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Seasonal Use of Railways by Wildlife

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Abstract: Despite the rapid advancements in the field of road ecology, very little research has been done in railway ecology. Basic research, such as railway use by wildlife, is relatively undocumented, albeit very important in understanding the potential negative and positive effects of railways on wildlife and ecosystems. We provide one of the first studies documenting wildlife railway use using motion-triggered cameras along a 20 km stretch of railway in Ontario. Our objectives were to develop a much-needed baseline understanding of railway use by endemic wildlife species, investigate differences in frequency of use among species, compare diurnal versus nocturnal use, and determine if railway use by wildlife was uniform or spatially varied. We found a significant proportion of medium-to-large resident mammalian fauna and several avian species non-uniformly using the studied railway. Some species used the railway as a travel corridor, while others appeared to use it incidentally. Diel and seasonal patterns of use were apparent for many species. Our findings emphasize the importance of species-specific investigations of railway ecology. The collection of baseline information on railway use by wildlife is critical in view of the dearth of available data, and we highly encourage further research in all aspects of wildlife–railway ecology.

Keywords: anthropogenic feature; biodiversity; mammals; birds; wildlife-train collisions; travel corridor

1. Introduction

Although the effects of roads on wildlife have been studied extensively over the past several decades, relatively little is known about the effects of railways on wildlife. The field of "railway ecology" is still in the development stage [1,2]. With a worldwide footprint of approximately 1 million km that is predicted to rise by 45% by 2050 [3], future ecological research of railways will be crucial to wildlife conservation.

Researchers often lump roads and railways together as linear corridors with the perception that the effects of railways are negligible [2]. Borda-de-Água et al. [4] state that: "Trains are not cars, and railway tracks are not roads". Road and railway structures differ physically and are used by different vehicles with different traffic rates and average speeds, and although they may affect wildlife and the environment in similar ways, the magnitude of such impacts is likely to differ considerably [1,2,4,5].

The known effects of railways on wildlife include direct loss of habitat, degradation of habitat quality, habitat fragmentation, barrier effects, disturbance, increased human exploitation, and mortality [2,6,7]. Wildlife responses to railway effects vary among species, and certain species can contradict generalities [2]. For example, railways can act as barriers to the movement of some species, such as marbled salamanders (*Ambystoma opacum*) [8] and Mongolian gazelles (*Procapra gutturosa*) [9], while others, such as moose (*Alces alces*), elk (*Cervus elaphus*), deer (*Odocoileus* spp.), and red fox (*Vulpes vulpes*) utilize railways for movement [10–14]. Interestingly, Vandevelde & Penone [15] show that railways can have positive effects for several wildlife taxa and communities—however, little research has been focused in this area.

Across the globe, more than 80 species of wildlife, ranging from mammals to herpetofauna and birds, have been reported killed by collisions with trains [16–21]. Train collisions can substantially impact wildlife populations, and for some species, are considered one of the leading causes of known mortality [14,22–25]. Although wildlife-train collision investigations are relatively common, the extent and motives of railway use by wildlife have been rarely documented. Rea et al. [13] reviewed YouTube™ video footage of ungulate-train encounters filmed with hand-held recorders—however, to our knowledge, unhindered use of railways by local wildlife in the absence of trains has not been documented. Documenting use rates will further our understanding of wildlife responses to non-road linear anthropogenic features, provide much-needed baseline information and insight into mortality risk (use versus collision rates), and inform the development of mitigation strategies for negative railway effects.

In light of the substantial underrepresentation of railway ecology, especially in terms of railway use by wildlife, our study is one of the first to document wildlife railway use by placing cameras along approximately 20 km of busy transcontinental railway in north-central Ontario. We aim to (1) develop a baseline understanding of railway use by regional wildlife species; (2) investigate differences in frequency of use among species; (3) compare diurnal versus nocturnal use among species; and (4) determine if railway use by wildlife is uniform or spatially varied.

