Highway 3: Transportation Mitigation for Wildlife and Connectivity

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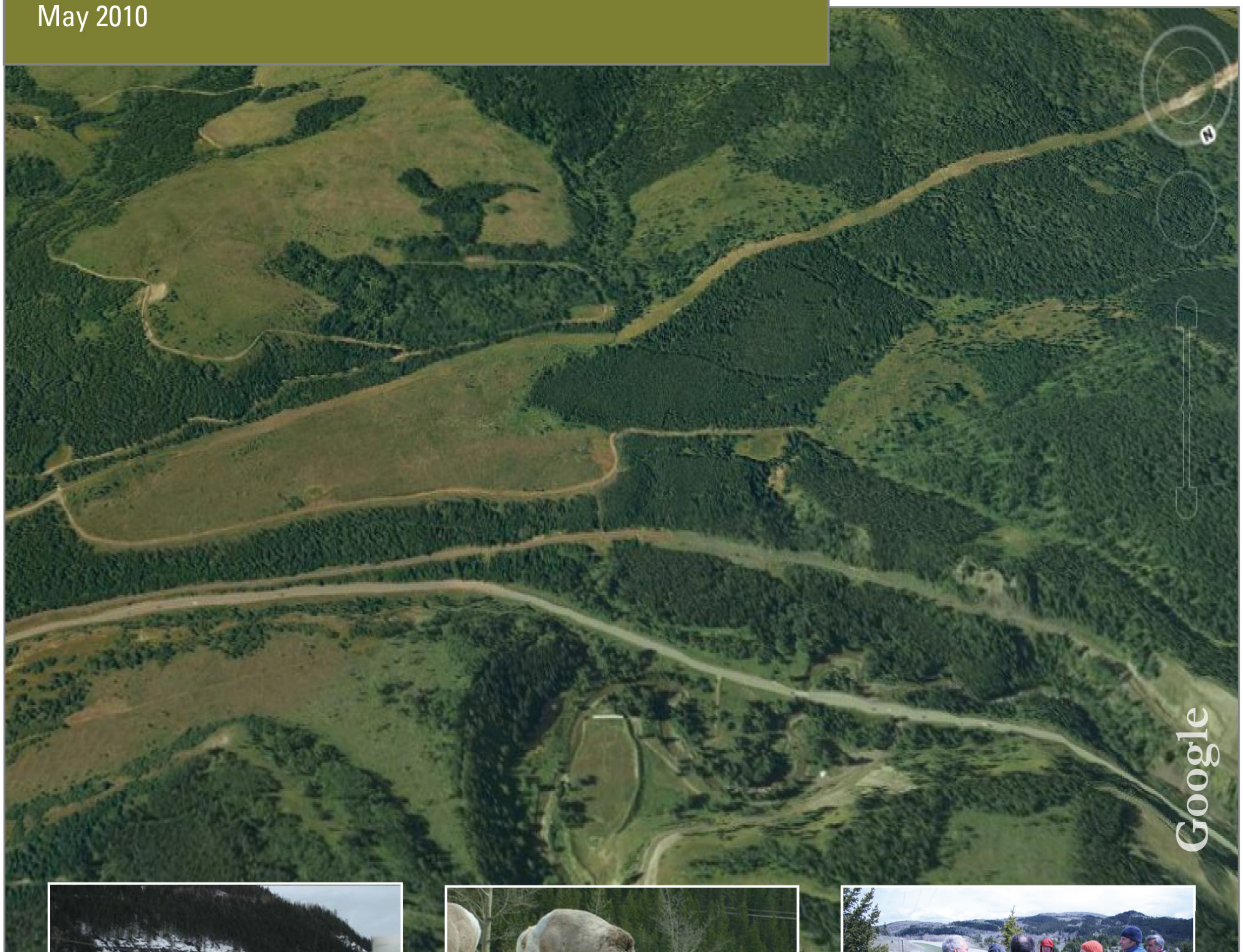

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HIGHWAY 3: TRANSPORTATION MITIGATION FOR WILDLIFE AND CONNECTIVITY IN THE CROWN OF THE CONTINENT ECOSYSTEM

Final Report without Appendices

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Introduction

The Highway 3 transportation corridor, including land use and development adjacent to the highway, has been identified as a major challenge to maintaining wildlife connectivity at the northern edge of the Crown of the Continent ecosystem. Highway 3 is a two-lane, east–west highway supporting 6,000 to 9,000 vehicles per day traveling over the Continental Divide at Crowsnest Pass in the southern Canadian Rockies. The current rate of wildlife–vehicle collisions involving large mammals along Highway 3 has raised concerns among agencies and the public regarding motorist safety. Although highway segments experiencing a high number of these collisions are predominantly found to involve deer, collisions also occur with less common species such as elk, moose, bighorn sheep, grizzly bear, wolf, lynx, bobcat and cougar.

The syntheses, field assessments and recommendations described in this report reflect the best available understanding and options for direct mitigation of highway impacts to local populations of large terrestrial wildlife. Although conservation measures at regional and landscape scales are critical in maintaining wildlife population connectivity**,** the focus of this report is at the finest scale necessary to address Highway 3 impacts on terrestrial wildlife—that of site-specific mitigation of the highway itself.

Ecological and social contexts

The management of transportation infrastructure that ensures local-scale wildlife conservation and motorist safety requires an understanding of the ecological and social context of the project area. These contexts comprise a unified foundation from which conservation and highway mitigation actions can be incorporated into decision-making.

Synthesis of existing information and research

A synthesis of existing biological data, analyses and reports regarding key landscapes, habitat linkages and wildlife mortality for large mammals describes the current conflicts between wildlife and the Highway 3 transportation corridor. The information reviewed includes species-specific landscape suitability and vulnerability in relation to Highway 3 for the following species: 1) carnivores—grizzly bears, lynx, badgers, bobcats, wolves, wolverines, and cougars; and 2) ungulates—elk, moose, deer, bighorn sheep and mountain goats.

Assessment of wildlife–transportation conflict areas

In British Columbia, the stretch of Highway 3 from the Rocky Mountain Trench to the provincial border at Crowsnest Pass contains 81 kilometers (km) of medium to very high wildlife–vehicle collision (WVC) segments, representing 59 percent of the highway and 79 percent of total WVCs. In Alberta there were 1359 WVCs recorded from 1998–2008 along a 44-km segment between the British Columbia/Alberta provincial border and Lundbreck, Alberta. This section has 27 km of medium to very high WVC segments, representing 61 percent of the highway and 77 percent of total WVCs. Deer were the most common species involved in collisions across the study area, representing 90 percent of the WVCs.

Identifying priority areas for highway mitigation

Thirty-one sites along Highway 3 in the project area were identified as key locales where highway mitigation could benefit wildlife conservation, habitat connectivity and motorist safety. Each site was visited in the field and evaluated using five different criteria: local conservation value, level of highway caused wildlife mortality, adjacent land-use security, regional conservation significance and opportunities for highway mitigation. Each criterion was assigned a score from 1 (low) to 5 (high). The average score of the five criteria helped determine the relative importance for mitigation efforts among the 31 sites. Each mitigation emphasis site is described in the report. During each site visit, an evaluation was conducted to make recommendations for a variety of short- and long-term wildlife mitigation measures.

Monetary cost–benefits of reducing wildlife–vehicle collisions

With growing rates of WVCs over the past two decades, agencies are increasingly seeking to mitigate highways to increase motorist safety as well as to provide for the conservation of wildlife. A summary of the recent advances in evaluating the monetary cost and benefits of various mitigation measures provides information for decision-makers, managers and the public to better understand the societal benefits of investing in those measures. We performed a cost–benefit analysis using annual rates of WVCs for each of the 31 mitigation emphasis sites along Highway 3 in British Columbia and Alberta.

The number of collisions per kilometer per year involving deer, elk, moose and bighorn sheep were summarized at each mitigation emphasis site and the total cost of these ungulate–vehicle collisions was (UVCs) compiled.

- Collision rates varied at the mitigation sites in British Columbia, from a low of 0.6 UVCs/kilometer/year (UVCs/km/year) at the Carbon Creek bridge site to a high of 3.1 UVCs/km/year at the Trench 3 site.
- UVC rates were higher in Alberta than in British Columbia, likely due to differences in data collection efforts between the two jurisdictions.
- Collision rates in Alberta ranged from a low of 1 UVC/km/year at the Rock Creek site to a high of 4.28 UVCs/km/year at the Leitch Collieries site. Nearly half of the Alberta sites had total UVC rates in excess of 3 UVCs/km/year.
- The bighorn sheep–vehicle collision rate of 2.55/km/year is notably high at the Crowsnest Lakes site.

Using the UVC rates at each mitigation site, the annual costs of the UVCs were then derived based on each ungulate species' average cost per collision (i.e., human fatalities and injuries, vehicle damage): deer ($6,617), elk ($17,483), moose ($30,760) and bighorn sheep ($6,617). In British Columbia, total annual costs of UVCs ranged from a low of $1,323 at the Alexander–Michel 2 site to $28,329 at the Fernie–Morrisey 4 site. In Alberta, total annual costs of UVCs varied from a low of $6,617 at the Rock Creek site, although road segments on both sides of this site were much higher, to a high of $31,405 at the McGillivray Creek site (all figures in 2007 Canadian dollars).

A recent cost–benefit analysis for a variety of highway mitigation measures across North America found the average cost of building and maintaining a wildlife underpass with fencing and jumpouts (escape ramps for wildlife) is $18,123 per year. Although underpasses are often considered an "expensive" infrastructure investment for wildlife, nearly one-third of the monetary costs for the sites in British Columbia were estimated in excess of $18,123 per year and half of the sites in Alberta had estimated annual costs in excess of this threshold number. This makes many of the mitigation emphasis sites in the study area excellent candidates for underpasses or other infrastructure investments. Further, if the underreporting of WVCs were accounted for, then investment in mitigation at even more sites would be considered cost effective. Focusing highway mitigation efforts in these areas could improve motorist safety, reduce wildlife mortalities, improve habitat linkage and animal movements across Highway 3 and be cost effective.

Highway 3 mitigation emphasis site evaluations

From the field evaluation of the 31 mitigation emphasis sites, recommendations were grouped into short-term and long-term actions. A description and summary for each mitigation emphasis site along Highway 3 is in Appendix A. The relative importance of each site varies by species and local landscape attributes across the 180-km highway corridor. A variety of mitigation measures were recommended, from simple to complex. Some required only a change in operations (e.g., de-icing alternatives), while others some level of construction (e.g., wildlife underpass, fencing).

Ten of the long-term mitigation measures are described, with photos, in Appendix B. Hosmer–Sparwood-1 had the highest priority score of the entire study area. The site is particularly important in terms of regional and local conservation and the land-use security is high, as a land trust owns the private lands on both sides of the highway. The site has good opportunities for highway mitigation. Twin culverts currently drain wetlands adjacent to the highway. Alexander–Michel 1 is within what is known to be the most critical habitat linkage in the entire Highway 3 corridor. Therefore, this site may be important in maintaining local- and regional-scale movements of wildlife, including grizzly bears, wolverines and lynx. It has moderately high opportunities for highway mitigation.

Fernie–Morrisey 1 was one of two sites with the highest scores for land-use security and is recognized for its importance for carnivore population connectivity across the lower Elk Valley. It has moderately high scores for local and regional conservation values; however, mitigation opportunities are limited. Elko–Morrisey 3 had moderately high scores for local conservation, land-use security and mitigation opportunities and is a high collision area for bighorn sheep. Elko–Morrisey 1 was particularly important in terms of local conservation and highway mitigation opportunities. Similarly, it is an area of very high rates of WVCs, primarily with deer, elk, bears and bighorn sheep.

Among Alberta mitigation sites, Rock Creek is of highest priority. This site is particularly important in terms of local conservation, and has high land-use security and highway mitigation opportunities. It is also an area of very high WVC rates. There are currently plans to replace an existing culvert with a new below-grade structure, creating an excellent opportunity to improve terrestrial and hydrologic flows in the area. Crowsnest Lakes was one of two sites with the highest WVC rate, primarily involving bighorn sheep. The area is moderately important for regional conservation, while the local conservation significance is mostly due to the local bighorn sheep population. Crowsnest East had the best opportunity for highway mitigation, while Iron Ridge had moderately high scores for local conservation and regional conservation significance.

Special consideration for American badgers

American badgers are "red-listed" in British Columbia and the subspecies in British Columbia is listed as an endangered species in Canada. Reducing road-related mortality is a key action in the Canadian recovery strategy for this subspecies of badger. The Trench 1, Trench 5, and Trench 6 sites were identified as locations to improve highway permeability and reduce mortality of badgers. Existing culverts should be made visible and passable to badgers. More culverts should be installed where data indicates they are needed.

Monitoring and research

Monitoring and research are needed to inform agencies by providing the most current data and site-specific information to help prioritize and guide decisions regarding planning and design on Highway 3.

- Coordinate activities aimed at collecting reliable and accurate information on wildlife–vehicle collisions and wildlife movement within the Highway 3 corridor.
- Evaluate existing below-grade highway structures (i.e., culverts, creek bridge structures) for their potential for passing wildlife safely across the highway.
- Conduct at-grade surveys, including snow tracking, to provide better information on existing species-specific crossing locations.
- Review and analyze existing Highway 3 infrastructure to determine the impacts of the highway to aquatic connectivity, species movement and conservation.
- Conduct a Canadian Pacific Railway wildlife strike zone assessment to better understand the location of any problem areas along the railway and develop potential solutions.
- Keep transportation and natural resource agencies working along Highway 3 informed about the most up-to-date and effective means of mitigating highways for wildlife via workshops, training courses and other technology transfer opportunities.

1. INTRODUCTION

The southern Canadian Rocky Mountains connect the Crown of the Continent Ecosystem (centered about Glacier–Waterton International Peace Parks) with the Banff–Jasper–Kootenay–Yoho mountain parks complex to the north. Maintaining landscape connectivity is crucial for the well being of the many native wildlife species that currently thrive in the region. One area that has been identified as a major challenge to maintaining wildlife connectivity is the Highway 3 transportation corridor and adjacent land use and development as they represent a potential fracture zone for wildlife movement at the northern edge of the Crown of the Continent ecosystem (Figure 1).

The Highway 3 transportation corridor runs west–east over the Continental Divide at Crowsnest Pass in the Canadian Rockies. Highway 3 is a two-lane highway supporting 6,000 to 9,000 vehicles per day, depending on the season and section of road. It serves local commuters from the communities of Elko, Fernie and Sparwood, British Columbia, as well as Coleman, Blairmore, Frank, Hillcrest and Bellevue, Alberta. Local transportation use is compounded by transcontinental trucking and the increased recreational needs of Calgary residents. A railway runs parallel to the road for the entire length of the corridor. Both modes of transportation are experiencing an increase in traffic volume. The implications to wildlife include direct mortality from collisions with highway vehicles and trains, fragmentation of the landscape, and avoidance behavior by wildlife due to the increased activity and presence of humans.

