EFFECTS OF CONCRETE BARRIERS ON WILDLIFE CROSSING IN THE WEST KOOTENAY REGION, BRITISH COLUMBIA

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February 29, 2020

Disclaimer

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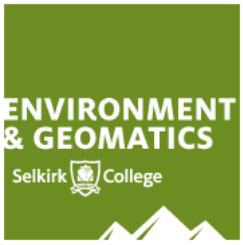


1. Abstract

I explored the effects that animal vehicle collisions have on vehicle operators as well as wildlife species through extensive literature based research. I also examined the relationship between roadways and wildlife, and specifically how roadways can isolate populations, fragment habitat, and fragment territories, as well as how structures along roadways impact animal crossing. I conducted a pilot study along the 42.6 kilometer stretch of Highway 3A from Castlegar to Nelson, British Columbia. The field work involved using ArcGIS's Survey123 application to record roadkill data points over a four-month study period. The objective of this study were to determine the animal species most frequently stuck along this stretch of highway, identify roadkill hotspots, determine if there is an increase in the number of animals hit when there are concrete barriers present along the sides of this highway, and to determine an effective roadkill mitigation technique that could be implemented along Highway 3A. From the pilot study I determined there is no obvious relationship between the number of animals struck and concrete barriers being present along the side of the highway. From my study I found wild turkeys to be the most frequently hit species, followed by black bears and squirrels. I identified and mapped out two prominent roadkill hotspots along Highway 3A and determined through background research that the most effective roadkill mitigation technique would be an overpass at each roadkill hotspot with at least five kilometers of fencing on either side of the entrances to the overpasses. I concluded that the relationship between roadways and wildlife needs to be better understood and that similar future studies would be valuable to better understand these relationships. It would be valuable for the Ministry of Transportation and Infrastructure to invest more money into implementing more roadkill mitigation techniques such as crossing structures combined with fencing to prevent future vehicle-animal collisions.

2. Introduction

Animal vehicle collisions have negative effects on both wildlife and people. According to wildlifecollsions.ca, it is estimated that, on average, three people are killed due to vehicle animal collisions, 6,100 animals are recorded as dead, and 18,300 animal deaths will go unrecorded in British Columbia (BC) every year (The Facts…c2004-2019). According to drivesmartbc.ca, 8000 collisions happen every year in BC resulting in ICBC paying out more than twenty million dollars for the insurance claims and the Ministry of Transportation paying out more than six

hundred thousand dollars in clean-up fees (Wildlife Collisions…c2004-2019). Looking at these statistics and the lack of studies done on ways to mitigate animal-vehicle collisions, it is obvious to me that there should be more research on this problem.

This paper will explore the impact that animal-vehicle collisions have on wildlife populations, different approaches scientists have taken to determine the causes of roadkill incidents, and whether or not certain mitigation strategies are actually keeping wildlife off roadways. Included in this examination is the results of a pilot study I conducted on the relationship between roadkill and concrete barriers in the West Kootenay region. I'll conclude this research paper with recommendations for future management of West Kootenay roads to mitigate the incidence of animal-vehicle collisions. The main goal of my pilot study was to determine whether or not there is a relationship between concrete barriers and animal crossing. The objectives of my study are to:

- Determine the animal species that are most frequently struck by vehicles on Highway 3A between Castlegar and Nelson, British Columbia.
- Identify roadkill hotspots along that same stretch of highway.
- Determine if there is an increase in animals hit when there are concrete barriers present along the roadside.
- Determine a potential effective roadkill mitigation technique for Highway 3A.