2. Materials and Methods

2.1. Study Area

We studied wildlife use of approximately 20 km of the transcontinental Canadian National Railway (CNR) located 20–40 km south of the City of Greater Sudbury, Ontario, Canada (from 46°20′30″, 80°50′30″ to 46°11′30″, 80°50′00″, Figure 1). Freight trains moved in a north-to-south direction with speeds varying between 60 and 80 km/h with a variable schedule, passing every 20–30 min during busy periods, but more commonly, every 2–3 h [21]. In the winter, the railway was regularly cleared of snow by the CNR with a specialized rail-plough. The studied section of the railway ranged in elevation from 200 to 230 m above sea level and traversed 5 major wetlands, Great Lakes-St. Lawrence conifer-hardwood mixed forest [26], and approximately 3 km of open grasslands. The Precambrian Shield topography comprised of several rock outcrops and ridge systems, as well as rivers and lakes. The regional climate was continental with an average winter snow depth of 28 cm (Environment Canada historical data: mean of December to February 1981–2010). Endemic ungulates in the study area included white-tailed deer (*Odocoileus virginanus*), reintroduced elk, and moose. Large carnivores included black bear (*Ursus americanus*), gray wolf (*Canis lupus*), Algonquin wolf (*Canis lycaon*) and their hybrids (*Canis* spp.), lynx (*Lynx canadensis*), and bobcat (*Lynx rufus*). Medium-sized mammals included the coyote (*Canis latrans*) and coyote–wolf hybrids (*Canis* spp.), red fox, raccoon (*Procyon lotor*), fisher (*Martes pennanti*), American marten (*Martes americana*), striped skunk (*Mephitis mephitis*), river otter (*Lutra canadensis*), groundhog (*Marmota monax*), porcupine (*Erethizon dorsatum*), mink (*Neovison vison*), and snowshoe hare (*Lepus americanus*) [27]. Due to the "Canis soup", or mixture of wolf species, coyotes, and hybrids in our study area, it was difficult to distinguish between species [28]. We therefore used the term "wolves" to describe the larger canids and their hybrids that populated our study area.

The Sudbury Ornithological Society [29] listed 174 bird species known to breed in the area. Of these, less than 30 remain in the area during winter. Northern species that do not breed locally but may be spotted in the area during winter include the rough-legged hawk (*Buteo lagopus*), golden eagle (*Aquila chrysaetos*), snow bunting (*Plectrophenax nivalis*), and snowy owl (*Bubo scandiacus*).

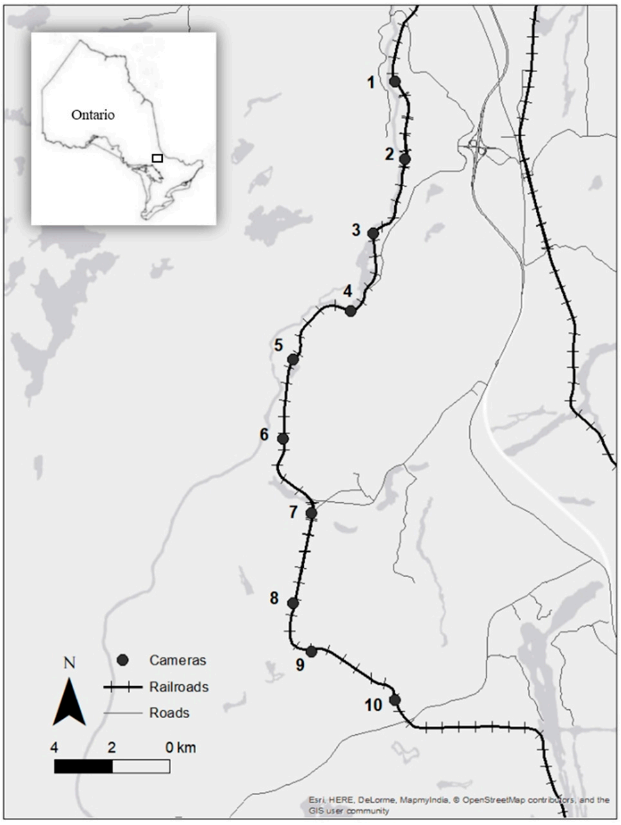

Figure 1. Trail camera placement along the 20 km studied section of the Canadian National Railway, approximately 20–40 km south of the City of Greater Sudbury, ON, Canada.