Understanding wildlife use and movements, associated behaviour, and habitats along this transportation corridor is essential for developing mitigation strategies to reduce transportation–wildlife conflicts and maintain connected populations. Fortunately, there have been a number of research projects in the past decade that allow us to better understand how a variety of different species use these landscapes (e.g., bighorn sheep, elk, grizzly bears). These include studies that have identified key linkages for several carnivores, including grizzly bears that cross Highway 3 and the Canadian Pacific railroad. However, the studies were not developed to focus solely on the highway and its increasing use. Therefore, scientists, agency personnel and conservationists gathered at a Highway 3 workshop in Fernie, British Columbia in January 2008 to share and discuss relevant and available knowledge on wildlife studies that may inform site-specific mitigation of Highway 3.

One recommendation from the workshop was for a sub-set of the attendees to complete a synthesis of the biological information relative to Highway 3 to inform an assessment of potential transportation mitigation sites and options. The syntheses, field assessments and recommendations described in this report reflect the best available understanding and options for direct mitigation of highway impacts to local populations of large terrestrial wildlife.

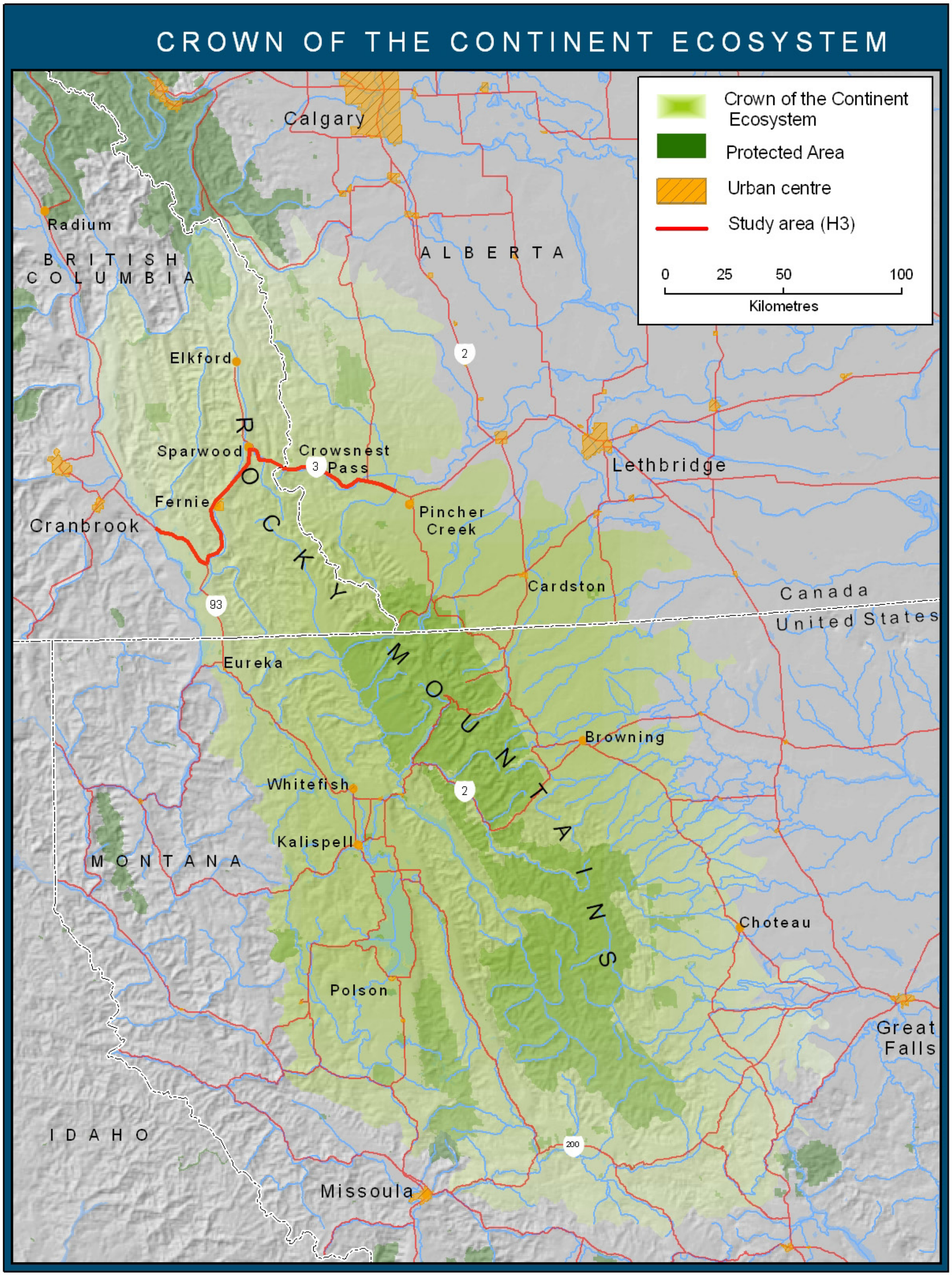

Figure 1: Highway 3 study area in the Crown of the Continent Ecosystem (courtesy Miistakis Institute).

2. BACKGROUND

2.1. Ecological Context

Ecological connectivity is a fundamental principle in the conservation of wildlife, ecosystems and biodiversity (Crooks and Sanjayan 2006). In a general sense, all animal and plant populations are shaped by, and persist because of, spatial connections. Habitat connections are needed for mobile animals to move through and survive within resident home ranges. At broader scales, landscape linkages allow individuals to move among core habitat areas, providing stability to regional populations and allowing range peripheries to be occupied through periodic or continual augmentation. The resulting genetic flow across large connected populations also contributes to localized adaptability to a changing environment and helps to ensure that only genes beneficial to individual fitness are expressed. Although ecological connectivity is nebulous and without definition as it pertains to species, habitats, spatial and temporal scales, thresholds and risk, the notion of connectivity is nonetheless central to effective conservation planning.

In a world dominated by human activity, the Rocky Mountain cordillera of North America, from Yellowstone to Yukon (Y2Y), is composed largely of wild lands that are relatively intact to various degrees. One key node in the Y2Y ecoregion is the transboundary Crown of the Continent Ecosystem, a critical collection of federal, state, provincial and private lands anchored by Waterton Lakes National Park in Canada and Glacier National Park in the United States. This ecosystem covers approximately 44,000 square kilometers (16,000 square miles) and is an integral part of the much larger Y2Y ecoregion. Recognizing the value to humans in maintaining fully intact and functioning natural ecosystems, and the ever-dwindling opportunities to do so, a variety of efforts are moving forward to protect, recover and enhance the integrity of local landscapes within the Crown of the Continent Ecosystem and the natural connections within and among them.

The southern Canadian Rocky Mountains encompass the northern half of the Crown of the Continent Ecosystem and comprise a zone of utmost strategic importance in the securing of connected wild land ecosystems (Tabor and Soulé 1999, Apps et al. 2007). Most of this region is managed for multiple values, including resource extraction, agriculture, human settlement, and tourism that includes both motorized and non-motorized recreation. And it is on this economic basis that local human communities have grown and thrived. While much of the southern Canadian Rockies is relatively undeveloped and ecologically intact, such landscapes are bounded and interspersed with human settlements and activity. Despite the significance of this region in supporting some of the greatest ecosystem and large mammal diversity in North America (CORE 1994, Apps et al. 2007), few landscapes in the southern Canadian Rockies are managed primarily for ecological values.

Wide-ranging species of low density and limited distribution are central to regional conservation planning across the southern Canadian Rockies. These native wildlife, mostly carnivores but also ungulates, are appropriate species on which to focus regional conservation planning because, as a group, they are good indicators of the general health of ecosystem processes and the well-being of native biodiversity. Carnivores also tend to sit at the top of often complex ecological food chains and are thus indicative of stable and functioning multi-species systems. Impacts to wide-ranging carnivore and ungulate species are largely manifested through roads and associated motorized human access and traffic. Roads affect wildlife populations through mortality due to collisions with vehicles (primarily on highways), legal and illegal killing, habitat loss and alienation, and the disruption of movement and seasonal-migration options (Trombulak and Frissell 2000, Forman et al. 2003). For ungulates, roads can have substantial local impacts as they limit movements between important seasonal foraging and/or reproductive habitats (e.g., Berger 2004). Changing the pattern of human access will also influence ungulate distribution, particularly in hunted populations.

For wide-ranging species, there is much concern and focus on the potential impacts of the Highway 3 transportation corridor that bisects the Crown of the Continent Ecosystem from west to east (Figure 1). From the Rocky Mountain Trench in the west to Alberta agricultural lands in the east, Highway 3 is associated with human settlement and development in and around the communities of Sparwood, Fernie and Elko, British Columbia, as well as the Municipality of Crowsnest Pass in Alberta. Given the existing communities, a large proportion of private land ownership and high human accessibility, much of the landscape through which Highway 3 passes is composed of, or is potentially subject to, permanent human development. Considering human demographic and socioeconomic trends, there is obvious potential for the highway corridor to fracture the north–south contiguity for populations of wide-ranging carnivores and some ungulates. As a source of high mortality and a constraint to the movements of resident and dispersing animals, the genetic and demographic implications of such a fracture zone can destabilize populations and increase the likelihood of localized extirpation. Moreover, human development and activity along the highway corridor undoubtedly results in extensive ancillary impacts, potentially reducing the effectiveness and security of core habitat areas within the larger region.

Hence, for wide-ranging species at least, Highway 3 has conservation implications that are embedded in cumulative landscape-level human impacts. Addressing cumulative impacts requires research and planning across multiple scales, with strategies tailored not only for transportation but simultaneously for public land management and the management and development of residential and industrial private lands. Associated planning tools and conservation priorities are addressed by Apps et al. (2007) and an ongoing research program. Within the Crowsnest Pass Municipality of Alberta, the potential upgrading/twinning of Highway 3 is expected to significantly impact ungulate use of existing winter range. Current and future wildlife–vehicle collisions (WVCs) in this area are also a major concern, with the potential to adversely impact wildlife populations, motorist safety and finances (Lee 2009).

There are a number of segments of Highway 3 where WVC rates are considered high and human safety is a concern. Although areas of high WVCs are predominantly associated with deer, there are numerous records of collisions with elk, moose, bighorn sheep and carnivore species, such as grizzly bear, wolf, lynx and cougar. In certain circumstances, wildlife mortality due to collisions with vehicles may have a local population-level effect, such as at Crowsnest Lakes where the local bighorn sheep population is declining almost 10 percent annually due to mortality caused by collisions with vehicles.

It is acknowledged that conservation measures at regional and landscape scales are critical in conserving and promoting connectivity of wildlife populations across Highway 3. **However, the focus of this report is at the finest scale necessary to address Highway 3 impacts on terrestrial wildlife—that of site-specific mitigation of the highway itself.** While the information and recommendations presented here are informed by studies and data across geographic scales, our focus is in best mitigating highway impacts in terms of wildlife movement and mortality specific to current and future transportation infrastructure scenarios.

There are several issues that this report does not address related to transportation and conservation in the Highway 3 corridor:

1. The needs of aquatic species.
2. The effect of the adjacent and parallel railroad on wildlife.
3. Potential new highway expansion alignments, particularly in Alberta.

2.2. Conservation Issues of Regional Significance and Associated Research

The Highway 3 conservation issue is essentially defined by potential impacts to wide-ranging species that persist at low densities and/or in limited distribution in the larger region. These are primarily carnivore species. Specific to large carnivores, particularly grizzly bears, the issue was initially highlighted by work done in the 1990s (Apps 1997). This late 1990s report was intended to focus attention on the potential for fracture of wide-ranging carnivore populations and its associated conservation implications, and to promote measures to secure the integrity of several multi-species population linkage landscapes that span the transportation and settlement corridor. Also, the report warned that without proactive planning, projections of future human development and activity along the highway corridor may result in the irreversible loss of habitat available for wildlife movement and/or unsustainable mortality risk, contributing to population isolation for some species.

Since the Apps (1997) report, several other researchers have independently corroborated the importance of Highway 3 as an issue in carnivore conservation. In a broad scale assessment across the Y2Y ecoregion, Carroll et al. (2001) identified Highway 3 as an emerging gap for several large carnivores. In his assessment of habitat connectivity for large mammals in the transboundary Flathead drainage, Weaver (2001) also reiterated the threat of population fracture from Highway 3 and associated land development. Theoretical predictions of population impacts were partially substantiated by Proctor (2003) in a study demonstrating that the Highway 3 transportation and settlement corridor has had a measurable impact in restricting gene flow among grizzly bears.

In 2001, several researchers embarked on a multi-species and multi-scale collaborative study specific to carnivores and Highway 3. This work was initiated in response to a need for more refined decision-support and planning tools to focus and direct conservation action at the scale of the larger region as well as landscapes within and around the highway corridor. The first two of three phases of this study culminated in a report addressing core areas and connectivity for carnivores, with a focus on Highway 3 (Apps et al. 2007). In Phase 1, the researchers selected a suite of six carnivore species that represent the broad variation in ecosystem conditions across the regional landscape. For each species, they developed and applied regional models of population distribution and vulnerability across the southern Canadian Rockies. In Phase 2, the study applied hair-snagging and DNA analysis to sample the actual distribution of grizzly bears and lynx within a zone 15–40 km wide along the highway corridor through the Rocky Mountains.

These data were used to test and refine regional models, and to inform a finer-scale assessment of landscape occupancy, relative abundance, and movements in landscapes directly adjacent to the highway. At the finest scale, Phase 3 is the most detailed and long-term study component.

This third phase involves intensive and representative sampling of grizzly bear movements by way of tracking collars and a multi-scale assessment of spatial and temporal factors influencing space-use and movements. Data and associated analyses are being used to predict seasonally important core habitats within home ranges, movement options among them, and dispersal opportunities. These predictions are especially relevant in multi-scale conservation planning to offset impacts associated with Highway 3. This specific study will culminate in a multi-scale assessment of the influence of both cumulative human and habitat influences on the movements and persistence of resident grizzly bears.

