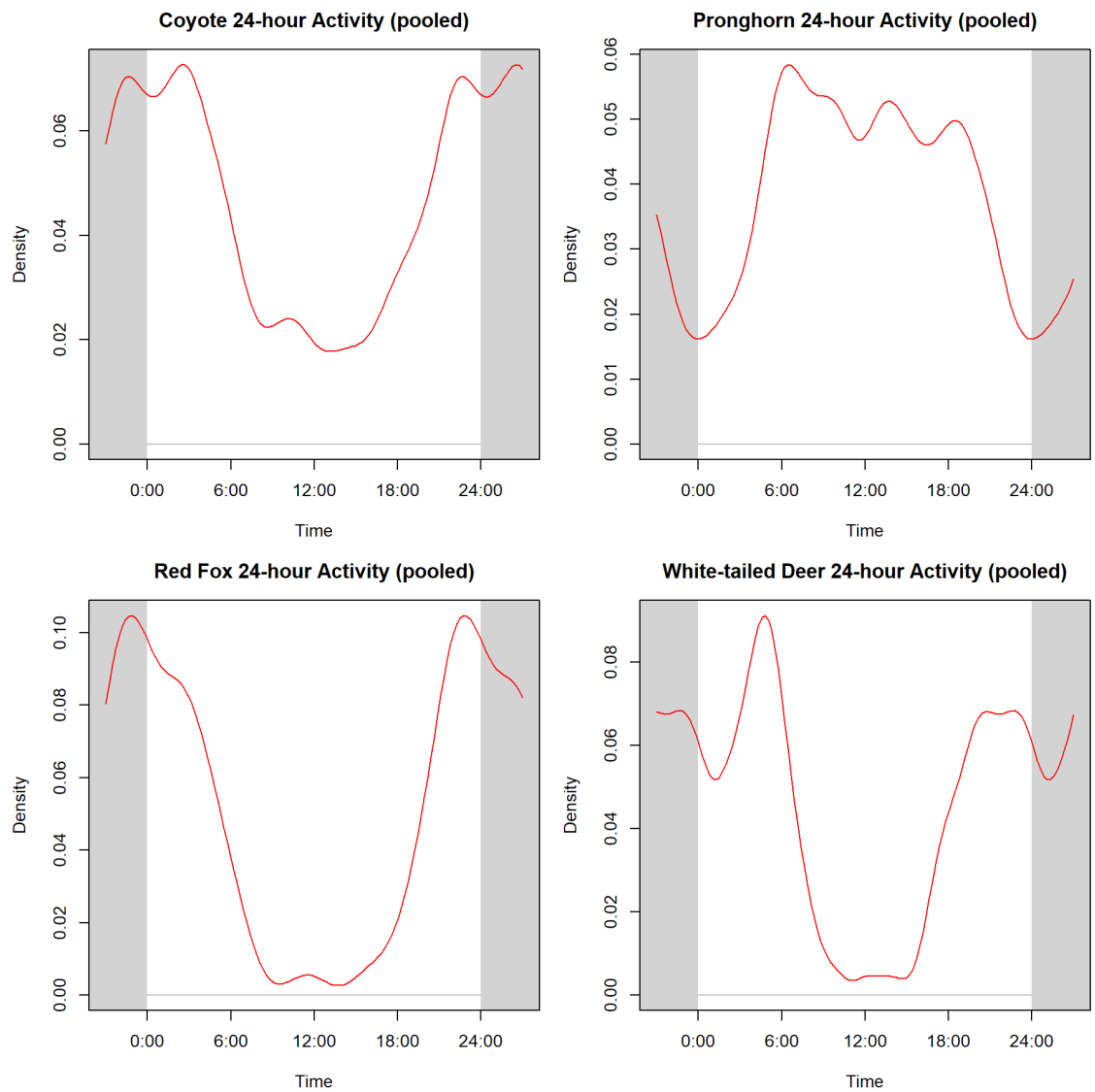


Figure 11: 24-hour temporal activity on remote cameras across sites for coyote, pronghorn, red fox and white-tailed deer during the study period.

Table 3: Overlap results for coyote, pronghorn and white-tailed deer comparing control and highway camera activity across sites.

species	Num, control	Num. highway	Dhat Type	Dhat value
Coyote	292	304	Dhat4	0.83
Pronghorn	498	172	Dhat4	0.92
White-tailed Deer	293	120	Dhat4	0.92

Discussion

What species did we detect at priority enhancement sites?