2.2. Cameras

From the beginning of July 2015 to the end of June 2016, 10 trail cameras (brands: Bushnell, Stealth Cam, Tasco) were placed along the 20 km stretch of studied railway, one every 2 km, attached to rail-side trees and directly facing the railway (Figure 1). Cameras were set to record a burst of 3 images when motion was detected, and to stop recording for 5 min after the initial burst to prevent an excess of train photos. Camera batteries and cards were replaced every 1–3 months, depending on the season. Because some wildlife species in our study area were gregarious in nature (e.g., elk), regardless of the number of animals in an image, one photo was considered a single capture event and the total number of capture events were documented per season. To reduce the chance of resampling the same animals, all capture events recorded within one hour from the initial capture were omitted from the data set. To account for occasional camera malfunction (e.g., dead batteries, fallen camera, vegetation growing to block image; affected 0 to 40% of cameras depending on season), we calculated the mean number of capture events/species/season/camera, weighting the mean with the percentage of times each camera functioned properly. We multiplied the resulting means by the number of cameras in 10 km ($n = 5$) to obtain the average number of capture events/species/10 km. Seasons were defined as "spring"—21 March to 20 June; "summer"—21 June to 20 September; "fall"—21 September to 20 December; and "winter"—21 December to 20 March. We also calculated the number of night- and day-capture events for each species per season, and the total number of species and capture events recorded per season and per camera.

3. Results

We analysed 689 capture events—488 of mammals and 201 of birds. Captured bird species included the American crow (*Corvus brachyrhynchos*), sandhill crane (*Antigone canadensis*), rock dove (*Columba livia*), common raven (*Corvus corax*), rose-breasted grosbeak (*Pheucticus ludovicianus*), turkey vulture (*Cathartes aura*), common grackle (*Quiscalus quiscula*), snow bunting, blue jay (*Cyanocitta cristata*), and ruffed grouse (*Bonasa umbellus*). Captured mammal species included the black bear, bobcat, white-tailed deer, elk, groundhog, snowshoe hare, marten, mink, moose, raccoon, red fox, and wolf (Figures 2–4).

Figure 2. Some of the birds and mammals captured by cameras along 20 km of the studied railway from 2015 to 2016 (clockwise from top-left: elk, sandhill cranes, wolf, turkey vultures).

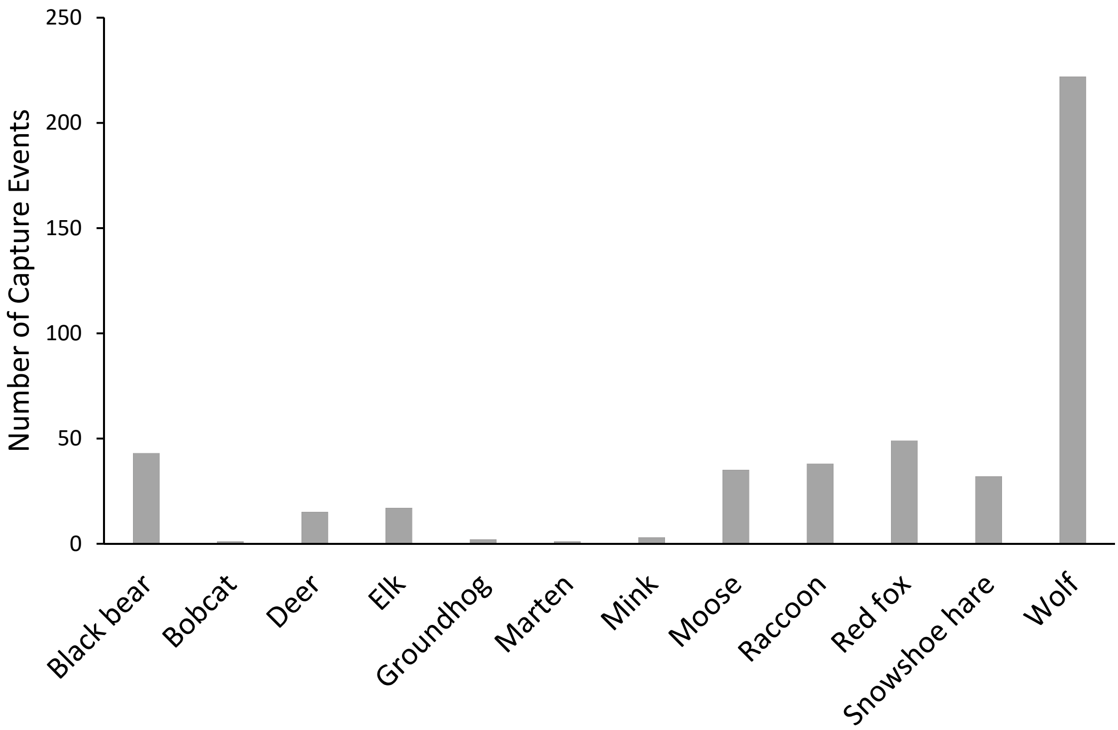

Figure 3. Mammal species capture events recorded by cameras on 20 km of the studied railway in one year (2015 to 2016).