The ways by which major highways influence wide-ranging carnivores and their populations varies among the species depending on their behavior and life-history. For all species, movements are influenced by highways but ultimately determined by underlying habitat quality and distribution in and around the associated landscape. To the degree to which highways bisect or coincide with landscapes of preferred habitats, transportation infrastructure can be an obvious mortality source either by way of direct vehicle collision or through facilitation of human access and permanent presence. Both movement restriction and mortality increase the potential for population fracture and isolation. The resulting loss of gene flow and the potential for inbreeding depression is a concern, but one that can be alleviated by even small measures of successful movement and breeding. Of much greater concern are the demographic effects of isolation including the loss of potential immigration, augmentation, and recolonization opportunities. Species that occur at low densities and/or in limited distribution may be vulnerable to such effects especially near range peripheries. Grizzly bears are particularly sensitive because they exhibit relatively low dispersal potential, especially among females. Dispersal by young bears is a gradual process that can take years, with adults residing close to their natal ranges and females usually overlapping their mother (McLellan and Hovey 2001). As a result, connectivity across highways requires consideration for specific movement options as well as landscape management for habitat effectiveness and security.

2.3. Social Context

The communities that lie between Elko, British Colombia, and Lundbreck, Alberta, took root at the turn of the twentieth century, with an economy based primarily on the plentiful coal resources of the region. The resource extraction industries attracted a large immigrant population to supply the manual and skilled labour for the mines. The transportation routes grew to meet the needs of these communities, including getting their raw resources to distant markets. The transportation infrastructure is not only for local use since Crowsnest Pass is one of a few geographically viable routes across the Rocky Mountains for both rail and highway making it a crucial transportation link between the prairies and the west coast. In addition, this route serves to transmit Alberta petroleum to the west coast of the United States via a major pipeline.

Based on local resources, the coal mining communities were largely economically separate from their agricultural neighbours to the east and formed their own unique culture and social identity. This was the social pattern, complicated by occasional fluctuations in the commodity markets, for most of the twentieth century.

The last two decades have seen a series of changes to this pattern. At both the east and west ends of the study area, the natural resource economies have been increasingly supplanted by tourism and recreation. In the Alberta portion of the study area, coal mining activities have gradually subsided and those still employed in the industry now commute down Highway 3 to the mines in

British Columbia. This loss of the traditional economic base has resulted in a decline in population of over 21 percent. While occasional fluctuations were part of the history of the community, the population dropped from 7302 in 1981 (Municipality of Crowsnest Pass 2001) to 5749 in 2006 (Statistics Canada 2006). The 2006 Canadian census records a population in the Crowsnest Municipality with a significantly higher median age (48) than the Alberta average (36) and lower levels of mobility and educational attainment than the provincial averages (Statistics Canada 2006), often indictors of a community in transition.

At the same time, the scenic beauty and outdoor recreation potential of communities such as Blairmore and Coleman have attracted both tourists and amenity migrants—affluent members of society who can choose to live in aesthetically valuable places. The relative proximity of Calgary and Lethbridge has brought citizens from those urban centres to buy recreational and second properties in the area. The Economic Development Office of the Municipality of Crowsnest Pass has estimated that 20 to 25 percent of utility bills are mailed to owners outside the municipality. As property ownership shifts to those who do not have year-round local residencies, increases to commuting distances and traffic volume occur, primarily on weekends and holidays.

Sparwood, British Columbia, has not experienced this shift to the same extent as Alberta communities, likely because coal mining continues in the upper Elk Valley. To its south, Fernie, however, has grown into a major recreational and tourism destination in both summer and winter. This is now the major economic driver for the town. The majority of visitors to the Elk Valley travel via Highway 3 from Alberta. The economic renewal that tourism and recreation appear to be bringing to the region is adding to the need for safe, sound Highway 3 design and operations.

Decision-making authority for Highway 3 in the study area is split between the provincial jurisdictions of the British Columbia Ministry of Transportation and Alberta Transportation. Alberta Transportation is currently conducting a long-term planning study with respect to the upgrading and potential realignment of Highway 3. British Columbia is not engaged at this time in transportation planning for Highway 3 or any major reconstruction projects in the study area.

The relationship between public land management, private land use and the future of Highway 3 is multifaceted. The transportation infrastructure has a major influence on local communities and their patterns of development. Conversely, land use decisions have the potential to impact Highway 3’s traffic patterns and traffic volumes. In addition, for highway mitigation to be effective in safeguarding wildlife and their movement, it must be accompanied by conservation measures on adjacent private land as well as compatible uses and management on public land. Thus, public and private land use decisions, the responsibility of public agencies and the municipalities along Highway 3 are integral to sound transportation design and implementation. In Alberta, the need to coordinate infrastructure and different levels of land use regimes has been recognized and is one of the tasks of the Alberta Land-Use Framework, a process which is currently underway.

This report aims to provide credible analyses and recommendations so officials at all levels of government involved with transportation and land use planning are aware of the relevant wildlife science and options available in the Highway 3 study area. For the report’s recommendations to be successful, wildlife mitigation measures for the highway should be coordinated with conservation planning on adjacent public and private lands.

3. SPECIES-SPECIFIC LANDSCAPE SUITABILITY AND VULNERABILITY TO HIGHWAY 3

3.1. Carnivores

Along the route by which Highway 3 passes through the southern Canadian Rockies, impacts and mitigation options for individual carnivore species vary according to inherent habitat potential in landscapes around the highway and the distribution of known core habitats. This knowledge is best informed by the Phase 1 and Phase 2 outputs of Apps et al. (2007).

For grizzly bears, landscape suitability is rather high in the mountains and higher foothills throughout much of the region, both south and north of Highway 3. Core habitats are specifically associated with the following areas: (1) the lower Flathead basin and adjacent Castle drainage, (2) east side of the Wigwam basin, (3) the upper reaches of the Flathead basin and adjacent Carbondale area, (4) Michel Creek and adjacent Ptolemy Creek area, (5) Alexander drainage and upper Oldman River basin, (6) upper Elk River basin and adjacent upper Highwood River drainage, (7) west side of the upper Elk River, and (8) Lizard Range. Movements of resident grizzly bears (C. Apps, unpubl. data) largely corroborate the major landscape linkages spanning Highway 3 that were identified by Apps et al. (2007).

One important zone is near the junction of Alexander and Summit Creeks, 3–5 km by highway west of the Continental Divide. Moving west, another key landscape spans the lower Elk Valley between Sparwood and Hosmer. A third linkage is located between Fernie and Morrissey. These data also suggest a movement zone of potential importance within the Rocky Mountain Trench linking seasonal foraging areas in the Sand Creek drainage to those around lower Kikomun Creek.

East of the Continental Divide in Alberta, there is less potential for cross-highway grizzly bear movement (Apps et al. 2007), compared to west of the Continental Divide. However, there is evidence that suggests potential for movement directly east of Crowsnest Lakes in the vicinity of Crowsnest Creek. The authors do not discount the potential for movement by grizzly bears across Highway 3 farther to the east.

For lynx, suitable habitat is unevenly distributed along major ridge complexes and upper valleys. This disjunct pattern indicates that the stability of the regional lynx population likely is dependent on the productivity, security, and connectivity among several key areas. Important landscapes include: (1) upper elevation basins east of Fernie and south of Sparwood, including the upper Flathead River drainage, (2) upper Elk Valley and the confluence of the upper branches of the White River in British Columbia, and (3) forested and subdued terrain just east of the Continental Divide extending from upper Racehorse Creek northward to upper Highwood River. Habitats adjacent to primary highways in the major valleys are generally suboptimal for lynx, but often used for travel between key areas.

Badgers generally occur at low elevations and in ecosystems that are relatively dry and open. The highest landscape suitability for badgers is associated with semi-arid, open grasslands of the Rocky Mountain Trench along Highway 93 in British Columbia and the Rocky Mountain foothills north and south of Lundbreck in Alberta. Highway right-of-ways are often attractive habitats for badgers. Their proximity to highways increases the risk of mortality from vehicles;

however, drainage culverts can be used to safely cross highways if positioned correctly or adapted for badger movement.

Bobcats in the region occur near a natural range limit. Their habitats are associated with low elevation forests within ecosystems characteristic of relatively dry and mild winter climatic conditions. Regional bobcat distribution is somewhat peninsular, with resident animals occurring mostly along the shoulders of the Rocky Mountain Trench parallel to Highway 93 in British Columbia as well as forested plains and foothills in Alberta.

The potential distribution of wolves through the region is generally associated with major valley networks—specifically the grasslands and foothills flanking the east side of the Canadian Rockies in Alberta and the larger montane valleys in British Columbia such as the Elk, Flathead, Kootenay, and Columbia River valleys. However, actual wolf distribution is largely influenced by current and historic human actions to reduce the resident wolf population. At present, wolf persistence in the region likely depends on the somewhat higher productivity and security of landscapes such as the Flathead River basin and the upper Elk Valley, and also the upper Carbondale–Castle River. Major valleys parallel to the Continental Divide from Glacier National Park up to Banff National Park and associated passes along the Continental Divide are conduits for wolf movements.

Wolverines are expected to occur at relatively low densities across the southern Canadian Rockies. Landscape suitability for wolverines is rather high in the mountains and higher foothills throughout much of the region. Many of the areas of high suitability for grizzly bear are also apparently conducive to core wolverine habitat. Like lynx, habitats in transportation corridors are typically suboptimal, but wolverines occasionally need to travel through these areas to access key resources.

Cougars generally are more widespread and ubiquitous across the southern Canadian Rockies than the aforementioned species. For this reason, they are not considered an ideal focal species in managing for connectivity (although acquiring reliable movement data for cougars is easier than for most other species). Along the Highway 3 corridor, individual cougars undoubtedly move and use habitats as determined by available prey that primarily include bighorn sheep, white-tailed and mule deer, and elk. In one local study, cougar movements were largely influenced by ungulate densities benefiting from habitat enhancements and reclamation associated with the Elkview coal mine (Spreadbury 1989). In Rocky Mountain ecosystems, cougars generally benefit from complex terrain in association with adequate vegetative cover (Jalkotzy et al. 1999). Accordingly, habitat model predictions in the Municipality of Crowsnest Pass suggest that cross-highway cougar movements are more likely between Blairmore and Frank, west of Coleman in association with Iron Ridge, and possibly between Crowsnest Lake and Island Lake (Chetkiewicz 2008).

Not surprisingly, Apps et al. (2007) indicate that wide-ranging carnivores are most vulnerable across the region where suitable landscapes occur in close proximity to settlements, highways, and primary roads that facilitate high-intensity recreation and motorized access. These include Highway 3, Highway 43 (Elkford Highway) and Highway 93 in British Columbia. In Alberta it includes Highway 3, Highway 22 (Chain Lakes Highway), Road 940 (Forestry Trunk Road) and Road 774 (Castle River Road).

In their report, Apps et al. (2007) review current knowledge regarding the impacts to carnivores of highways, railways, and their associated traffic. However, the authors stress that the greatest impact of highways on carnivores is the cumulative human activity and spin-off development that they facilitate over time. It is the linear pattern of these impacts along the highway route that are the ultimate reason why Highway 3 may fracture some carnivore populations. To inform carnivore conservation planning at multiple landscape scales, the authors describe 15 core areas across the southern Canadian Rockies, which they rate in terms of conservation significance and relative security. Interdependent on these core areas, the authors map and describe 11 landscape linkages and key movement options across and adjacent to Highway 3. They also rate these connectivity options in terms of conservation significance and vulnerability. Readers should refer directly to the above report for a detailed treatment of core areas and connectivity for carnivore populations in relation to Highway 3.

3.2. Ungulates

Impacts and mitigation options for different ungulate species may be addressed with various strategies depending on topography and highway path across both ranges and movement routes of ungulates. Valley bottoms are typically important wintering areas for ungulates that provide access to forage and cover to ensure survival during the critical and population-limiting winter season. These low-lying areas are also associated with the route of Highway 3 and associated human settlement. In both Alberta and British Columbia, key ungulate winter range is primarily found in broad valleys and associated slopes of south or southwest aspect where soils, climate and topography can provide both winter forage and cover to satisfy thermal and security needs. Elk, moose and deer winter ranges can overlap depending on specific plant communities. Elk and bighorn sheep are grazers with a preference for grasses, whereas deer and moose are browsers and prefer shrub communities. Ungulate winter range is mapped for both provinces (Alberta Sustainable Resource Development 2005, British Columbia Environment, Lands and Parks 2005) and overlap to varying degrees along and around Highway 3 (Figure 2). We believe that impacts of highway upgrades on wildlife connectivity, vehicle collisions on wildlife mortality, and improved motorist safety can be partially mitigated through structural engineering that includes proper placement of overpasses and underpasses with respect to landscape context, habitat and terrain.

Landscape suitability for elk is generally high along and around the entire span of Highway 3 through the southern Canadian Rocky Mountains, and includes high quality and critical winter range. During winter, hundreds of elk rely on associated grassland and mixed forest habitats bisected by the highway. The herds in British Columbia and Alberta are partially migratory with some residing in the valleys and adjacent slopes during summer and others migrating to summer ranges often at higher elevations. Core winter ranges are found in association with (1) Natal Ridge, (2) lower Michel and Alexander creeks east of Sparwood, (3) adjacent to the highway between Sparwood and Fernie, and (4) within the Rocky Mountain Trench west of Elko (Jalkotzy 1994, Gibson and Sheets 1997, Lee 2009). Within Alberta, our current understanding of elk winter range and movements suggests considerable potential for disruption from additional highway development from Sentinel to Iron Ridge (known locally as the West Block) and in the eastern portion of the Crowsnest Pass municipality, in the vicinity of Burmis and Rock Creek.

Mule deer and white-tailed deer winter ranges are generally associated with windblown valleys and rolling montane forests commonly found along the Highway 3. Winter habitats provide accessible browse forage and important reproductive and thermal requirements. Along the highway, the largest populations of both species occur near Sparwood, Morrisey, and Elko in British Columbia and Lundbreck/Burmis and Coleman in Alberta.

Moose occupy primarily riparian habitats along Highway 3, making use of available willow and dogwood browse. Locally, moose occur at low densities relative to other ungulates, but seasonal ranges with important forage and reproductive habitats are found adjacent to the highway across the Rockies. Based on local knowledge and road mortalities, key areas for moose along the highway are associated with Alexander Creek, Hosmer, and between Fernie and Morrissey in British Columbia and near the Crowsnest River Bridge east of Crowsnest Lakes in Alberta.

Bighorn sheep prefer open or semi-open habitats in close proximity to escape terrain consisting of steeply sloped rocky cliffs and outcrops. Along the highway bighorn sheep are found at the following four sites that are low-elevation connections between primary ranges on shoulders of adjacent mountains: (1) a seasonal crossing on the highway just east of Blairmore between Bluff and Turtle Mountain; (2) roadside habitat adjacent to the highway near Crowsnest Lakes used during spring green, fall rutting periods, and winter; (3) at a short section along the highway along lower Alexander Creek; and (4) southwest of the highway tunnel between Morrissey and Elko where important spring, fall rut, and wintering habitats are found. Movement options for bighorn sheep near the Crowsnest Lakes and Elko sites we consider to be of regional significance. The presence of bighorn sheep along Highway 3 is frequently due to their attraction to salt that they lick off the roads.