Autonomous Recording Units (ARUs) detected multiple grassland bird species at risk across the six priority sites over the monitoring period. Species recorded included Chestnut-collared Longspur (Endangered), Sprague's Pipit (Threatened), Thick-billed Longspur (Threatened), Long-billed Curlew (Special Concern), Lark Bunting (Threatened), and Ferruginous Hawk (Threatened), among others. Several sites supported multiple at-risk species, indicating that these locations function not only as movement pathways but also as important habitat for prairie obligate birds. The consistent detection of grassland specialists, many of which are known to respond negatively to habitat fragmentation and to disturbance associated with roads, trails, and energy infrastructure, highlights the broader ecological significance of these proposed enhancement sites (Bernath-Plaisted et al. 2023). Enhancing permeability at these locations may therefore contribute to maintaining grassland bird habitat integrity in the region.

Over a 15-month monitoring period, remote cameras documented a diverse assemblage of large and medium-sized mammals at the six proposed enhancement sites. Because our cameras were placed at known pronghorn movement sites (Jakes et al., 2018), and they were our focal species, they were the most frequently detected species in our images (18%). But cameras also detected substantial activity from other native wildlife. Coyote (16%) and white-tailed deer (11%) were frequently detected, indicating regular use of these sites by wide-ranging carnivores and ungulates. Additional native species included red fox, American badger, mule deer, striped skunk, common raccoon, long-tailed weasel, porcupine, and moose, though at lower detection frequencies. The presence of American badger is notable given its conservation relevance in prairie systems. Domestic livestock (primarily cattle; 44%) were also common, reflecting the working landscape context of these sites. Overall, camera detections demonstrate that proposed enhancement locations are used by a broad mammal community beyond pronghorn, including species with varying habitat needs and movement behaviours. This suggests that mitigation measures designed for pronghorn permeability may provide multi-species benefits.

Which of the proposed enhancement sites had the most wildlife activity?

Ungulate activity varied across sites, with the strongest overall signals at the eastern locations, especially Piapot and Tompkins. These sites showed the highest and most consistent activity for mule deer and white-tailed deer, while pronghorn were recorded across all sites but were generally more active at control cameras than at highway-adjacent cameras. Moose detections were rare and limited to Piapot, and Dunmore also showed some mule deer activity near the highway. Together, these patterns suggest that Piapot and Tompkins are the strongest candidates for prioritizing crossing structure planning for all ungulate species. Ongoing collaring work by the Government of Alberta and Alberta Conservation Association will help clarify mule deer and pronghorn movement and whether migration routes across the TCH have shifted over time.

These site patterns are also broadly consistent with the habitat context. Most sites are dominated by tame pasture with wetland inclusions, which likely support use by open-country ungulates and also provide habitat for a range of grassland- and wetland-associated species at risk (Hamel and Neufeld 2018; Serran and Creed 2015). Sites with a native grassland component, such as Dunmore and Walsh, may be particularly important for some grassland birds, while wetlands likely add habitat value for both birds and mammals by providing water, forage, and movement cover. The presence of deciduous trees

at Dunmore North and Tompkins South may also help explain use by some species that benefit from greater structural cover or habitat diversity, and the crop–pasture mosaic at Tompkins South may contribute to site-level differences in wildlife activity. Overall, the habitat descriptions suggest that variation in vegetation structure and wetland presence likely help explain some of the differences in species detections among sites.

When were species active at priority enhancement sites?

Across the six monitored sites, species at risk were detected repeatedly by ARUs during the regional breeding season, with detections concentrated between April and September and peaking between May and July. This seasonal pattern is consistent with published breeding phenology for prairie grassland birds, including Chestnut-collared Longspur, which arrives on breeding grounds from late March to late April, Sprague’s Pipit, which occurs on breeding grounds from April to early May through September or October, and Thick-billed Longspur, a species associated with sparsely vegetated short- and mixed-grass prairie during the breeding season (Shaffer et al. 2020a; Shaffer et al. 2020b; Shaffer et al. 2019). Chestnut-collared Longspur was the most consistently recorded species, being detected across all sites and multiple months, which aligns with its broad use of native mixed-grass prairie during the breeding period (Shaffer et al. 2020a). Sprague’s Pipit and Thick-billed Longspur were also detected at several sites, but within narrower windows, consistent with species-specific habitat selection and localized occupancy in prairie landscapes (Shaffer et al. 2020b; Shaffer et al. 2019). Long-billed Curlew and Common Nighthawk were recorded intermittently, primarily in late spring and early summer, which is consistent with their known breeding-season timing, nesting activity, and seasonal detectability (Shaffer et al. 2019c; Hannah et al. 2022). Together, these detections support the interpretation that the monitored sites provide seasonally important habitat for multiple species of conservation concern.