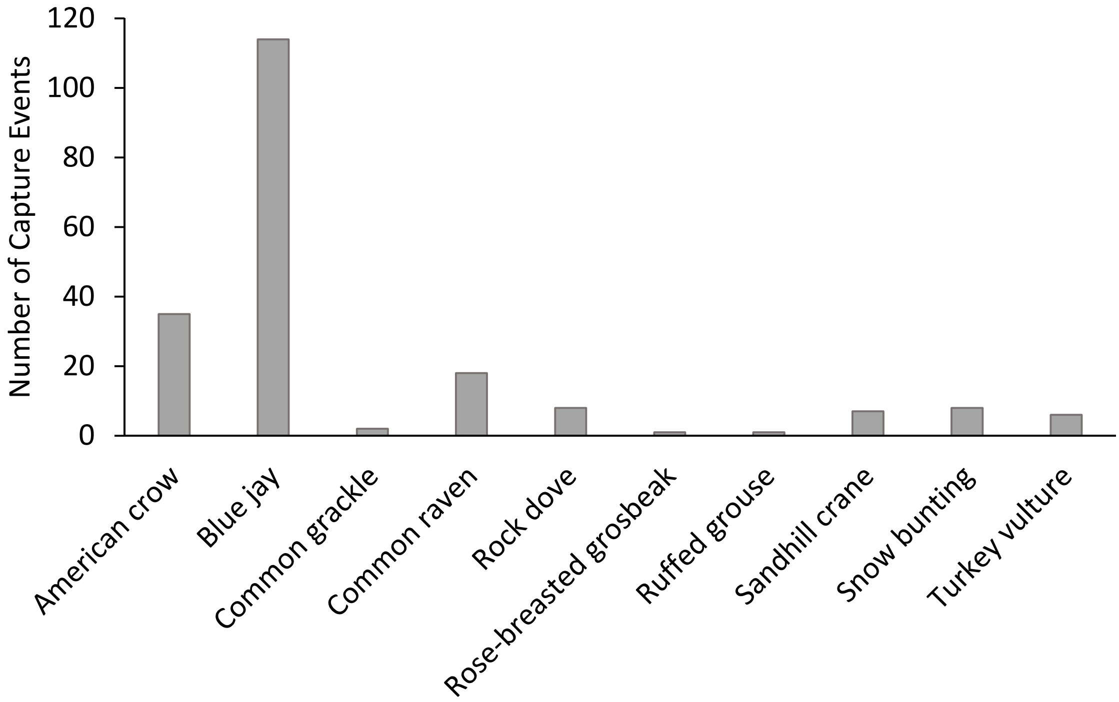

Figure 4. Bird species capture events recorded by cameras on 20 km of the studied railway in one year (2015 to 2016).

All three endemic ungulates and all endemic large carnivores (black bear and wolves) used the railway regularly in the course of the year. The bobcat was photographed on the railway only once, and the lynx, rare in the area, was not recorded. Three medium-sized mammals (red fox, raccoon, and snowshoe hare) also used the railway with regularity. In total, 13 out of the 17 (77%) medium-to-large mammal species living in the area were recorded on the railway at least once during the year. Wolves used the railway more frequently than any other mammal species, totalling 222 capture events, whereas other mammal species were captured between 1 and 49 times (Figure 3). Wolves were recorded at least once at 9 of the 10 camera sites. Most wolf capture events (66) were obtained from camera 7, followed by 60 events at camera 9. These two camera sites were in the southern, mostly forested half of the studied railway section with little human presence. Scrutiny of daylight wolf pictures revealed up to 30 different individuals on the 20 km of railway. Some of the wolves appeared at multiple camera sites, indicating a wide range of movement along the railway. The red fox was the second most frequently photographed mammal on the railway, with 47 capture events (Figure 3).

The diversity of captured bird species paled in comparison to the diversity of the recorded mammal species—however, the capture ability of cameras likely differed between birds and mammals as birds may quickly move through a frame. The blue jay was recorded on the railway more than any other bird species, with a total of 114 capture events. However, 105 of these events occurred at camera 6 between November and May. Other frequently recorded birds were the American crow with 35 capture events, and the common raven with 18 capture events. All three corvid species remained in the area year-round. Capture events for all other bird species ranged from 1 to 8, indicating relatively low use or capture ability of the camera as animals flew through the frame (Figure 4).