Mountain goats, like bighorn sheep, prefer precipitous terrain and occasionally subalpine forests. They sporadically cross Highway 3 near the Crowsnest Lakes.

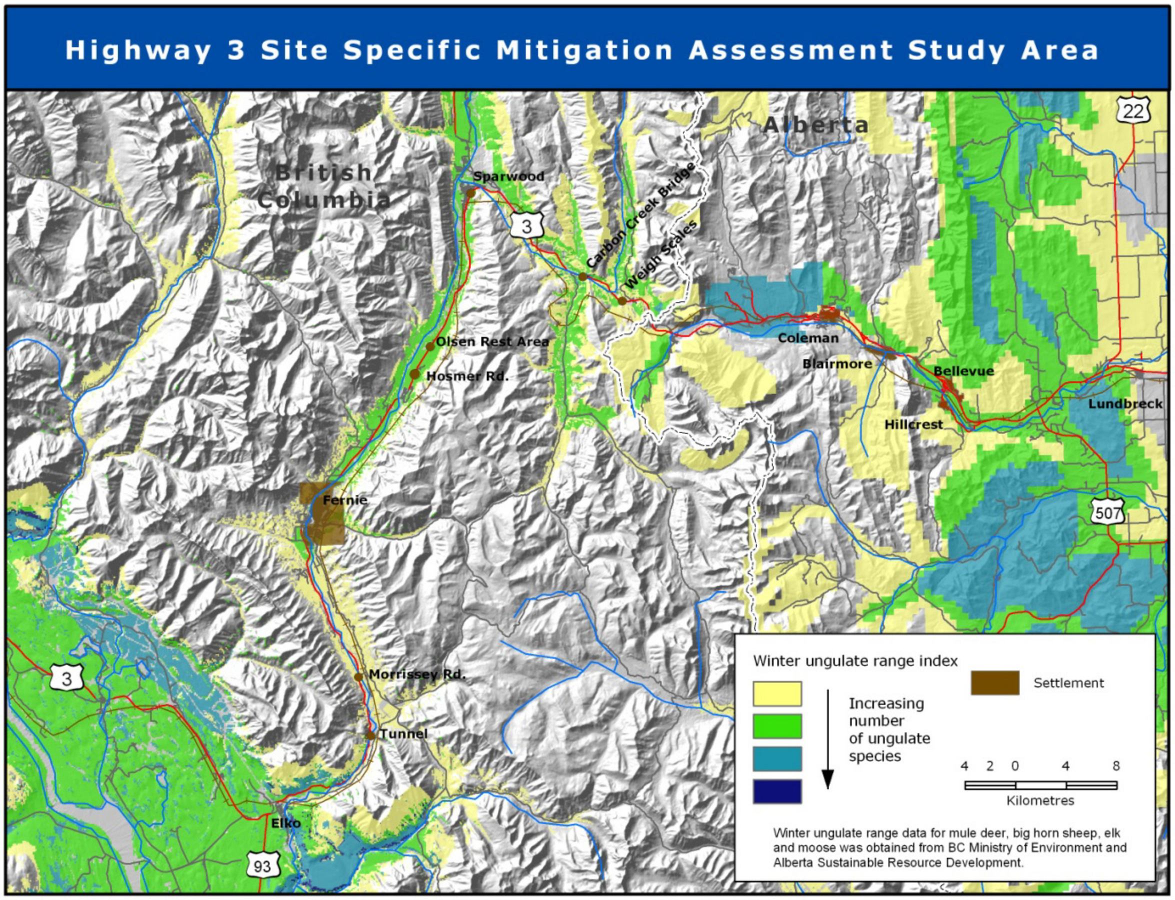

Figure 2: Distribution of ungulate species in association with the Highway 3 transportation corridor in the southern Canadian Rocky Mountains.

4. WILDLIFE–TRANSPORTATION CONFLICT AREAS ASSESSMENT

4.1. Introduction to Wildlife–Transportation Conflict Areas

Roads constitute the most ubiquitous and extensive human footprint on the global landscape. The traffic associated with the extensive and growing network of roads results in a large number of wildlife–vehicle collisions (WVCs). WVCs are the leading source of human-caused mortality to land vertebrates and are the source of significant population effects for some species (Forman et al. 2003). WVCs pose both wildlife conservation and human safety issues and have recently received widespread attention from ecologists, transportation planners and local communities (Trombulak and Frissell 2000). The effects reach beyond individual wildlife populations and pose broader conservation, economic and social consequences, including a considerable human safety risk (Husijer et al. 2007). In Canada, collisions between large mammals and vehicles occur at a rate of four to eight per hour resulting in approximately 17 human deaths and over 2,000 injuries a year. In 2003, Alberta recorded a loss of 11,632 large mammals, an 80 percent increase in WVCs from 1992 (L.P. Tardif and Associates 2003). In 2008, approximately 10 percent of all reported vehicle collisions involved animals (primarily wildlife) resulting in 498 human casualties and nine deaths (Alberta Transportation 2009). British Columbia reported over 9,000 animal-related vehicle collisions in 2004 costing the insurance system over $23 million (Wildlife Collision Prevention Program 2009). Reducing WVCs has become an issue of increasing importance for human safety and wildlife conservation.

Addressing wildlife transportation issues requires access to timely, accurate information on the spatial and temporal movement patterns of motorists and wildlife. Research emphasizes that the success of mitigation measures to ensure wildlife movement while reducing collisions is highly dependent on having an accurate understanding of wildlife distribution and movements (Clevenger and Waltho 2005, Huijser et al. 2007).

To address concerns where species pose a risk to motorists, the identification of WVC "hotspots" (locations with high WVC occurrence) is an important first step. There are many factors that result in certain segments along the roadway having a higher number of WVCs (e.g., topographical features, habitat patches, traffic volume, line of sight (Litvaitis and Tash 2008). Identification of WVC hotspots typically involves identifying clusters of WVCs. Therefore, the accuracy of locations of WVCs is an important consideration in any analysis to identify collision hotspots (Gunson et al. 2009). Unfortunately, transportation planners often rely on WVC data that is spatially inaccurate and statistically problematic.

The current rate of WVCs is a concern along Highway 3 through the Crowsnest Pass region. Issues of wildlife movement and motorist safety may further be complicated by a proposed upgrade of Highway 3 from two to four lanes in Alberta. Identifying the location of high WVC hotspots along Highway 3 provides important information for managers responsible for reducing WVCs and facilitating wildlife movement, especially when planning for highway expansion. We report here on the analysis of WVC hotspots using existing wildlife mortality data.

4.2. Methods

4.2.1. Mortality Data

Mortality data were acquired independently for Alberta and British Columbia. The datasets for Alberta and British Columbia were processed independently because data are collected using different processes resulting in inconsistencies in rates of recording and accuracy of location.

In Alberta, data were acquired from three sources:

- Highway Maintenance Contractors (Volker Stevin) (1997–2008)
- Road Watch in the Pass (2005–2008)
- Alberta Sustainable Resource Development (SRD), Fish and Wildlife (1997–2007).

Highway maintenance contractors from Volker Stevin are responsible for removing carcasses found along the highway on weekdays. They record on hard copy sheets the date, time, species, number of individuals and distance to nearest local landmark for each carcass collected.

Road Watch in the Pass is a community-based monitoring project that enables citizens in the region to enter their wildlife observations, including mortality data, into an on-line mapping tool. Participants enter their observations, through a project website, directly onto a high-resolution map that includes local landmarks, roads and river features. A pop-up form then allows the participant to enter information on species, number of individuals, date, and time of day.

Alberta SRD, Fish and Wildlife Division maintains an Enforcement Database (ENFOR) that tracks responses by Fish and Wildlife officers to wildlife concerns in the Crowsnest Pass Region. The database includes WVC reports where Fish and Wildlife officers respond to calls reporting injured wildlife along the highway and/or species of special interest involved in WVCs such as any carnivore species or bighorn sheep. Data were extracted by Fish and Wildlife personnel and used in this report.

Each dataset was converted into spatial layers by Geographic Information System (GIS) software using tools in ArcMap® (Environmental Systems Research Institute 2009) and the HawthsTools extension (Beyer 2009). The three datasets were assessed for duplicate records. Duplicate records were deleted based on the following conservative assumptions: same species on the same day within 1000 meters of each other. In cases with duplicates, the most spatially accurate record was selected. The order of preference for datasets was: highway maintenance contractors (the same individuals for the last ten years), ENFOR and Road Watch data. The point files from the three datasets along Highway 3 were merged together to form one file of WVC data.

In British Columbia, point data were provided by British Columbia Ministry of Transportation. Locations were provided to the nearest kilometer marker along Highway 3. A file of mortality points was created along Highway 3 using the GIS software and extensions. To the best of our knowledge this is the only WVC dataset available for the region.

4.2.2. Data Error

All datasets used in this analysis identified WVCs in relation to the nearest road reference or landmark, therefore the spatial accuracy of WVCs is unknown and of lower quality than data collected using GPS units. To address this issue, WVC data obtained without a GPS were referenced to the nearest kilometer segment along Highway 3.

In addition, data on WVC occurrence is generally underestimated because data are collected when driving roads. Underestimating mortality is common as injured animals may move away from the road or vegetation may obscure carcasses. In addition species may be removed by passing vehicles or scavenging animals. It is difficult to quantify the percentage of large mammals that go unrecorded, but our observations are likely on the conservative side. A comparison for the Alberta datasets between mortality observations collected by Volker Stevin's staff and Road Watch participants showed an increase by 22 percent in the number of observations through the union of the two data sources. British Columbia Ministry of Transportation estimates that reported wildlife mortality represents only 25 to 35 percent of actual number of animals killed (Wildlife Collision Prevention Program 2009).

4.2.3. Identifying Wildlife–Vehicle Collision Zones

For each region, datasets were examined in a GIS to identify WVC hotspots for large mammals occurring along 1.0 km segments on Highway 3. Mortality data points were assigned to the nearest highway segment. To address the potential for spatial error and possibility of observations occurring on the segment boundary, a smoothing function was implemented where the mortality observations per road segment were equated to the sum of the road segment and its two neighboring segments.

The number of WVCs per segment was then categorized into 20, 40, 60 and 80 percentiles equating to "very low" (>0–20%), "low" (20–40%), "medium" (40–60%), "high" (60–80%), and "very high" (80–100%) as modeled after Huisjer et al. (2008). Segments with no observations were excluded from the analysis. Zones meeting medium, high and very high standards were identified as WVC hotspots.

4.3. Results

On the 136 km British Columbia section of Highway 3, 1906 wildlife mortality observations were recorded from 1998–2007 between Rocky Mountain Trench (Highway 3/93 junction to Fort Steele) and the British Columbia/Alberta provincial border. Local experts were asked to review the WVC maps for each large mammal species as provided by the British Columbia Ministry of Transportation. Based on local expert knowledge the WVC hotspots were deemed spatially accurate but the wildlife mortality dataset appeared to underestimate the true rate of mortality occurring along Highway 3 (Lee 2009).

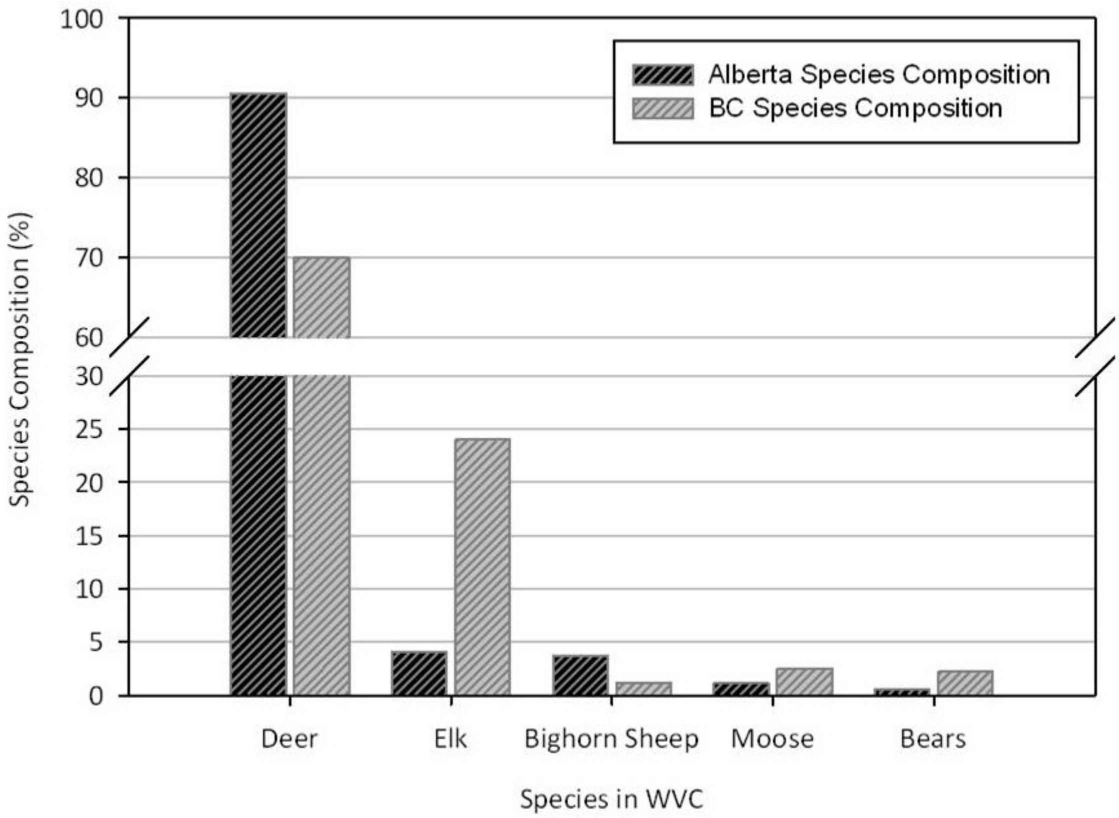

Figure 3: Large mammal composition of wildlife–vehicle collisions in the Highway 3 study area.

The stretch of Highway 3 from Rocky Mountain Trench to the provincial border at Crowsnest Pass contains 81 km of medium to very high WVC segments, representing 59 percent of the highway and 79 percent of total WVCs (Figure 4). Very high WVC segments occur along most of the Rocky Mountain Trench and the first few kilometers east of Elko (Figure 5). High WVC segments occur at the town of Sparwood, Sparwood dump site (Hosmer–Sparwood 3), Olsen Rest Area (Hosmer–Sparwood 2), north of the town of Fernie (Fernie–Hosmer 1), Fernie Ski Hill Access, at the Town of Elko (Fernie–Morrissey 4) and several locations within the Rocky Mountain Trench (Trench 4 and Trench 5) (Figure 5 and Figure 6).