3. Background Information

We lose many wildlife species to animal-vehicle collisions in Canada every day, for a variety of reasons that are not totally clear to scientists because of the lack of studies and understanding on the topic. It appears that many studies document the incidence and types of roadkill species but do not focus on the reasons why these animals have been struck. A study conducted by Plante et al. (2018), for example, demonstrated that roads are a serious killer for a variety of species in Canada. The authors collected roadkill data along Highway 175, located between Jacques-Cartier National Park and the Montmorency Forest in Quebec. During the three-year study period the authors observed a total of 839 animals killed due to being struck by a vehicle (Plante et al. 2018). A similar study, also in Canada by Bishop et al. (2013), focused on the negative effects that roadways have on birds. They found that 157 different species of birds and at least 14,287

individuals were killed per day per km in Canada. On one to two lane roads 1,167 birds are killed per 100 km during the 122-day breeding season (Bishop et al. 2013). They concluded that, in Canada, every year approximately 0.28% of our total land birds are killed due to roadkill (Bishop et al. 2013). This is relevant because it puts into perspective just how much wildlife we lose throughout Canada due to roadkill, as well as why it is so important to obtain information on the relationships between wildlife and roadways.

Certain species are negatively affected by roads on multiple scales because of a lack of understanding of the relationship between wildlife crossing and roadways. Habitat fragmentation, population isolation, and territory fragmentation, are some of the secondary effects roadways have on wildlife. For instance, Sunga et al. (2017) modelled the effects of human development on badger burrow placement and found that road density within home ranges of badgers ranged from 0.48-3.52 km^2. The researchers tagged and tracked nine badgers and three of these badgers were killed due to vehicle collisions (Sunga et al. 2017). They concluded that road mortality was the leading cause of death for radio tracked badgers in this study and likely for badger carcasses found throughout Ontario. Roads affected badgers at multiple spatial scales, including burrow site selection, and movement within their home ranges (Sunga et al. 2017). A study conducted by Find'o et al. (2019) examined brown bear (*Ursus arctos)* roadkill in Slovakia over an 895 km stretch of road. The authors concluded that high traffic areas (defined as having volumes exceeding >4000 vehicles every 24 hours) impeded the bears' movements and that the likelihood of collisions increased with these higher traffic volumes (Find'o et al. 2019). A study by Howell et al. (2019) concluded that roadways can isolate individual spotted turtle (*Clemmys guttata*) populations and, in doing so, drastically decrease the population's intrinsic growth, ultimately leading to population extinction. Four turtles were found dead over the three-year study period due to vehicle collisions, meaning 13% of the entire North Wetland Complex turtle population was lost (Howell et al. 2019). There is a need to better understand the relationship between wildlife habitat and roadways so that in the future, roads can be constructed in a more accommodating way for wildlife, allowing more connectivity for different wildlife populations.

The need to better understand the relationship between animals and the structures alongside roads is important. Are the structures installed alongside roads a hindrance to animals crossing

the road or do these barriers help prevent roadkill from happening? A relevant study by Kreling et al. (2019) demonstrated a relationship between artificial streetlights and fencing and the amount of roadkill. A total of 473 animals were killed by vehicle collisions over a 10.5-year period on a 50 km stretch of road in the United States. Their original inference that fencing would prevent roadkill was actually incorrect. They concluded that fencing length was related to roadkill numbers (Kreling et al. 2019). This study demonstrates the need to better understand the relationship between structures alongside our roadways and how they might have an effect on wildlife crossing.

A study in British Columbia was conducted by Eye et al. (2018) to explore the relationship between exclusion fencing and the effects it has on the Northern Pacific Rattlesnake (*Crotaus oreganus*), Great Basin Gopher Snake (*Pituophis catenifer deserticola*), and Western Yellow-bellied Racer (*Coluber constrictor mormon*). The rattlesnake and the gopher snake are listed as threatened in Canada and the racer has been recommended for listing as threatened (Eye et al. 2018). In order to mitigate negative human-snake conflicts a four-kilometer exclusion fence was built in 2006 to separate natural snake habitat from high human traffic areas (Eye et al. 2018). But, in 2006, after initial construction of the fence, dead snakes were observed along a newly constructed section of the fence (Eye et al. 2018). The fence was responsible for 33% of snake mortalities. The specific section of the fence where the most snake mortalities were observed runs parallel to a lake, restricting access to riparian habitat and allowing the snakes to rehydrate, hunt, and seek shelter from extreme summer heat (Eye et al. 2018). The authors found that relatively active species of snakes, or snakes that migrate, are more likely to encounter these fences and other disturbances, and become isolated from crucial resources (Eye et al. 2018). This study highlights the lack of understanding of the relationship between mitigation techniques and select species. It also confirms the lack of understanding of the behaviour of snakes and that these mitigation techniques and roads alike, can both cause unintentional habitat fragmentation.