Site-level patterns show that Maple Creek West, Dunmore, Piapot, and Tompkins supported multiple at-risk species across several months, while Walsh and West Suffield also demonstrated repeated detections of key grassland obligates. The concentration of detections during late spring and early summer highlights the importance of these priority enhancement locations not only as movement corridors but also as active breeding and foraging habitat for prairie species at risk. Collectively, the temporal distribution of detections suggests these sites function as seasonally important habitat nodes within the broader grassland landscape.

Temporal use patterns derived from events per 100 camera trap days indicate that mammal activity varied seasonally but remained consistent across sites in overall timing. Ungulates (pronghorn, white-tailed deer, mule deer, and moose) showed elevated detections during spring and fall, corresponding with known migratory and transitional movement periods, while carnivores (coyote, red fox) and other small mammals exhibited more consistent activity throughout the year with modest seasonal variation (Figure 9). Monthly pronghorn detections per 100 camera trap days aligned with previously identified migration windows, with increased activity during spring (March 22–April 10) and fall (October 31–November 10) periods across multiple sites (Figure 10), supporting the biological relevance of these priority enhancement locations. Pronghorn showed predominantly daytime activity, with lowest use during the night and highest activity during daylight hours, indicating a largely diurnal activity pattern (Jones et al. 2026). Diel activity analyses further demonstrated that white-tailed deer, red fox, and coyote maintained primarily crepuscular and nocturnal activity patterns (Figure 11) (Kitchen et al. 2000; Kautz et al. 2022). Overlap coefficients comparing 24-hour activity distributions between control and highway camera sites ($\Delta = 0.83\text{--}0.92$) indicate strong similarity, providing limited evidence of temporal displacement associated with highway proximity (Table 2); suggesting little evidence that animals shifted the timing of daily activity in relation to highway proximity.

Collectively, these results suggest that while mammals' use of these sites varies seasonally, particularly during migration periods, there is little indication that highway presence is altering the timing of daily activity. However, it seems ungulates tend to avoid the highway when they are not migrating. In the absence of the highway, we assume the enhancement sites would provide good quality summer (breeding season) habitat. But the presence of the road had changed this. Thus, while adjacent habitats may be suitable for summer occupation, they are no longer. Thus, animals like pronghorn and white-tailed deer are active by the highway for the interval when they are moving such as during migration. We assume that a road enhancement project that enables safe movement across the TCH will also improve use of habitat on the approach up to the TCH.

Which species should we consider when designing crossing structures?