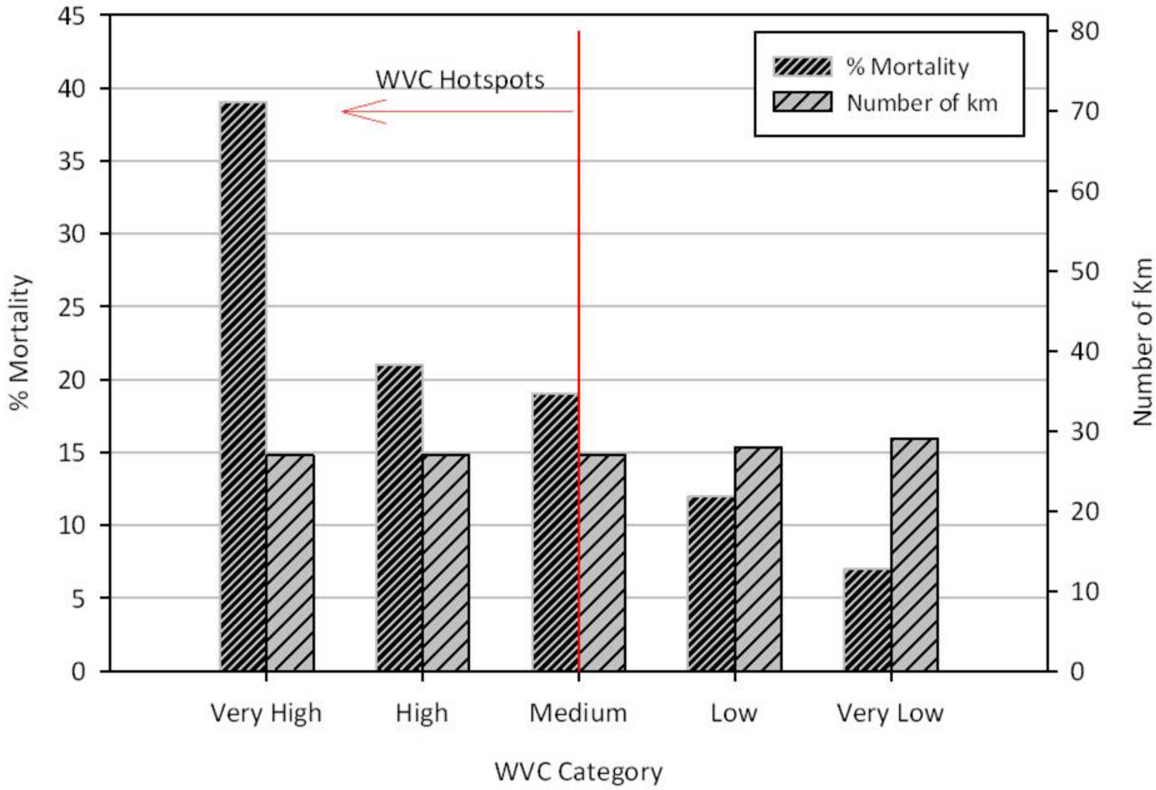

Figure 4: Percentage of wildlife–vehicle collisions (WVCs) and kilometers of highway by WVC category along Highway 3 in the British Columbia portion of the study area.

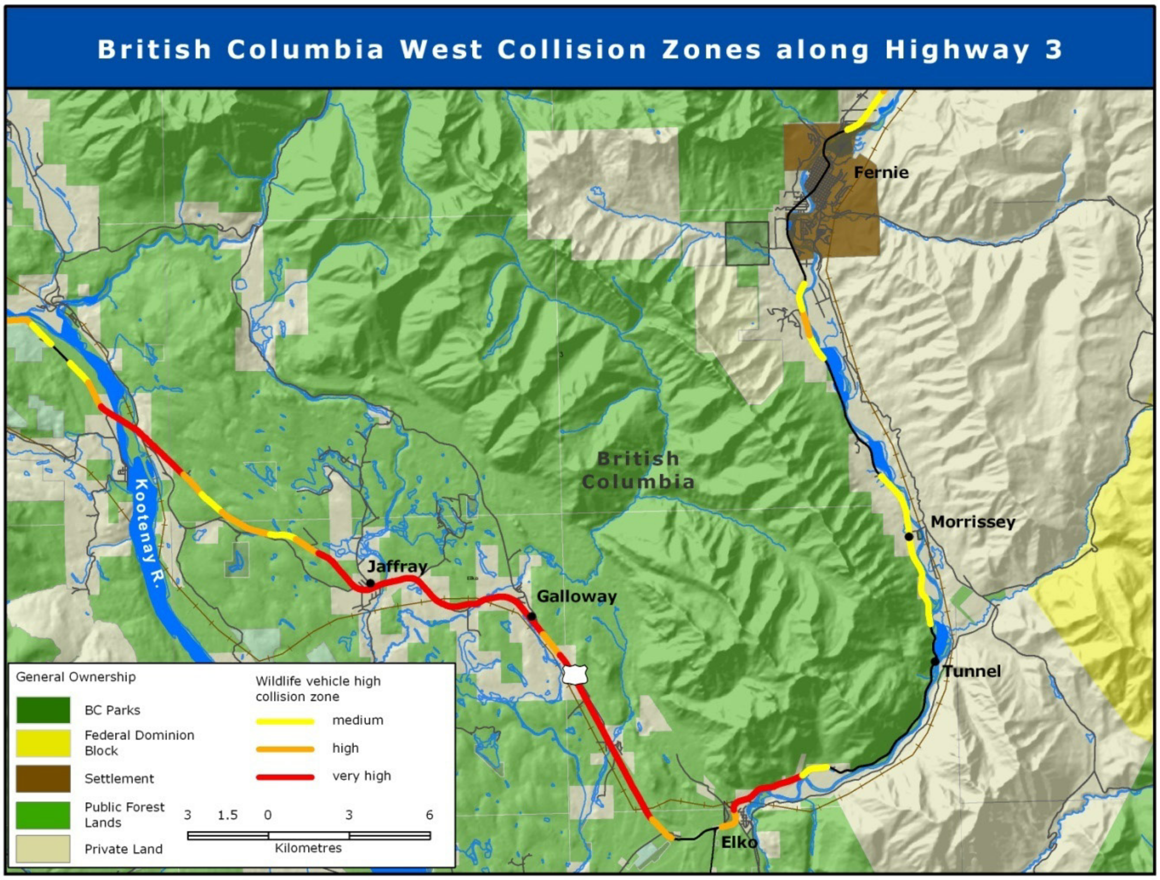

Figure 5: Wildlife–vehicle collision segments (categorized as very high, high and medium) along Highway 3 from the Columbia River to Fernie, BC.

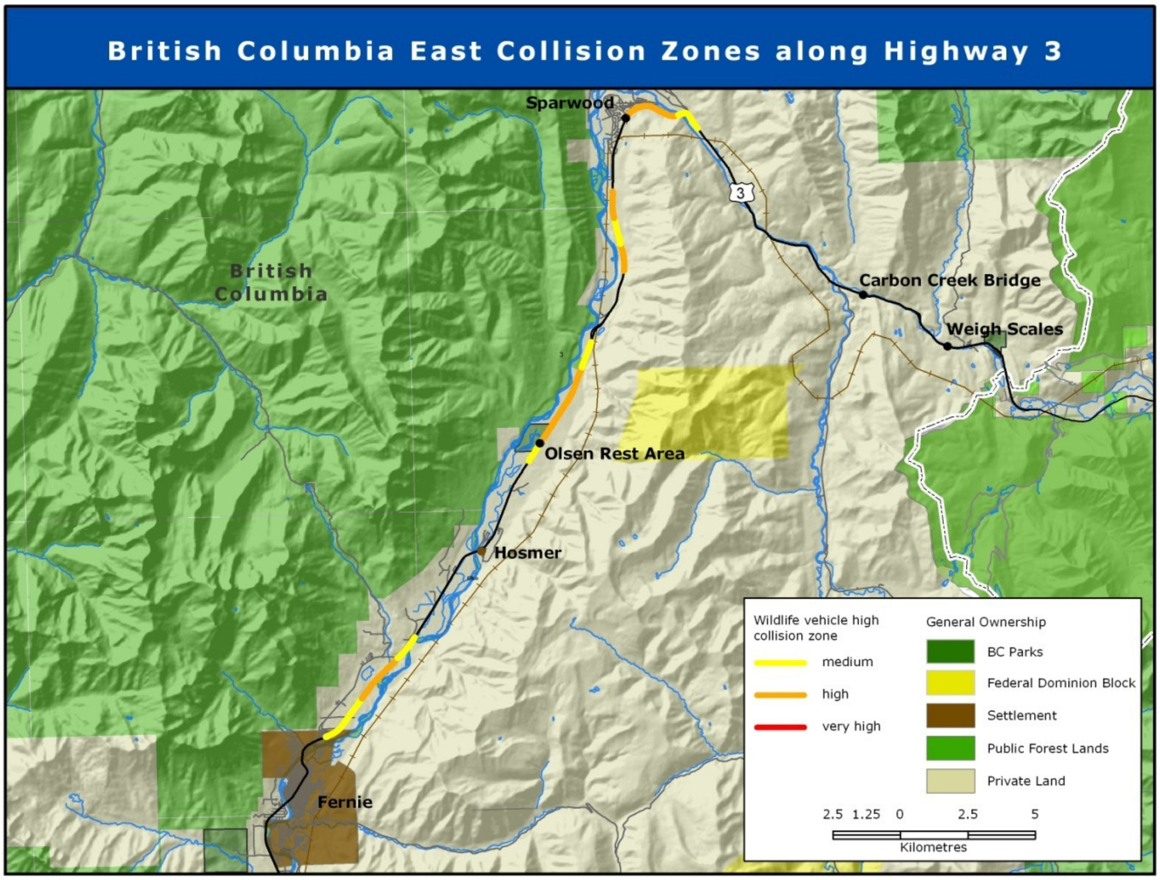

Figure 6: Wildlife–vehicle collision segments (categorized as very high, high and medium) along Highway 3 from Fernie, BC to the Alberta provincial border.

On Highway 3 in Alberta there were 1359 WVCs recorded from 1998–2008 along the 44 km section between the British Columbia/Alberta provincial border and Lundbreck. Deer were the most common species involved, representing 90 percent of the WVCs. The section from the provincial border to Lundbreck has 27 km of medium to very high WVC segments, representing 61 percent of the highway's length and 77 percent of total WVCs (Figure 7). Very high WVC segments occur along Highway 3 from Highway 22 to the intersection with Highway 507 (mid-point is Crowsnest East) and a stretch of Highway 3 around Leitch Collieries (Figure 8).

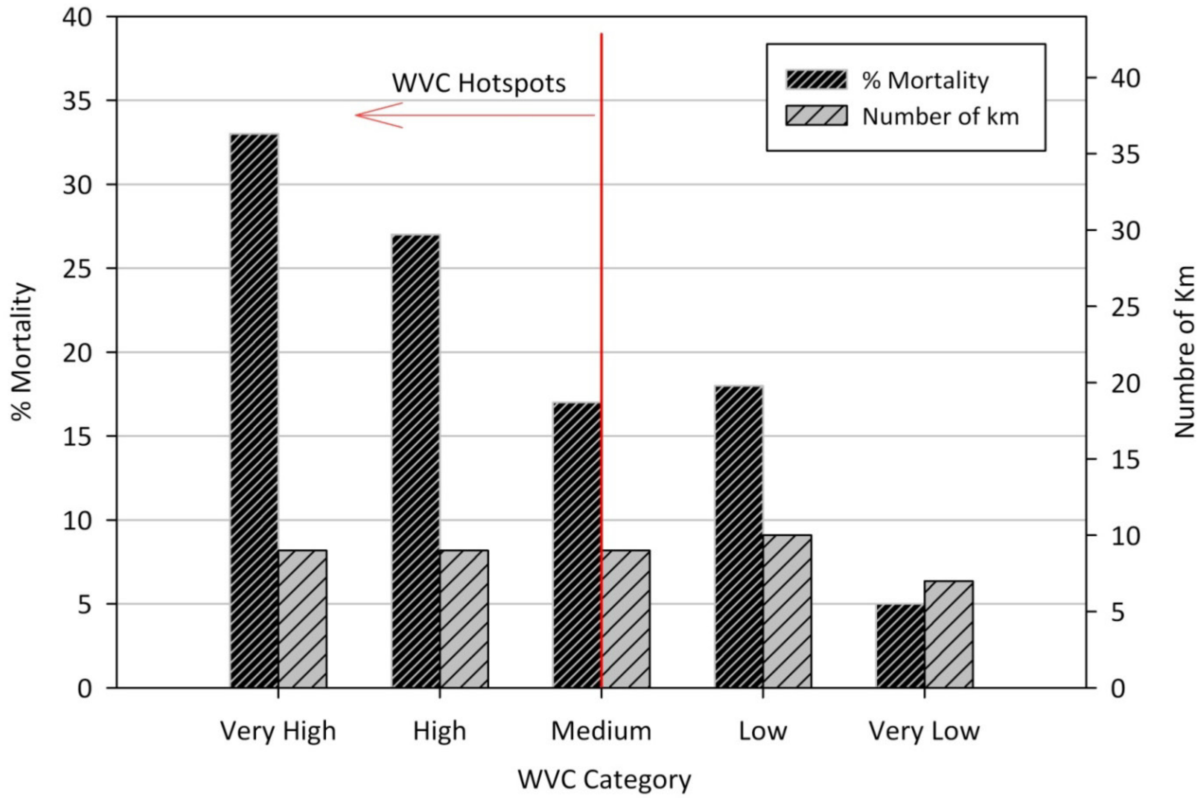

Figure 7: Percentage of WVC mortality in and kilometer of highway per WVC category for Highway 3 in the Alberta portion of study area.

For ungulate species, WVCs are primarily a concern because they pose a motorist safety issue; however, from a conservation perspective, the impact of WVCs on local populations has little impact. The exception may be for bighorn sheep, a blue listed species in British Columbia. Bighorn sheep are highly susceptible to WVCs where their home ranges cross Highway 3, as they are attracted to the highway to lick salt. Four well defined areas along Highway 3 were identified where bighorn sheep are frequently found on the roadway: Elko-Morrissey 3 and Carbon Creek Bridge mitigation sites in British Columbia (Figures 5 and 6) and the East Blairmore Bridge and Crowsnest Lakes mitigation sites in Alberta (Figure 8). Of the four sites, the Crowsnest Lakes population may be impacted the most given approximately 10 percent of the population is killed on the highway annually.