There isn't a lot of information readily available that compares the effectiveness of roadkill mitigation techniques available on the market and studies previously done on the topic are lacking certain pertinent information on the before and after effects of these techniques. The problem with these roadkill mitigation techniques is that they are typically chosen on the basis of cost and that there is little reliable information about the relative effectiveness of these measures

in reducing roadkill numbers (Rytwinski et al. 2016). The reason why choosing the right mitigation technique can be so challenging for decision makers is because studies that evaluate the effectiveness of these mitigation techniques often lack comparisons between impact sites and control sites, data collection before the mitigation technique is applied, replication in space and time, and randomization of impact and control sites across the pool of potential study sites (Rytwinski et al. 2016). Rytwinski et al. (2016) determined that mitigation techniques reduce roadkill by approximately 40% when compared to controls. The authors determined that fences, with or without crossing structures reduced roadkill by 54%. Fencing alone was determined to reduce roadkill by 86%, and when combined with crossing structures, reduced roadkill by 51% which is likely due to the fact that when fencing is paired with crossing techniques, the fences tend to be shorter than when compared to fencing-only designs, which tend to cover longer stretches of roads (Rytwinski et al. 2016). The author also determined that crossing structures were not effective at reducing roadkill unless fences were present. The author determined that more expensive mitigation techniques were more effective at reducing roadkill than the more inexpensive techniques. For example, Rytwinski et al. (2016) observed an 83% reduction in roadkill for fencing with crossing structures, and a 57% reduction for animal detection systems, compared to 1% for wildlife reflectors. This study demonstrates the importance of better understanding the effectiveness of these roadkill mitigation techniques, as well as the importance of understanding that the cheapest mitigation technique is not the most effective, and that in the future we should invest more money into proper mitigation techniques. As a result of these mitigation techniques, not only will wildlife be better protected, but so will the people operating vehicles on these roadways.

4. Pilot Study

4.1 Methods

4.1.1. Study Area

My study area is located on Highway 3A, from 301 Frank Beinder Way (Selkirk College) to the intersection between Granite Road and Government Road in Nelson, British Columbia (Figure 1). It is a 42.6km length of a two-lane highway. Along this stretch of highway there are several concrete barriers along one or both sides of the road to help prevent drivers from driving off the shoulder of the road. This

stretch of highway runs along the Kootenay River and a set of train tracks. The highway runs beside several rural homes, a few farms, and other types of industrial development.

My study area is located in the Very Dry Warm Interior Cedar-Hemlock (ICHxw) BEC Zone, with the Very Dry Warm Interior Cedar-Hemlock Warm Phase (ICHxwa) adjacent to it (Mackillop et al. 2016). This BEC Zone is commonly made up of Douglas fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), and pine grass (*Calamagrostis rubescens*). But western redcedar (*Thuja plicata*), grand fir (*Abies grandis*), and western white pine (*Pinus monticola*) are also abundant in this unit (Mackillop et al. 2016). According to Mackillop et al. (2016) this BEC zone is characterized by high shrub cover of mallow ninebark (*Physocarpus malvaceus*), oceanspray (*Holodiscus discolor*), mock-orange (*Philadelphus lewisii*), snowberry (*Symphoricarpos albus*), beaked hazelnut (*Corylus cornuta*), Oregon-grape (*Mahonia aquifolium*), and Douglas maple (*Acer glabrum*). At some points along Highway 3A there is dense forest cover which provides cover for a variety of species of wildlife and could potentially make wildlife alongside the roadway harder to see.