Seasonal use of the railways varied among the recorded wildlife species (Tables 1 and 2). Average use for all mammals was greatest in summer, followed by fall, spring, and winter, respectively (Table 1). It was apparent that some mammal species, like the bobcat, groundhog, American marten, and mink, were photographed on the railway only incidentally. However, other species, like the wolf, red fox, moose, raccoon, black bear, and snowshoe hare used the railway regularly, some showing distinct seasonal use patterns (Table 1). Black bears hibernate from late fall to early spring, and were thus absent from the railway in winter. Similarly, raccoons showed only sporadic winter activity, primarily during thaw periods. Deer migrate out of the study area during the fall and return in early spring. Elk frequented the railway mostly in late fall and early spring (Table 1).

Table 1. Mean number of seasonal camera capture events of mammals per 10 km of railway for one year (2015 to 2016).

Species	Spring	Summer	Fall	Winter
Black bear *	6.5	14.3	3.0	0.0
Bobcat	0.5	0.0	0.0	0.0
Deer	1.5	6.8	0.0	0.0
Elk	3.5	1.1	4.2	0.5
Groundhog	1.0	0.0	0.0	0.0
Snowshoe hare	4.0	10.3	3.0	0.6
Marten	0.0	0.0	0.6	0.0
Mink	0.0	1.1	0.6	0.0
Moose	3.0	4.6	7.1	5.0
Raccoon	9.0	6.8	1.2	3.3
Red fox	10.0	5.7	5.9	5.0
Wolf *	13.5	41.1	43.3	27.8
Total	52.5	91.9	68.9	42.2

* Adapted from Donovan and Popp [30].

Table 2. Mean number of seasonal camera capture events of birds per 10 km of railway for one year (2015 to 2016).

Species	Spring	Summer	Fall	Winter
American crow	9.0	6.3	0.0	3.0
Blue jay	5.0	4.0	16.0	35.0
Common grackle	0.5	0.6	0.0	0.0
Common raven	0.5	8.6	0.0	1.0
Rock dove	0.5	1.1	3.0	0.0
Rose-breasted grosbeak	0	0.6	0.0	0.0
Ruffed grouse	0.5	0.0	0.0	0.0
Turkey vulture	3.0	0.0	0.0	0.0
Sandhill crane	3.5	0.0	0.0	0.0
Snow bunting	1.5	0.0	0.0	2.5
Total	24.0	21.1	19.0	41.5

Seasonal use of the railway by birds appeared highly dependent on the species' migratory habits. However, with the exception of blue jays, most capture events were recorded in the spring (Table 2). Incidental and/or opportunistic use of the railway during the snow-free period was recorded for the ruffed grouse, turkey vulture, sandhill crane, and rose-breasted grosbeak. The blue jay, common raven, American crow, rock dove, and common grackle were present on the railway in at least two seasons. Migratory species left the study area in the fall, and only the snow bunting, blue jay, American crow, and common raven used the railway regularly during winter (Table 2).

On average, railway use by mammals was most frequent during the night; however, some species (e.g., black bear, elk, groundhog, marten) were recorded mostly during the day. As no owls or other nocturnal birds were captured by the cameras, bird use was documented exclusively during the day (Table 3).

The number of mammal and bird capture events, as well as the number of recorded species, varied among cameras for both birds and mammals (Tables 4 and 5).

Table 3. The percentage and total number (n) of camera capture events of mammals on the railway during the day and night for each season (2015 to 2016).

	Spring			Summer			Fall			Winter		
Species	**Day**	**Night**	***n***	**Day**	**Night**	***n***	**Day**	**Night**	***n***	**Day**	**Night**	***n***
Black bear	85	15	13	62	38	26	20	80	5	-	-	0
Bobcat	0	100	1	-	-	0	-	-	0	-	-	0
Deer	100	0	3	0	100	12	-	-	0	-	-	0
Elk	86	14	7	0	100	2	86	14	7	-	-	0
Groundhog	100	0	2	-	-	0	-	-	0	-	-	0
Snowshoe hare	25	75	8	56	44	18	0	100	5	0	100	1
Marten	-	-	0	-	-	0	100	0	1	-	-	0
Mink	-	-	0	0	100	2	0	100	1	-	-	0
Moose	13	88	5	25	75	8	42	58	12	33	67	9
Raccoon	15	85	16	17	83	12	0	100	2	0	100	6
Red fox	15	85	20	13	88	8	20	80	10	0	100	9
Wolf	38	63	32	30	70	76	22	78	73	39	61	62
Total n	46	61	107	54	110	164	31	85	116	27	60	87

Table 4. Mammal capture events and number of species at each camera along the 20 km studied section of railway from 2015 to 2016.