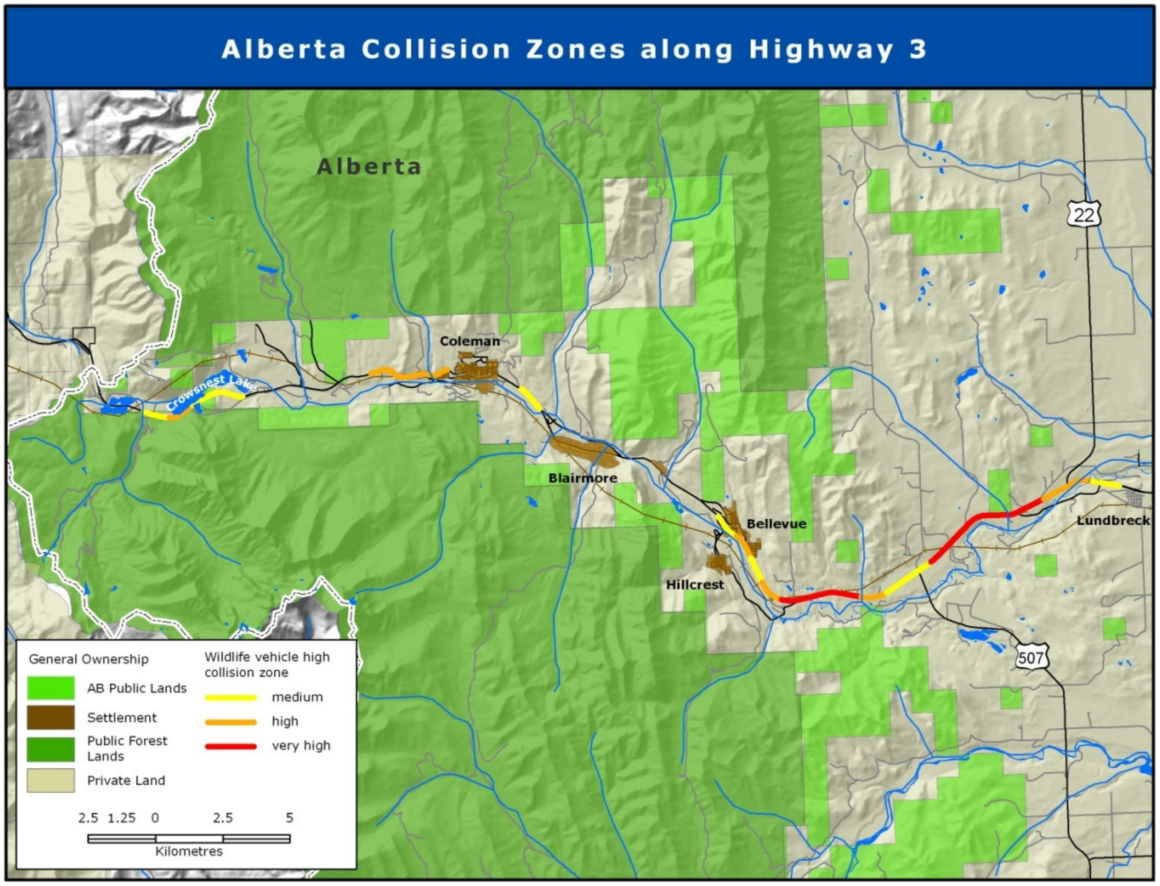

Figure 8: Highway segments of interest due to WVCs (categorized as very high, high and medium) as well as potential mitigation sites along Highway 3 from the Alberta provincial border to Lundbreck, AB.

5. VALUATION OF WILDLIFE CORRIDOR AND WILDLIFE–TRANSPORTATION CONFLICT ZONES

5.1. Identifying Priority Areas for Highway Mitigation

Below, we describe specific sites along Highway 3 that have been identified as in need of mitigation of current impacts on wildlife mortality and movement. The importance of specific locations varies by species, landscape and conservation concern. These "mitigation emphasis sites" are at the relatively fine scale necessary for highway planning and mitigation. The mitigation emphasis sites are identified through a synthesis of information provided by detailed wildlife movement data, habitat models, highway data, researcher opinion, available anecdotal reports, and opportunities and constraints with respect to adjacent land ownership and use (Figure 9).

The selected mitigation emphasis sites were visited in the field and evaluated for mitigation potential. Furthermore, to assist in ranking sites for mitigation priority, we assigned each site a subjective score from 1 (low) to 5 (high) on the basis of the following criteria:

- *Local Conservation Value* – the value of the highway mitigation to local wildlife conservation regardless of regional significance
- *Highway Mortality* – relative rate of wildlife–vehicle collisions as a proxy for motorist safety risk
- *Land-Use Security* – the degree to which lands adjacent to the site are secured *de facto* for conservation
- *Opportunities for Highway Mitigation* – the degree to which mitigation options are available and can be implemented with reasonable cost
- *Regional Conservation Significance* – the potential significance of highway mitigation to address wildlife conservation concerns of regional significance

Table 1 and Table 2 display the scores for each criteria and the average for all five criteria for each mitigation emphasis site, by province. These matrices may assist transportation planners in prioritizing sites for wildlife mitigation based on the five criteria. In British Columbia, Elko–Morrisey 1, Elko–Morrisey 3, Fernie–Morrisey 1, Hosmer–Sparwood 1 and Alexander–Michel 1 have the highest average scores in the matrix. In Alberta, Crowsnest West, Leitch Collieries and Rock Creek have the highest average scores in the matrix. Figure 9 depicts the location of the mitigation emphasis sites along Highway 3 in both British Columbia and Alberta.

Table 1: Highway 3 wildlife mitigation emphasis sites prioritization matrix in British Columbia.

Site Name	Species	Local Conservation Value	Highway Mortality	Land Use Security	Transportation Mitigation Options	Regional Conservation Significance	Average
Trench 1	Multi	3	4	4	4	2	3.4
Trench 2	Multi	3	4	4	3	2	3.2
Trench 3	Multi	1	5	1	1	1	1.8
Trench 4	Multi	2	5	2	1	2	2.4
Trench 5	Multi	3	5	3	2	4	3.4
Trench 6	Multi	3	5	4	3	3	3.6
Elko-Morrisey 1	Multi	4	5	3	4	3	3.8
Elko-Morrisey 2	Multi	4	3	3	3	3	3.2
Elko-Morrisey 3	BHS	4	4	4	4	3	3.8
Fernie-Morrisey 1	Multi	4	3	5	3	4	3.8
Fernie-Morrisey 2	Multi	3	3	3	3	4	3.2
Fernie-Morrisey 3	Multi	3	3	2	2	4	2.8
Fernie-Morrisey 4	Multi	5	4	2	2	5	3.6
Hartley Creek	Multi	4	4	1	4	4	3.4
Hosmer	Multi	2	2	3	5	3	3
Hosmer-Sparwood 1	Multi	5	3	5	4	5	4.4
Hosmer-Sparwood 2	Multi	3	3	4	4	4	3.6
Hosmer-Sparwood 3	Multi	2	4	3	3	2	2.8
Michel Creek	Multi	5	2	2	3	2	2.8
Carbon Creek Bridge	BHS	3	4	3	2	2	2.8
Alexander-Michel 1	Multi	5	2	3	4	5	3.8
Alexander-Michel 2	Multi	4	2	3	3	5	3.4

Table 2: Highway 3 wildlife mitigation emphasis sites prioritization matrix in Alberta.

Site Name	Species	Local Conservation Value	Highway Mortality	Land Use Security	Transportation Mitigation Options	Regional Conservation Significance	Average
Crowsnest Lakes	BHS	4	5	3	2	3	3.4
Crowsnest West	Multi	5	2	3	4	4	3.6
Iron Ridge	Multi	4	4	2	2	4	3.2
McGillivray Creek	Multi	3	3	2	3	3	2.8
Crowsnest Central	Multi	2	2	2	1	2	1.8
East Blairmore Bridge	BHS	3	2	3	3	2	2.6
Leitch Collieries	Multi	4	4	3	4	4	3.8
Rock Creek	Multi	5	5	4	4	3	4.2
Crowsnest East	Multi	3	4	3	5	2	3.4

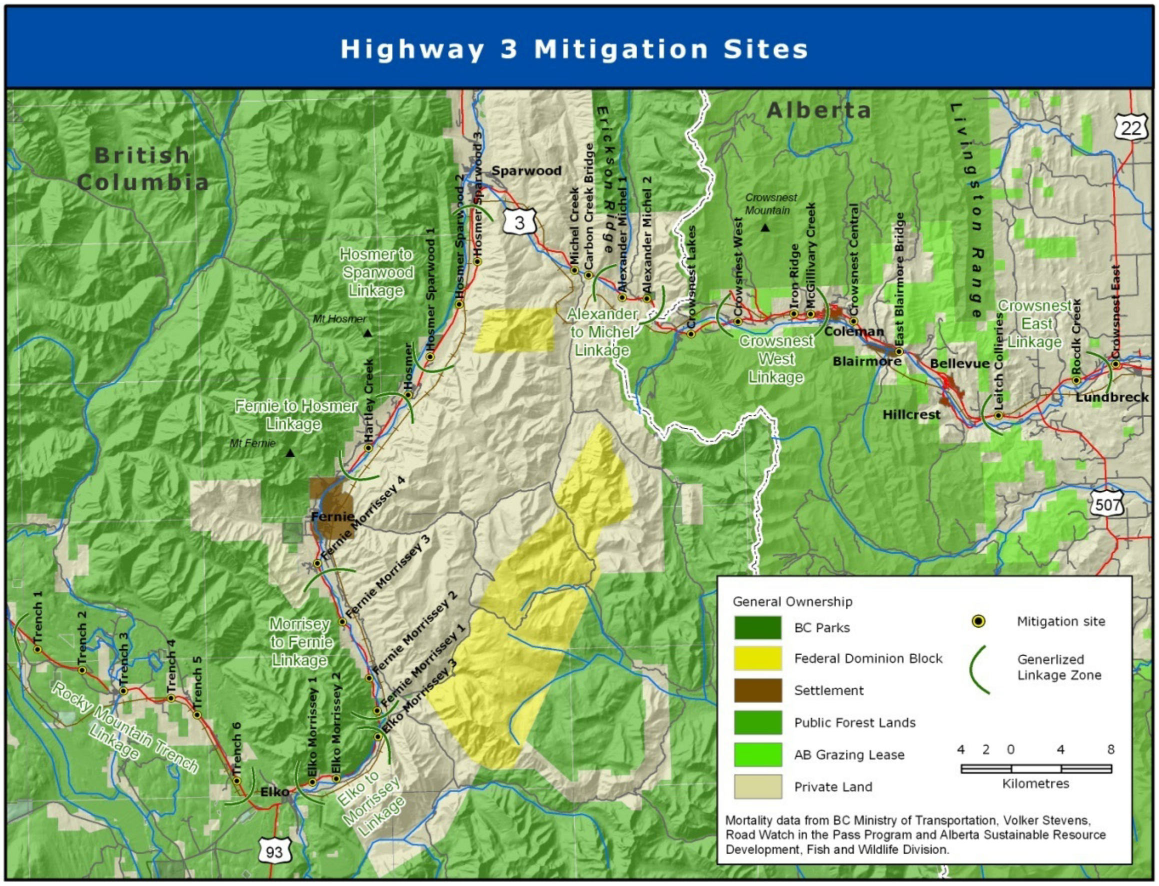

Figure 9: Mitigation emphasis site locations along Highway 3 within the study area.

5.1.1. Rocky Mountain Trench Linkage Zone

This section of Highway 3 occurs within the Rocky Mountain Trench and is of importance for ungulates, especially during winter, as well as carnivores that include bobcat, badger, and cougar. As noted below, grizzly bears are also known to make occasional localized movements into the Trench during fall. While land ownership in the greater landscape is largely provincial public, lands directly abutting several mitigation emphasis sites are under private ownership.

Trench 1 – Land ownership is entirely public north of the highway. South of the highway, it is also mostly public but some private land exists along a secondary road within a kilometer of this site.

Trench 2 – This site is surrounded by public land that is relatively contiguous both north and south of the highway.

Trench 3 – Situated on Sand Creek, this site is on what would likely be a wildlife movement conduit under more natural circumstances. However, the immediate area is currently built up in association with the community of Jaffray and is surrounded by private land.

Trench 4 – Lands directly to the north are under private ownership. The public land that occurs to the south is itself largely surrounded by private land.

Trench 5 – Fall movement by grizzly bears has also been documented through this area. Land ownership is private south of the highway and public to the north.

Trench 6 – Grizzly bear movements across the highway have been documented in this specific area. Bears are typically moving between the Sand and McDermit drainages and lower Kikomun Creek where they have opportunities for feeding on kokanee salmon in the fall. Land on both sides of the highway is under private ownership, other than the strip between the highway and the forestry road to the east.

5.1.2. Elko to Morrissey Linkage Zone

This section of Highway 3 from Elko through the only tunnel on the highway to Morrissey separates the Elk River and associated bottom flats to the South and the south end of the Lizard Range to the north. This area is important for ungulate species including deer, elk and bighorn sheep; all of these species frequently cross the highway to move from valley bottom to the mountains, particularly near Elko.

Elko–Morrissey 1 – Total wildlife–vehicle collisions along this section are very high, mostly with deer, elk, bears and bighorn sheep. There is the potential for subdivision of the private lands north of the highway. There is a strip of private land directly south of the highway, but public land lies south of the Elk River.

Elko–Morrissey 2 – Public lands are north of the highway, with a strip of private lands directly south of the highway, further south of this strip are public lands and a private land trust south of the Elk River.

Elko–Morrissey 3 – This area represents a very high collision zone for bighorn sheep, where they are often observed licking salt that gets trapped in the highway's rumble strips. The tunnel access pit is used as a carcass pit for wildlife involved in wildlife–vehicle collisions. The ownership surrounding this site is primarily public lands to the west of the highway and private conservation lands held by a land trust east of the highway and the Elk River.

5.1.3. Morrissey to Fernie Linkage Zone

The importance of this landscape for carnivore population connectivity has been well documented (Apps 1997, Apps et al. 2007). Across the lower Elk Valley the linkage zone connects the valleys of Morrissey Creek with the east slopes of the Lizard Range. While there is some human development within the valley bottoms, extensive movement by resident GPS-collared female grizzly bears has been documented as well as anecdotal evidence of lynx movement. This linkage zone is rated as having high conservation significance, with reasonable movement permeability and moderate vulnerability (Apps 1997, Apps et al. 2007). For highway mitigation, there are four potential sites for consideration.