This BEC zone is habitat to a variety of species at risk such as Lewis's woodpecker (*Melanerpes lewis*), western screech-owl (*Megascops kennicottii kennicottii*), great blue heron (*Ardea herodias Herodias*), and little brown myotis (*Myotis lucifugus*) (Mackillop et al. 2016). In the ICHxw BEC zone you can also find a variety of at-risk reptiles in rocky outcrops and cliff areas such as the western skink (*Plestiodon skiltonianus*), northern rubber boa (*Charina bottae*), and North American racer (*Coluber constrictor)* (Mackillop et al. 2016). The BEC unit also provides key winter ranges for mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), elk (*Cervus elaphus*), and bighorn sheep (*Ovis canadensis*) (Mackillop et al. 2016). It is also important to note that this BEC unit also has the highest bird diversity in the region (Mackillop et al. 2016).

4.1.2. Data Collection

For my study I collected field data as well as relied on volunteers to collect data on my behalf. I had four volunteers collecting data starting from October 19, 2019 until February 9, 2020. These people volunteered to collect data because they commuted every day from Nelson to Castlegar for school. They drove the study area typically once in the morning and once in the early afternoon or evening. The most efficient method of data collection was done by a passenger in a vehicle to ensure accurate data collection as well as the safety of the person collecting the data. If data collection was done by one individual then it was safest for that person to pull off on a wide shoulder of the road or a pullout and turn on their hazards to ensure their own safety, and to get accurate data collection. Data was collected by recording roadkill points along Highway 3A on a tablet that is GPS enabled. I used ArcGIS's Survey123 application to

collect the data points. It is important to note that in order to be able to collect data the user is required to download the Survey123 application as well as my survey onto their device.

Components of my survey include:

- Automatically updated time and date of collection
- GPS location of the data point
- A required field to fill out the name of the person collecting the data
- A dropdown menu to select the species found. There is the option for an 'other' category if the species wasn't listed in the dropdown menu, as well as 'unknown' if the volunteer can't properly identify the species.
- There was also a question asking whether or not there was a concrete barrier present alongside the road. The answers included 'yes', 'yes, one on each side', and 'none present'.
- The final fillable area of the survey was a comment section where users could choose to add any other relevant information to their survey submission.

4.1.3. Data Analysis

Each time a data point was collected with my survey the information was sent to me through the ArcGIS Survey123 website. Once I closed my survey, I could see all the data points collected, what species were found, whether there were barriers present, and the number of each species that had been found.

I used ArcMap to build the map and used a high-quality base map layer provided by ArcMap to be able to see the concrete barriers from a satellite view. I then created a line feature class by tracing the barriers I could see on the image that were located in close proximity to a roadkill data point.

4.2 Results

There was a total of fifteen roadkill points documented using my survey from October 22, 2019 to November 27, 2019. The roadkill species that were documented the most were wild turkeys (*Meleagris gallopavo*), followed by squirrels (*Sciuridae sp.*) and black bears (*Ursus americanus*). From the survey it was determined that along the side of Highway 3A where a mule deer carcass was found, there was one concrete barrier present. There were also two other occasions were a concrete barrier was present alongside the highway where two turkey carcasses were found. There were two key roadkill hotspots identified on Highway 3A that were approximately three to four kilometers in length (Figure 1). Other than the three cases recorded in the survey, the rest of the roadkill points don't have a concrete barrier present alongside the road. The other species identified during the survey period included a domestic cat

(*Felis catus*), a raccoon (*Procyon lotor*), a striped skunk (*Mephitis mephitis*), a song bird, and a hare (*Lepus sp)*.

5. Discussion

From the results of this pilot study, the presence and distribution of concrete barriers do not appear to be related to a higher incidence of wildlife killed by vehicles along Highway 3A. In general, these roadside barriers tend to be in areas that do not appear to be conducive for wildlife corridors or habitat and are less than one meter in height and, therefore, easy for large mammals to pass over. This is likely due to the fact that these barriers are typically placed in areas near bridges and sharp corners with steep embankments to one side of the road. It can be speculated that areas where these barriers are located don't offer very desirable habitat due to the steepness of the slopes and the amount of infrastructure such as bridges or intersections where these barriers are placed.