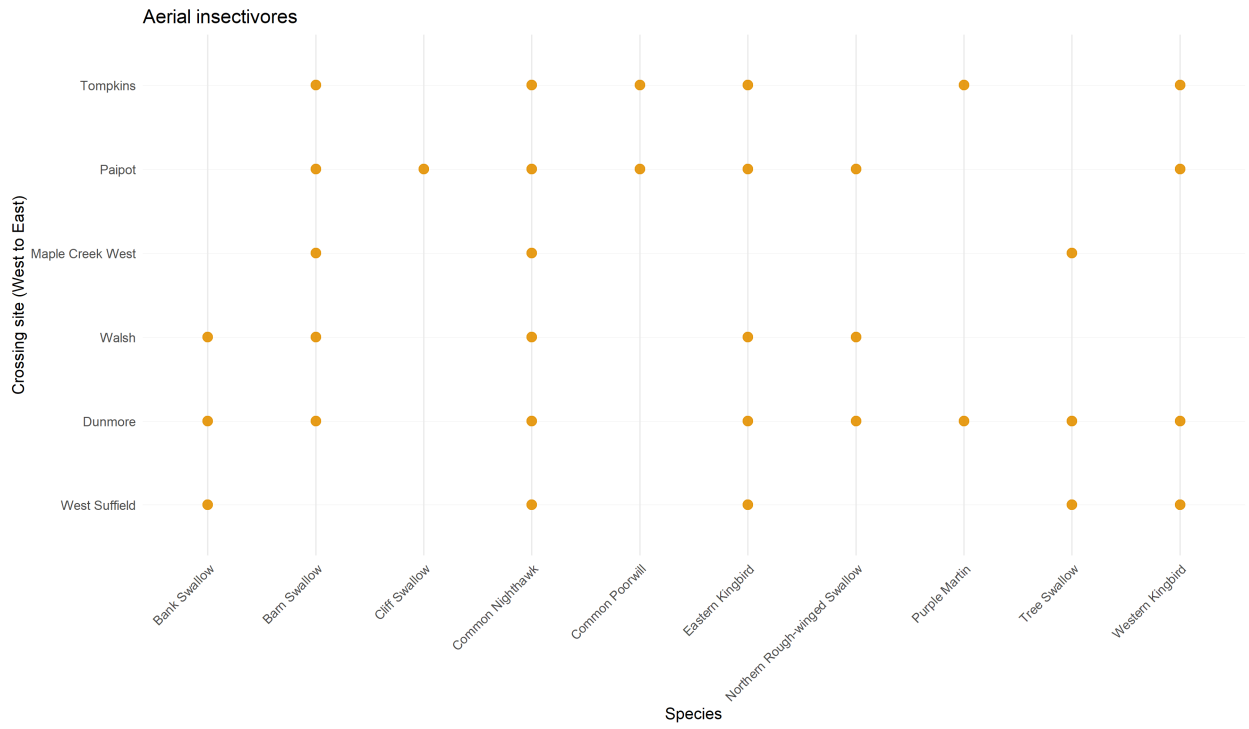
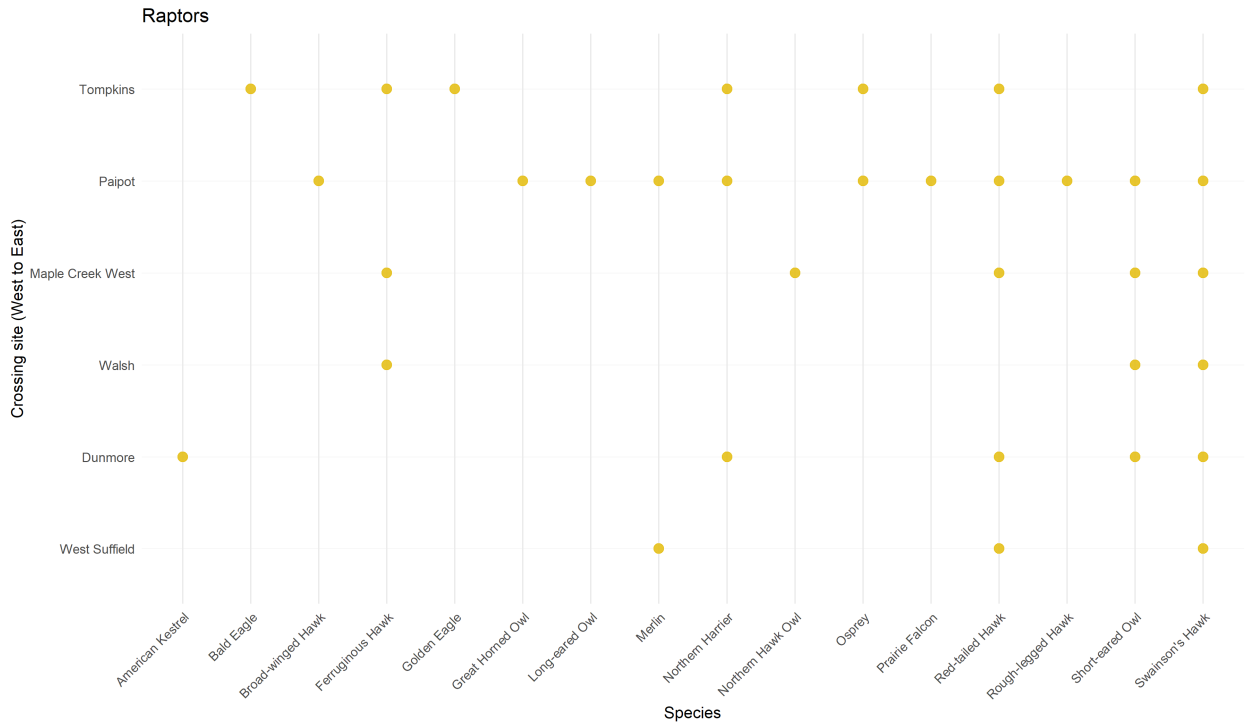
While pronghorn were the focal species for road mitigation planning, crossing structure design should consider the broader suite of species documented at these sites. Large ungulates such as white-tailed deer and mule deer generally benefit from relatively open, wider crossing structures that maintain permeability for movement (Sawyer et al. 2012; Simpson et al. 2016). Medium-sized carnivores such as coyote and red fox can use a variety of crossing structures, but their use is often shaped by structure openness, substrate, and the habitat context surrounding entrances (Jensen et al. 2022; Huijser et al. 2022). Although birds may not use crossing structures directly, repeated detections of grassland species at risk underscore the importance of minimizing additional habitat fragmentation and maintaining open prairie conditions adjacent to crossing approaches, as many prairie specialists are sensitive to patch size, edges, woody encroachment, and infrastructure-related habitat degradation (Shaffer et al. 2020; Mahony et al. 2022; Shaffer et al. 2019). Designing structures with multi-species functionality in mind will increase ecological return on investment and ensure that mitigation supports broader landscape connectivity beyond pronghorn alone. We recommend a more detailed assessment of these species to provide guidance on crossing structure design.