Fernie–Morrissey 1 – This site corresponds with known cross-highway movements of grizzly bears, consistent with habitat and topographic features. Ownership is public west of the highway and private conservation lands to the east. Associated human influence is low and habitat security appears to be high on both sides of the highway.

Fernie–Morrissey 2 – This second site of the linkage zone is just north of the Hwy 3 and Morrissey Road junction. While grizzly bears have moved through this zone, this site has less potential than the previous one due to private land ownership and residency on either side of the highway. This site represents a high wildlife–vehicle collision zone including mortality records for deer, elk, and bear. There is two-meter high fence (to exclude elk) along the northwest edge of the highway.

Fernie–Morrissey 3 – There has been extensive grizzly bear movement in this vicinity, particularly by females. This site is within a natural movement conduit associated with Lizard Creek and closely links private conservation lands east of the Elk River with public lands to the west. A small piece of private land is, however, integral to this connection.

Fernie–Morrissey 4 – Despite relatively high human activity associated with the ski area and private land, this site is within an obvious multi-species movement route associated with Lizard Creek. The site is also proximal to core grizzly bear habitats and many highway crossings have been documented. There is adequate security cover on either side of the highway. This site represents a very high wildlife–vehicle collision zone including mortality observations for deer, elk, moose and bears. To the west, land ownership is private. To the east, ownership is unknown between the highway and the Elk River. Beyond the river, lands to Cokato Road are under multiple private owners and have little security cover. Beyond that, land is under private corporate ownership with no restrictive covenants. Zoning associated with the site is rural/residential with a minimum size of two- to four-hectare parcels. According to the Fernie Area Land Use Strategy, these lands will be maintained as agricultural and will not be annexed into Fernie. Lands west of the highway are subject to development in the expansion of the Fernie Alpine Resort and are currently zoned for such.

5.1.4. Fernie to Hosmer Linkage Zone

This section of highway is not considered part of a linkage zone due to the high concentration of human settlement, use and activity. Nonetheless, we know that grizzly bears have occasionally moved across the Elk Valley here, undoubtedly influenced by home range distribution and associated habitats.

Hartley Creek – Despite high human presence near the highway, grizzly bears (and presumably other species) funnel into this area to and from Hartley Pass. It is also close for bears whose home ranges are centered in Lizard Basin and that occasionally move around Fernie to the east via the Coal Creek drainage. Several known movements and one mortality are focused within a fairly well-defined location here. This natural route funnels to a point where Hartley Creek passes under the highway and enters the Elk River. This mitigation emphasis site is within a very high wildlife–vehicle collision zone, primarily elk and deer. The specific highway crossing site is, however, between private land, with adjacent land in the Dicken Road area zoned for two- and eight-hectare parcels. Private corporate land (no covenant) abuts the Elk River to the east, beyond which are private corporate moratorium lands.

Hosmer – This site is located where the Elk River passes under the highway just outside of Hosmer. Lands are under private ownership on both sides of the highway, except for those within the river's course.

5.1.5. Hosmer to Sparwood Linkage Zone

Hosmer–Sparwood 1 – The area surrounding this site has good security cover and low human presence. Any of a number of locations would work well for mitigation. However, the fine-scale terrain conditions here are more conducive to multi-species movement, and the site is central to the secure private conservation lands that abut both sides of the highway (timber rights are retained to the east). Elk Valley Provincial Park is also adjacent to this site to the north.

Hosmer–Sparwood 2 – Although there are few empirical data of wildlife movement within this linkage zone, landscape and site attributes do suggest high value for at least cross-valley connectivity. In relation to Hosmer–Sparwood 1, this second site is farther east and closer to Ladner Creek, which some wide-ranging species use to move into and out of the Elk Valley. This site is situated in a very high wildlife–vehicle collision zone, mostly with deer, elk and bear. A carcass pit for wildlife involved in collisions with vehicles is located near the Olsen railway crossing; local wildlife experts suggest this is an attractant for carnivore species drawing them closer to Highway 3 and the Canadian Pacific railway. East of the highway is private conservation trust land on which there are corporate timber rights. Lands to the west are also mostly under free-hold ownership by a land trust.

Hosmer–Sparwood 3 – This site is slightly less optimal than Hosmer–Sparwood 1 and 2 from a landscape-linkage perspective, but site-specific conditions warrant consideration as a mitigation option. This site is situated in a very high wildlife–vehicle collision zone, primarily with deer, elk and bears. Lands to the west are under public ownership. Lands east of the highway are owned by a corporation and a different company owns the private land just to the north (no existing conservation covenant).

5.1.6. Michel and Carbon Creeks

Michel Creek – Few empirical data exist confirming multi-species movement; nonetheless, this site where Michel Creek passes under Highway 3 near the mouth of the Erickson Valley is an obvious candidate for mitigation. Elk wintering and calving habitats are near both sides of the highway and large carnivore movements can be expected. Private corporate lands are on both sides of the highway.

Carbon Creek Bridge – Selected because it is a site where bighorn sheep interact with Highway 3 and mortality from wildlife–vehicle collisions may be having an impact on this relatively small herd.

5.1.7. Alexander to Michel Linkage Zone

This is a very important linkage zone and there is good evidence that it is functionally intact for multiple carnivore species. A private company has restricted motorized access north of the highway on the east side of Michel Creek. Private corporate lands south of the highway are gated.

Alexander–Michel 1 – This site at the base of Alexander Creek maximizes landscape and site-specific potential and likely is most optimal for highway mitigation. Security cover is available for wildlife on both sides of the highway and human influence is relatively minimal. North of the highway, animals have the option to continue along the creek or stay higher along a ridge that has moderate forest cover. Among carnivores, grizzly bears and wolves are known to have moved across the highway here. A gun range is just to the west of Alexander Creek but should not detract much from the potential of this site. A private company is the primary landowner north and south of the highway, with land north of the highway and west of Alexander Creek owned by a different corporation.

Alexander–Michel 2 – This site is of lower priority than the previous, but conditions may allow some mitigation options immediately to the west of the parking lot for the provincial park and spacing from the previous site is appropriate. Private corporate lands are on both sides of the highway. There has been a proposal for quarry development to the south but the status of this plan is unknown.

5.1.8. Crowsnest Lakes

Crowsnest Lakes – This site was selected to address a very high bighorn sheep mortality area from Island Lake to Emerald Lake. There is concern that the impact of bighorn sheep mortality from collisions with vehicles may be adversely affecting the local population. Public lands are on both sides of the highway.

5.1.9. Crowsnest West Linkage Zone

Known as the West Block locally, this region represents an important movement area for carnivores (both grizzly bear and wolf have been documented crossing Highway 3 in this area). It also represents key ungulate winter range for elk. There are considerable private land conservation efforts underway within this region. Private land is interspersed with public parcels (grazing leases) before giving way to public forest reserve lands.

Crowsnest West – This site, the most obvious for mitigation within the local landscape, is where the Crowsnest River passes under the highway. There is evidence of carnivore movements at this site, as it is within the home range of the Crowsnest wolf pack and they have been documented crossing the highway. This site is associated with moderate human presence and relatively low security cover. The area north of the highway is privately owned, while south of the highway it is a mix of private, public and municipal reserve lands.

Iron Ridge – This site is where the highway bisects what is locally known as Iron Ridge. The area represents a high wildlife–vehicle collision zone, mainly with deer and elk. Lands to the west represent important ungulate winter range, particularly for elk. Carnivore movement has been noted here including a recent grizzly bear mortality. This area has high potential for conservation as land to the north of the highway is owned by Alberta Transportation, a land trust or the public. There is also a piece of land in municipal reserve on the south side that is important for providing land security to this mitigation site. To the south there is a small piece of private land before linking to public lands (forestry reserve). However, to create connectivity between the various ownerships on both sides of the highway, there are a few key private parcels that would need to be secured for conservation purposes.

5.1.10. Crowsnest Central Linkage Zone

This linkage zone occurs between the two Albertan communities of Blairmore and Coleman. It is the most compromised of all the linkage zones in the study area due to human development.

McGillivray Creek – This site is in a valley situated between the town of Coleman and the East Coleman access road. It contains a high wildlife–vehicle collision zone predominantly due to deer.

Crowsnest Central – Although this site is not within a linkage zone of regional significance, it may be associated with natural movements of local resident ungulates. Land trusts have conservation lands to the south of the highway on the wetland parcels. There are no conservation lands to the north and developments such as Iron Stone are recent additions to the landscape.

East Blairmore Bridge – This site was selected to address bighorn sheep movement across the Crowsnest Highway. Wildlife–vehicle collisions are rare for this site and the sheep have been observed to cross under the existing Crowsnest River bridge. In addition, conservation officers actively attempt to keep the sheep off the highway due to their close proximity to town. Future concerns include increased human use of a footpath running under the bridge.

5.1.11. Crowsnest East Linkage Zone

There are large blocks of private land where the predominant land use is cattle grazing in this linkage zone. There is antidotal evidence of carnivores, including grizzly bears, using this landscape directly north and south of the highway in addition to a crossing that was recorded at the Leitch Collieries. In addition, high levels of wildlife-vehicle collisions occur throughout the area, especially to the east and west of Rock Creek.

Leitch Collieries – This site is within an important wildlife linkage zone and is in a high wildlife–vehicle collision zone, predominantly deer. It lies on the boundary between the Municipality of Crowsnest Pass and the Municipality of Pincher Creek and is directly east of the Leitch Collieries parking lot. Grizzly bears have been known to cross the highway in this area and have been observed consuming berries at the historic site. Private conservation lands exist on both sides of the highway, but there are additional private parcels on both sides of the highway that are important to secure for conservation purposes for this site.

Rock Creek – This site is located where Rock Creek passes under the Crowsnest Highway through a small culvert. This site may provide movement opportunities for carnivores and other species. There are very high wildlife–vehicle collision zones to the east and west of the guard rails, predominantly driven by deer that are forced up out of the valley to cross the highway and due to attractive foraging habitat north and south of the highway. Public land parcels occur just to the north and south of the highway as do sections of private land of which some are already under conservation easement.

Crowsnest East – This site is situated where the Crowsnest River flows under Highway 3 near Lundbreck. There has been little documentation of carnivore movement in this area. Wildlife mortality from collisions with vehicles increases to the west toward the Highway 3–Highway 22 junction. Land on both sides is under private ownership and conservation potential has not been explored.

6. HIGHWAY 3 WILDLIFE MITIGATION OPTIONS

6.1. Introduction

In rural and suburban areas of North America, accidents with wildlife are quickly becoming a major safety concern for motorists. In Alberta, collisions with large ungulates (deer, elk, moose) comprise 50 percent of all accidents on rural roadways with an average of five human fatalities per year (Peter Mah, personal communication; Alberta Transportation 2003). In 2006, these accidents cost Albertans more than $250 million (Clevenger et al. 2008).

Road mitigation measures are designed to facilitate the safe movement of wildlife across roads and increase motorist safety. Warning signs and reflectors have become standard measures used by transportation agencies for decades; however, research shows that they along with many other tools that agencies routinely use are not effective in preventing accidents and wildlife mortality (Huijser et al. 2007).

Wildlife crossing structures are being designed and incorporated into road construction and expansion projects to help restore or maintain animal movements across roads. Engineered wildlife crossings are designed to meet the dual needs of allowing animals to cross roads with reduced hazard to motorists and wildlife. Typically crossing structures are combined with high fencing and jump-outs (escape ramps), and together are proven measures to reduce road-related mortality of wildlife and connect populations (Clevenger et al. 2001, Dodd et al. 2007).

Construction of wildlife crossings has been increasing in North America in the last decade. Alberta Transportation has built crossings for large mammals along the Trans-Canada Highway in Canmore, Dead Man's Flats, and near Calgary, while the British Columbia Ministry of Transportation has built a wildlife overpass on the Coquihalla Highway and a number of other crossings province-wide designed for wildlife ranging from amphibians to moose and elk.

6.2. Benefits of Reducing Wildlife–Vehicle Collisions

There are many benefits provided by mitigation measures aimed at reducing WVCs, such as fewer motorist accidents that may include human injuries, deaths, and property damage. Benefits to wildlife include protecting individual wildlife from death or injury, keeping populations intact, allowing individuals free movement to access important habitats and resources, thus enhancing long-term survival and population viability. A review of 13 different mitigation measures used by transportation agencies to reduce WVCs (Huijser et al. 2009)—such as warning signs, vegetation removal, fencing, and wildlife crossing structures—indicated estimated effectiveness can vary from as low as a 26 percent reduction in WVCs (seasonal wildlife warning signs) to a 100 percent reduction in WVCs (elevated roadway). Each mitigation measure has a different cost to implement and maintain and thus the selection of the appropriate mitigation measure should take into account the different safety and conservation goals as well as its effectiveness in reducing WVCs.

6.3. Monetary Costs and Benefits of Highway Mitigation Recommendations

As the rates of WVCs have increased over the past two decades (Huijser et al. 2008b), transportation and natural resource agencies are increasingly seeking to mitigate highways to increase motorist safety as well as provide for the conservation of wildlife. To support their efforts, recent advances in evaluating the monetary costs and benefits of mitigation measures are helping decision makers, managers and the public better understand the trade-offs of investing in a variety of mitigation measures to reduce WVCs. Unfortunately, estimations of the economic costs and benefits of maintaining local- and landscape-level connectivity for wildlife have not been developed at this time.

6.4. Summary of Ungulate–Vehicle Collision Rates at Each Mitigation Site

Alberta and British Columbia collect WVC data separately and use different methodologies as noted in the Methods section (section 4.2). In British Columbia, point data were provided by British Columbia Ministry of Transportation. In Alberta, data were acquired from three sources: (1) Highway Maintenance Contractors (Volker Stevin; 1997–2008), (2) Road Watch in the Pass (2005–2008) and (3) ENFOR data from Alberta SRD (1997–2007). Locations were provided to the nearest kilometer marker along Highway 3 in each province.

Total ungulate–vehicle collision rates varied at the mitigation emphasis sites in British Columbia between a low of 0.6 WVCs/kilometer/year (WVCs/km/year) at the Carbon Creek bridge segment to a high of 3.1 WVCs/km/year at the Trench 3 site (Table 3). These relatively low numbers are most likely a result of underreporting based on British Columbia's information collection system. As a result, it has been estimated that for every observed WVC in British Columbia there are three unreported collisions (Hesse 2006). Hesse's research finding is further supported by a local expert knowledge assessment of wildlife mortality and movement zones on the British Columbia portion of the Highway 3 study area, where wildlife–vehicle collision zones were deemed accurate but the number of wildlife records was considered low (Lee 2009). Therefore, Table 3 totals could be multiplied by a factor of four to reach a more realistic estimate of ungulate–vehicle collision rates at these mitigation emphasis sites in the study area.