Wild turkeys are a commonly found species in the West Kootenay region, and as a result, are quite commonly struck by vehicles in this region. Wild turkeys were the most commonly killed wildlife species during the study likely due to their large numbers in the region, the ease of identification of this distinctive large bird, and their slow and often unpredictable movements. Another source determined that pheasants, which are similar ground dwelling birds to turkeys, are commonly killed due to their short flight distances and relatively small brains (Unknown…2017). The fact that turkeys were the most frequently struck species could be linked to a variety of reasons, one of which, is the fact that wild turkeys are common in the area. The wild turkey population was estimated to be approximately 4000-5000 birds in 2004 (Wild Turkey…c2015-c2020)), and has likely increased since that time because the species has expanded throughout the Kootenay region (Wild Turkey…c2015-c2020). Other reasons could be that they are observed regularly along roadways or that they are more noticeable when hit due to their large size and characteristic appearance when compared to other birds and small mammals, therefore they are more likely to be recorded.

Black bears were the only bears found during the time of my roadkill survey likely due to their high population in the West Kootenay region and the timing of the survey. At the time of my survey for roadkill, during October and November, fall is an active time for black bears to begin bulking up fat reserves to be able to survive hibernation. Bears go through a phase of nonstop eating and drinking in order to gain weight in the fall called hyperphagia (When Bears…c2018-c2020). My theory is that during these fall months the black bear roadkill numbers are more likely to increase due to the active survival driven nature of the black bears at this time. I believe their active nature during fall makes them more desperate to find food, and as a result, more active and vulnerable to being struck by a vehicle. It is also

necessary to note that black bears are more easily habituated to people than grizzly bears are. This is likely why they are more likely to be struck by a vehicle than a grizzly bear would be. Although grizzly bears can be found in the West Kootenay region (Grizzly Bear…c2012-c2020), they are less likely to be struck by a vehicle due to their inherent nature to avoid people populated areas. It can be speculated that the reason why black bears are recorded frequently when compared to other species is due to their large size and characteristic appearance. People would be more likely to notice a road killed black bear than say a road killed songbird or rodent.

From my pilot study I found two roadkill hotspots located along Highway 3A, each of which ranges from two to three kilometers in length, and contains at least four roadkill points within each area. From the data I mapped two prominent roadkill hot spots along Highway 3A (Figure 1). Each roadkill hot spot has about four roadkill points spread about half a kilometer to one kilometer apart. Highway 3A is a pretty bendy road with dense trees to either side of the highway in sections, and steep rocky embankments that reduce visibility for drivers as they drive around corners. According to Ogletree et al. (2019) curves and hills are factors that lead to roadkill hotspots due to the limited line of sight, particularly in the evening or at night. A study by Williams et al. (2019) determined that species abundance, road placement, and behaviour can play a role in roadkill rates. Williams et al. (2019) also found that roadkill counts are higher in areas of the animal's preferred habitat. From this observation, one can speculate that my roadkill hotspots are potentially wildlife corridors or just ideal habitat areas for the species observed during my survey. Certain species are scavengers and rely on carrion to survive, and what better source for food than roadkill? For example, the striped skunk (*Mephitis mephitis*) that was recorded was located right next to a hare (*Lepus sp.*) carcass . As the striped skunk is a scavenger and typically an opportunistic species when it comes to feeding, I think it was likely feeding on the rabbit when it too was struck by a vehicle.

The estimated number of roadkill along Highway 3A is a conservative estimate of the actual amount of wildlife struck because there are likely many animal carcasses that go unnoticed or are otherwise unrecorded. It is easy to miss certain vehicle-killed species due to their small size or because of the location where they were struck. It is also important to note that after being struck, some animals drag themselves into the trees or ditch to die because they are frightened and trying to escape the predator (a vehicle). It is also important to note that because my volunteers and myself were not travelling at night, there was likely roadkill that went unrecorded because we weren't on the road at the time it was struck. The timing of the survey could have affected the results as well. There were certainly data points that were missed because my volunteers and I were committed to other activities, such as attending college courses. Furthermore, I have observed that in British Columbia, the roadkill cleanup services are efficient and dead wildlife can be cleaned up within a matter of an hour or two and, therefore, it could be easily

missed. It is also potential that as fall turned to winter the density of wildlife likely decreased. For example, black bears which were recorded during early fall would have likely been hibernating before I ended my survey in February, hence, less bear mortalities to be recorded.