Camera	Total Capture Events	Number of Species
1	8	3
2	24	5
3	58	10
4	62	6
5	5	3
6	59	6
7	111	7
8	49	6
9	105	10
10	7	4

Table 5. Bird capture events and number of species at each camera on the 20 km stretch of studied railway from 2015 to 2016.

Camera	Total Capture Events	Number of Species
1	2	1
2	17	3
3	16	3
4	2	1
5	6	1
6	111	4
7	8	3
8	2	2
9	32	5
10	5	1

4. Discussion

We documented frequent railway use by the majority of medium-to-large mammal species endemic in our study area. Mammals frequented the railway more than twice as much as birds; however, cameras may have had reduced capture ability for birds, which are likely to quickly enter and exit a frame. Larger species, such as moose, elk, and wolves, and medium species, such as the raccoon and red fox, often used the railway as a travel corridor, while other species appeared to use the railway incidentally. Railway corridors can provide relatively direct and easy travel routes for large- and medium-sized mammals, such as ungulates, carnivores, rodents, and lagomorphs [18].

Although frequent railway use could result in increased mortality risk through wildlife-train collisions, Hamr et al. [21] found that ungulates were the most common species killed by trains in our study area, although we showed that wolves used the railway most frequently. During 10 years of winter mortality surveys of the same 20 km section of railway, Hamr et al. [21] found 50 elk, 26 moose, 2 wolves, and 1 bear killed by trains. Other species killed by trains which were found during the surveys included 20 ruffed grouse, 4 coyotes, 4 snowshoe hares, 2 white-tailed deer, 2 raccoons, 1 porcupine, 1 turkey vulture, and 1 snow bunting. A general comparison of wildlife railway mortality and use from both studies suggests that carnivores (e.g., wolves, bears, foxes, racoons) are more adept at avoiding train collisions than ungulates and gallinaceous birds. Herbivores are generally struck more often by trains than carnivores, which could, however, be reflective of their relative abundance [31]. Our findings confirm that wildlife responses to railway effects vary among species [17,31,32], and species-specific investigations are important and much-needed due to very little existing railway ecology research.

Variable diel and seasonal use of the railway by birds and mammals also reflected species-specific activity, habitat use, and migratory patterns. Use was not uniform along the railway, suggesting that some specific areas were preferred by wildlife. Further investigation of habitats in relation to use would be ideal. Rea et al. [13] found that moose recorded on video using railways were always found in forested areas with mosaics of plantations and streams. Heerschap [33] reported moose-train collisions in forested areas of central Ontario. These findings suggest that habitat is an important predictor of wildlife railway use. Although very little research has investigated patterns of wildlife railway use, railway collision hotspots have been identified for several species and are likely an artifact of changes in habitat and topography along the railway [21,32,34].

Aside from railways acting as an easy travel corridor for wildlife, other attractive attributes of railways have been identified. Railways can increase forage opportunities for herbivorous and granivorous species through grain spills and rail-side vegetation management [5,25,35,36], and also create scavenging opportunities for carnivores and omnivores through carcasses resulting from wildlife-train collisions [35]. Gangadharan et al. [36] found that train-spilled grain along a 134 km stretch of railway in Alberta, Canada, could provide the entire annual caloric needs of 42 to 54 grizzly bears. Incidental observations in our study area confirmed that birds were attracted to grain spills along the studied railway section. We also found several photos of wolves carrying meat from a dismembered carcass along the railway and vultures congregating for long periods at one camera site, likely due to a recent train-kill. Scavenging opportunities further exuberate train-collision risk to animals attracted to the railway.

5. Conclusions

We provided one of the first documentations of wildlife railway-use through motion-triggered cameras. Our study revealed the presence of a significant proportion of the resident medium-to-large mammalian fauna on the railway in the course of one year, and extensive non-uniform seasonal use of the railway as a travel corridor by some species. Railways have been in place for a long time and are treated by animals as another habitat feature; however, little is known about the variable effects of railways on wildlife species. Large knowledge gaps still exist with respect to railway ecology. A greater understanding of wildlife–railway interactions could assist with collision prevention and other mitigation strategies, providing insight as to the effects of different linear landscape features on wildlife population dynamics, especially for species at risk. We highly encourage further research of all aspects of wildlife–railway ecology.

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