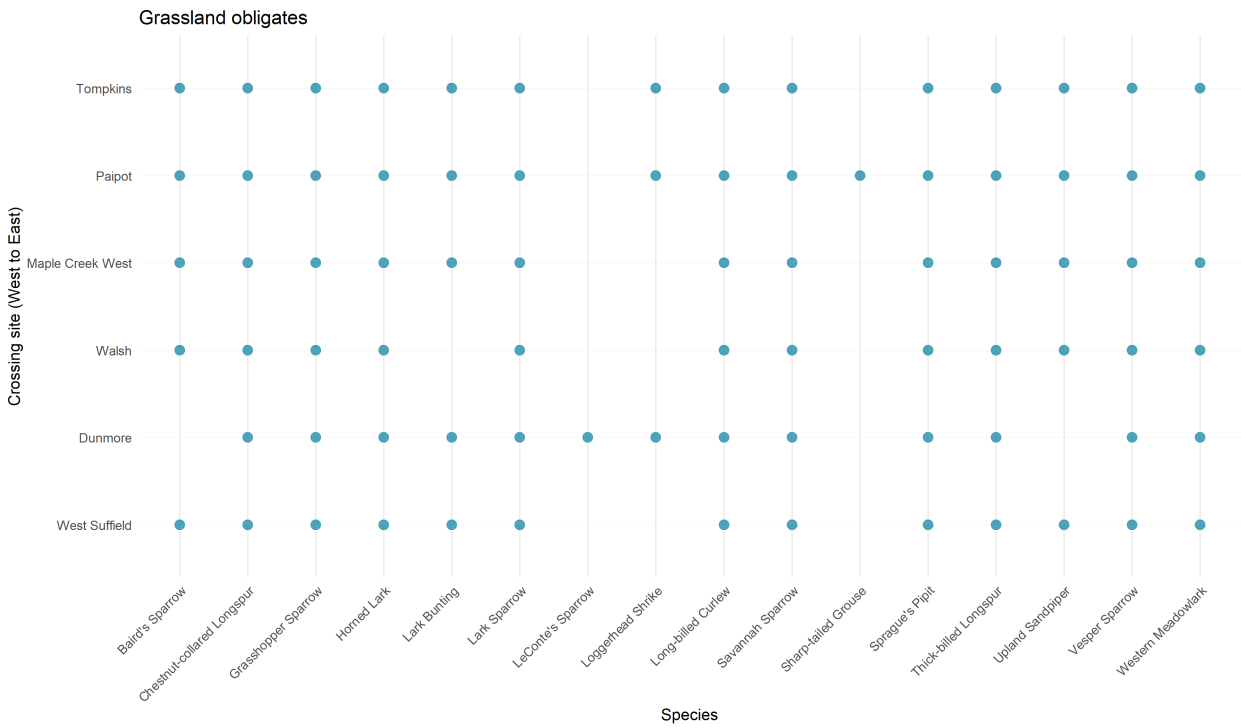
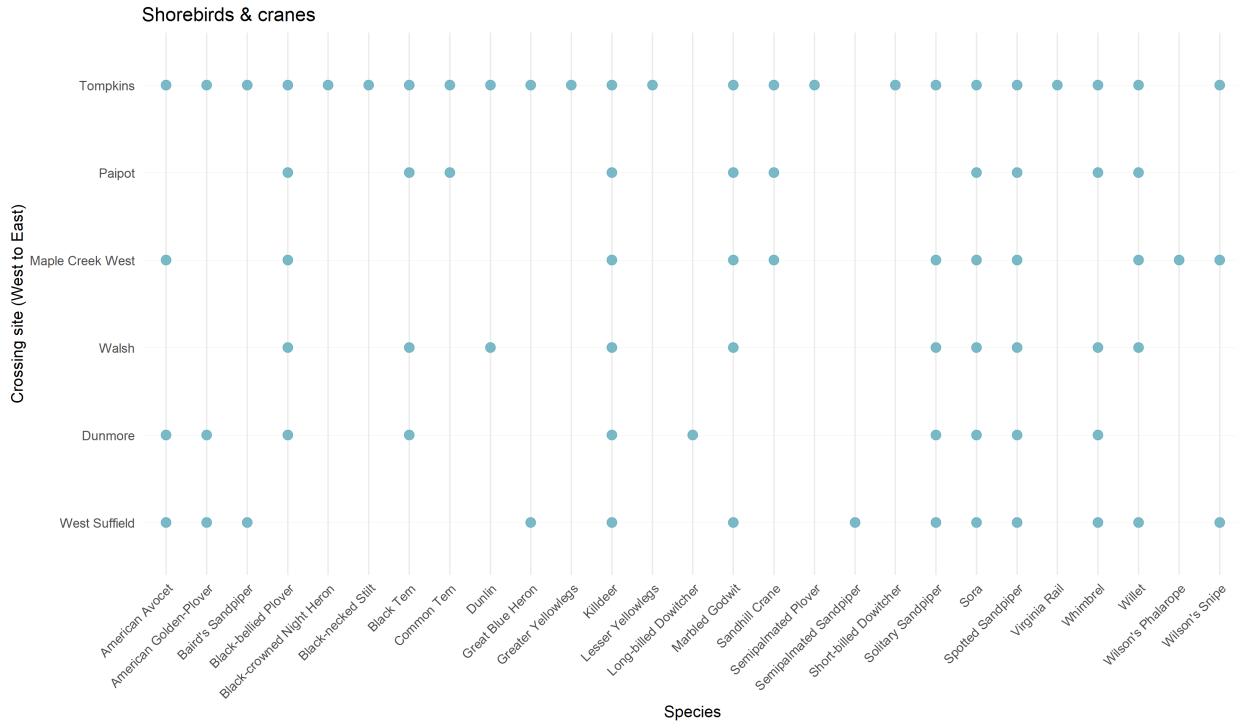
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Appendix A: Bird species per functional groups per priority road enhancement site