From this pilot study, as well as from extensive background research, I have determined that the best way to reduce the numbers of future vehicle-animal collisions along Highway 3A would be to install an overpass at each of the two roadkill hotspots, complete with at least five kilometers of fencing on each side of the overpasses (resulting in a total of ten kilometers of fencing on each side of the road) to ensure wildlife would be directed to use the overpasses instead of the highway to cross. Rytwinski et al. (2016) determined that fencing less than five kilometers in length was less effective in reducing large mammal-vehicle collisions than fencing greater than five kilometers in length. According to Rytwinski et al. (2016), the cheaper alternatives such as signage and wildlife reflectors are far less effective when compared to the more expensive techniques such as overpasses or mitigation fencing. Although an overpass would be far more expensive compared to the cheaper, more commonly used alternatives, it is proven to be the most effective way to minimize vehicle-animal collisions. The use of an overpass and mitigation fencing would also save money spent on roadkill cleanup and insurance claims made to ICBC, so over time the overpass would potentially pay itself off as well as potentially prevent fatal vehicle-animal collisions from happening.

6. Future Recommendations

I think it is very worth-while to further study the relationship between wildlife and our roadways, as well as to better understand the effectiveness of roadkill mitigation techniques. Transportation agencies, such as the Ministry of Transportation and Infrastructure should work towards investing in more effective roadkill mitigation techniques such as overpasses combined with fencing, instead of opting for the most inexpensive technique that just isn't as effective at mitigating vehicle-animal collisions. In doing this our roadways will not only be safer for wildlife, but also for drivers. It is important for the Ministry of Transportation and Infrastructure to realize that the cost-benefit of these more costly mitigation techniques have shown high returns on investment, with ongoing benefits exceeding their cost over time (Rytwinski et al. 2016). This means that the money spent to build this mitigation technique would be paid off by the money saved in roadkill cleanup fees, ICBC payments, and even medical bills, not to mention the pricelessness of the potential lives being saved by preventing fatal collisions.