Appendix A: Number of species events per functional group from remote cameras.

functional group	species	events
Birds	Vesper Sparrow	165
	Brown-headed Cowbird	61
	Swainson's Hawk	41
	European Starling	31
	Western Meadowlark	29
	Black-billed Magpie	27
	Savannah Sparrow	22
	Eastern Kingbird	21
	Brewer's Blackbird	18
	Chestnut-collared Longspur	18
	Lapland Longspur	18
	Horned Lark	17
	American Robin	12
	Ferruginous Hawk	10
	Sharp-tailed Grouse	10
	Western Kingbird	9
	Red-winged Blackbird	8
	American Crow	7
	Common Raven	7
	Gray Partridge	6
	Snow Bunting	6
	Canada Goose	5
	Chipping Sparrow	5
	Clay-colored Sparrow	5
	Lark Sparrow	5
	Northern Harrier	4
	Sprague's Pipit	4
	White-crowned Sparrow	3
	Lark Bunting	2
	Loggerhead Shrike	2
Song Sparrow	2	
Bald eagle	1	
Common Grackle	1	
Ring-necked Pheasant	1	
Short-eared Owl	1	
Tree Swallow	1	
Yellow-headed Blackbird	1	
Domestic	Domestic Cow	1631
	Domestic Donkey	6
	Domestic Dog	5
	Domestic Horse	3

	Domestic Cat (House Cat)	1
Human	Human	181
Ungulates	Pronghorn	670
	White-tailed Deer	413
	Mule Deer	19
	Moose	1
Mesocarnivores	Coyote	596
	Red Fox	106
	American Badger	47
	Striped Skunk	7
	Common Raccoon	6
	Long-tailed Weasel	4
	Porcupine	4
	Weasels and Ermine	1
Small Mammals	White-tailed Jack Rabbit	189
	Richardson's Ground Squirrel	50
	Voles, Mice and Allies	21
	Northern Grasshopper Mouse	1
Unidentified	Unidentified Bird	76
	Unidentified Sparrow	46
	Unidentified	11
	Unidentified Mammal	5

Miistakis Institute
EB3013, Mount Royal University
4825 Mount Royal Gate SW
Calgary, Alberta T3E 6K6

www.rockies.ca