6.1 Limitations

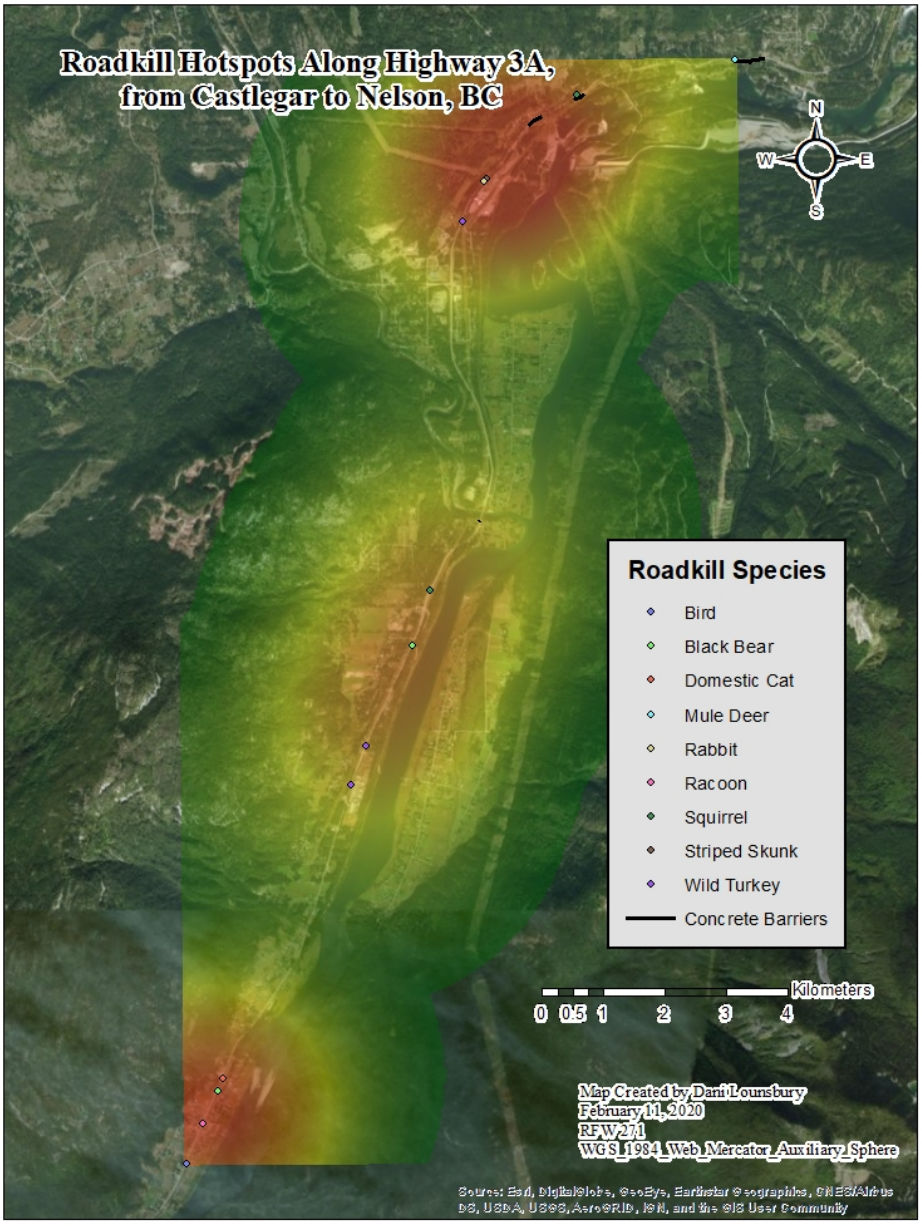
The limitations I encountered while doing this roadkill pilot study are important to discuss so someone who wishes to replicate my project can avoid some of the challenges I faced. Unlike me, I think the

person conducting this work in the future should live in Nelson and commute daily to Castlegar for school or work. It would be far more practical because the person carrying out the study would be driving to and from Castlegar at least twice a day, once in the morning and once in the evening, and would be able to collect more data than someone who has to go out of their way to drive from Castlegar to Nelson at more sporadic times. This would result in more consistent data collection and not having to rely on volunteers to do data collection. Although citizen scientists and volunteers do play a role, there are certain downsides such as lack of commitment and inconsistency in the data that can occur from the use of volunteers.

The earlier this kind of study can be started, the better because it will allow for a larger window for data collection to occur, and as a result, more data points and more results to examine. Beginning data collection in early spring and carrying it out until late fall would be best to avoid having to collect data during the winter months. During spring to fall, animals are giving birth to babies, bears are fattening up for winter, and overall wildlife tends to be more active during this time compared to winter time. Not only is it harder to collect data in the winter due to poor visibility and poor road conditions, but also roadkill is more likely to be plowed off the road by a snow plow before being recorded. Also, certain species such as bears and certain squirrels also go into hibernation, resulting in less wildlife active and on the roads.

From my experience, trying to mark concrete barriers along roadways in the field is not the most efficient way to map them out. Initially I had attempted to mark the concrete barriers along the highway using a line drawing feature on a tablet using Avenza, but discovered that this method was very unsafe due to a lack of safe pullouts along the highway, heavy traffic, and the large numbers of concrete barriers in locations that were too challenging to walk and mark. I tried staying in my vehicle as a passenger and driving by the concrete barriers to mark them, but unfortunately the application couldn't keep up to the eighty-kilometer speed of the vehicle. From my experience, using a base map on ArcMap was the safest and most practical way to be able to view and then create a line feature class of the concrete barriers in order to map them out.

Figure 1. Roadkill hotspots identified along Highway 3A from Castlegar to Nelson, BC.



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