Table 3: Average annual number of ungulate–vehicle collisions for the Highway 3 road segment at each mitigation emphasis site in British Columbia.

Highway 3 - British Columbia: Mitigation Emphasis Site	Average Collision Rates: Species/Kilometer/Year				Total Annual Average Ungulate Collision Rate
	Deer	Elk	Moose	Bighorn	
Trench 1	0.8	0.4	0	0	1.2
Trench 2	1.4	0.1	0	0	1.5
Trench 3	2.9	0.1	0.1	0	3.1
Trench 4	2	0.7	0	0	2.7
Trench 5	1.1	0.8	0	0	1.9
Trench 6	2.2	0.2	0	0	2.4
Elko-Morrissey 1	0.9	0.1	0.1	0.1	1.2
Elko-Morrissey 2	1.2	0	0	0	1.2
Elko-Morrissey 3	0.6	0.1	0	0.05	0.75
Fernie-Morrisey 1	1.2	0.1	0.1	0.1	1.5
Fernie-Morrisey 2	1.05	0.2	0.1	0	1.35
Fernie-Morrisey 3	0.5	0.1	0.3	0	0.9
Fernie-Morrisey 4	0.9	0.4	0.5	0	1.8
Hartley Creek	0.9	1.1	0	0	2
Hosmer	0.4	0.1	0	0	0.5
Hosmer-Sparwood 1	0.8	0.2	0.1	0	1.1
Hosmer-Sparwood 2	0.4	1.1	0	0	1.5
Hosmer- Sparwood 3	0.8	0.6	0	0	1.4
Michel Creek	0.6	0.1	0	0	0.7
Carbon Creek Bridge	0.1	0	0	0.5	0.6
Alexander-Michel 1	0.8	0.9	0.2	0	1.9
Alexander-Michel 2	0.2	0	0	0	0.2

Total ungulate–vehicle collision rates were higher in Alberta than in British Columbia, most likely the result of the more concentrated effort to record WVCs in Alberta. Total ungulate–vehicle collision rates varied at mitigation sites in Alberta between a low of 1 WVC/km/year at the Rock Creek site to a high of 4.28 WVCs/km/year at the Leitch Collieries site (Table 4). The Rock Creek site has a large culvert and the highway is slightly elevated in this area, which may account for the relatively low collision rate; however, on the adjacent kilometer of highway on either side of this mitigation site, deer–vehicle collision (DVC) rates are very high, 8.45 DVCs/km/year to the east and 4.73 DVCs/km/year to the west of the Rock Creek site. Nearly half of the Alberta sites (n=4) had total ungulate–vehicle collision rates in excess of 3 WVCs/km/year. The bighorn sheep–vehicle collision rate of 2.55/km/year is notably high at the Crowsnest Lakes mitigation emphasis site (Table 4).

Table 4: Average annual number of ungulate–vehicle collisions for the Highway 3 road segment at each mitigation site in Alberta.

Highway 3 - Alberta: Mitigation Emphasis Site	Average Collision Rates: Species/Kilometer/Year				Total Annual Average Ungulate Collision Rate
	Deer	Elk	Moose	Bighorn	
Crowsnest Lakes	0.36	0.36	0	2.55	3.27
Crowsnest West	0.82	0.9	0	0	1.72
Iron Ridge	1.36	0.45	0	0	1.81
McGillivray Creek	4.09	0.09	0.09	0	4.27
Crowsnest Central	1.73	0.09	0	0	1.82
East Blairmore Bridge	2	0	0	0.18	2.18
Leitch Collieries	4.28	0	0	0	4.28
Rock Creek	1	0	0	0	1
Crowsnest East	3.27	0	0	0	3.27

6.5. Direct Monetary Costs of Ungulate–Vehicle Collisions

Huijser et al. (2009) summarized the costs of the most prevalent group of ungulates—deer, elk, moose—that are the source of over 90 percent of WVCs in North America (Table 5). All three species are present in the Highway 3 corridor and have been recorded in the mortality databases for Highway 3 in both Alberta and British Columbia. Although Huijser et al. (2007) developed monetary costs in U.S. dollars, for the purposes of this report it is reported in Canadian dollars at a par exchange rate.

Table 5: Summary of the monetary costs of the average wildlife–vehicle collision in North America for three common ungulates.

Description	Deer Dollars (2007)	Elk Dollars (2007)	Moose Dollars (2007)
Vehicle repair costs per collision	$2,622	$4,550	$5,600
Human injuries per collision	$2,702	$5,403	$10,807
Human fatalities per collision	$1,002	$6,683	$13,366
Towing, accident attendance, and investigation	$125	$375	$500
Hunting value animal per collision	$116	$397	$387
Carcass removal and disposal per collision	$50	$75	$100
Total	$6,617	$17,483	$30,760

Highway records indicate that bighorn sheep are the cause of frequent WVCs in certain sections of Highway 3 within the study area. For this report's cost–benefit analyses, a conservative average bighorn sheep–vehicle collision monetary cost value of $6617 (2007 $) is used (the equivalent to deer). This is a conservative estimate since the average bighorn sheep weighs more than the average deer and thus is more likely to cause higher vehicle repair costs per collision, as well as higher average human injuries or fatalities per collision. In addition, the average hunting value for a bighorn sheep is typically higher compared to deer.

6.5.1. Cost-effectiveness Thresholds

For mitigation to be cost-effective there needs to be a break-even point or a dollar value threshold. Huijser et al. (2009) thoroughly detailed these values for deer, elk and moose in North America. The number of deer–, elk–, and moose–vehicle collisions per kilometer per year were compared to the actual cost of different mitigation measures and the realized effectiveness of each technique. For example, if a road section averages 4.4 deer–vehicle collisions per kilometer per year, a combination of wildlife fencing, under- and overpasses, and jump-outs would be economically feasible, because the threshold value of 4.3 is exceeded (see Table 6). The threshold value for less costly mitigation of fencing, jump-outs and wildlife underpasses, however, is 3.2 deer–vehicle collisions per kilometer per year. Because we know the cost of different mitigation measures per year (Table 6) and their effectiveness at reducing WVCs (Huijser et al. 2007), we can calculate the break-even point for sections of Highway 3 with high WVC rates.

Table 6: Threshold values for different mitigation measures used to reduce deer–vehicle collisions by more than 80 percent (adapted from Huijser et al. 2009). Shaded area is referred to in "cost-effectiveness thresholds" section.

Threshold values	Discount rate[1]	Fence	Fence, underpass, jump-outs	Fence, under- and overpass, jump-outs	ADS[2]	Fence, gap, ADS, jump-outs	Elevated roadway	Road tunnel
$ Cost (2007)/yr	3%	$6,304	$18,123	$24,230	$37,014	$28,150	$3,109,422	$4,981,333
Deer/km/yr	3%	1.1	3.2	4.3	6.4	4.9	470	752.8

[1] For explanation of discount rate, see Huijser et al. 2009.

[2] ADS: Animal detection system

6.6. Monetary Costs for Ungulate–Vehicle Collisions at Mitigation Emphasis Sites

Table 7 and Table 8 summarize the costs at each mitigation emphasis site based on average annual collision rates for each ungulate species from Table 3 and Table 4 that are combined with the costs for each species from Table 5 in combination with the average monetary cost of $6617 used for bighorn sheep, where appropriate. In British Columbia, total annual monetary costs of ungulate–vehicle collisions varied between $1,323 at the Alexander–Michel 2 site and $28,329 at the Fernie–Morrisey 4 site (Table 7). Nearly one-third (7 of 22) of the mitigation emphasis sites in the British Columbia section of Highway 3 were in excess of $18,123 in annual monetary costs, making them excellent cost-effective candidates for infrastructure mitigation using underpasses, fencing and jump-outs. If underreporting of wildlife–vehicle collisions were accounted for, multiplying monetary costs by a factor of four would make ungulate–vehicle collision costs for most mitigation emphasis sites in Alberta and British Columbia much more expensive and therefore the cost-effectiveness of implementing highway mitigation would be more attractive at additional mitigation emphasis sites.

In Alberta, total annual monetary costs of ungulate–vehicle collisions varied between $6617 at the Rock Creek site (does not include very high WVC rates occurring immediately to the east and west of this mitigation site) and $31,405 at the McGillivray Creek site (Table 8). Over one-half (5 of 9) of the mitigation emphasis sites in Alberta had annual monetary costs in excess of $18,123 per year.

Table 7: Costs of wildlife–vehicle collisions at each Highway 3 mitigation emphasis site in British Columbia (sites in grey are potentially cost-effective for the use of underpasses, fencing and jump-outs to mitigate ungulate–vehicle collisions).

Highway 3 - British Columbia: Mitigation Emphasis Site	Average Estimated Costs of Collisions (in 2007 $)				Total Average Annual Costs (in 2007 $)
	Deer	Elk	Moose	Bighorn	
Trench 1	$5,294	$6,993	$0	$0	$12,287
Trench 2	$9,264	$1,748	$0	$0	$11,012
Trench 3	$19,189	$1,748	$3,076	$0	$24,013
Trench 4	$13,234	$12,238	$0	$0	$25,472
Trench 5	$7,279	$13,986	$0	$0	$21,265
Trench 6	$14,557	$3,497	$0	$0	$18,054
Elko-Morrissey 1	$5,955	$1,748	$3,076	$662	$11,441
Elko-Morrissey 2	$7,940	$0	$0	$0	$7,940
Elko-Morrissey 3	$3,970	$1,748	$0	$331	$6,049
Fernie-Morrisey 1	$7,940	$1,748	$3,076	$662	$13,426
Fernie-Morrisey 2	$6,948	$3,497	$3,076	$0	$13,520
Fernie-Morrisey 3	$3,309	$1,748	$9,228	$0	$14,285
Fernie-Morrisey 4	$5,955	$6,993	$15,380	$0	$28,329
Hartley Creek	$5,955	$19,231	$0	$0	$25,187
Hosmer	$2,647	$1,748	$0	$0	$4,395
Hosmer-Sparwood 1	$5,294	$3,497	$3,076	$0	$11,866
Hosmer-Sparwood 2	$2,647	$19,231	$0	$0	$21,878
Hosmer-Sparwood 3	$5,294	$10,490	$0	$0	$15,783
Michel Creek	$3,970	$1,748	$0	$0	$5,719
Carbon Creek Bridge	$662	$0	$0	$3,309	$3,970
Alexander-Michel 1	$5,294	$15,735	$6,152	$0	$27,180
Alexander-Michel 2	$1,323	$0	$0	$0	$1,323

Table 8: Costs of wildlife–vehicle collisions at each Highway 3 mitigation emphasis site in Alberta (sites in grey are potentially cost-effective for the use of underpasses, fencing and jump-outs to mitigate ungulate–vehicle collisions).

Highway 3 - Alberta: Mitigation Empahsis Site	Average Estimated Costs of Collisions (in 2007 $)				Total Average Annual Costs (in 2007 $)
	Deer	Elk	Moose	Bighorn	
Crowsnest Lakes	$2,382	$6,294	$0	$16,873	$25,549
Crowsnest West	$5,426	$15,735	$0	$0	$21,161
Iron Ridge	$8,999	$7,867	$0	$0	$16,866
McGillivray Creek	$27,064	$1,573	$2,768	$0	$31,405
Crowsnest Central	$11,447	$1,573	$0	$0	$13,020
East Blairmore Bridge	$13,234	$0	$0	$1,191	$14,425
Leitch Collieries	$28,288	$0	$0	$0	$28,288
Rock Creek	$6,617	$0	$0	$0	$6,617
Crowsnest East	$21,638	$0	$0	$0	$21,638

6.7. Mitigation Measures

As described in section 5, mitigation emphasis sites are specific locations within the Highway 3 study area where opportunities for reducing wildlife–vehicle collisions and improving connectivity for all wildlife are highest, including fragmentation-sensitive species (Figure 9). Focusing highway mitigation efforts in these areas should improve motorist safety, reduce wildlife mortalities and improve habitat linkages and animal movement through transitional habitat along these highway segments.

From the field evaluation of the 31 mitigation emphasis sites, recommendations were grouped into actions that can be carried out in the short-term and long-term. *Short-term* mitigation consists of relatively simple, low-cost actions to reduce wildlife–vehicle collisions and improve the local and regional conservation values of the area. This type of mitigation may be combined with other highway construction or upgrade projects in the area (e.g., bridge reconstruction, culvert replacement, passing lanes). Recommendations for *long-term* mitigation would typically occur during major reconstruction and lane expansion of Highway 3 in the study area.

We developed recommendations for mitigation opportunities at each mitigation emphasis site along Highway 3. The relative importance of each site varies by species and local landscape attributes across the 180-kilometer highway corridor. Each site and conservation ranking (see Table 2 and Table 3) was informed by field data on wildlife movement, wildlife mortality, expert opinion, and opportunities and limitations with respect to adjacent land use (see "Identifying Priority Areas…," Section 5.1). A variety of mitigation measures are recommended, from simple to complex, some requiring a change in operations (e.g., de-icing alternatives), while others necessitating structural work (e.g., wildlife underpass construction).

In a recent report to the U.S. Congress commissioned by the Federal Highway Administration, Huijser et al. (2007) summarized 36 different animal–vehicle collision mitigation measures currently in use throughout the world. The mitigation measures were grouped into four types:

1. Measures that attempt to influence driver behaviour (18).
2. Measures that attempt to influence animal behaviour (10).
3. Measures that seek to reduce wildlife population size (4).
4. Measures that seek to physically separate animals from the roadway (4).

As part of the 2007 report, a Technical Working Group was convened that included seven national experts in the area of animal–vehicle collisions. One of their tasks was to rank the current animal–vehicle collision mitigation measures into three categories:

1. Measures that should be implemented (where appropriate).
2. Measures that appear promising but require further investigation.
3. Measures or practices that are proven ineffective.

The recommendations for improving motorist safety and wildlife connectivity for Highway 3 include a total of 11 different proven or promising mitigation measures. Table 9 includes a list of the measures, their effectiveness in reducing WVCs (if data are available), the target of the measure (type) and the ranking category as presented in the Huijser et al. (2007) report.

Table 9: Wildlife mitigation measures, their focus and effectiveness.

Mitigation measure	Effectiveness	Type[1]	Category[2]
Intercept feeding (salt licks)	N/A[3]	Animal	Promising
De-icing alternatives	N/A	Animal	Promising
Variable message sign	N/A	Driver	Promising
Animal detection system	87%	Driver	Promising
Fencing	86%	Separate	Proven
Badger tunnel	86%	Animal	Proven
Underpass with water flow	86%	Animal	Proven
Underpass – wildlife	86%	Animal	Proven
Underpass – multi-use	86%	Animal	Proven
Overpass – wildlife	86%	Animal	Proven
Overpass – multi-use	86%	Animal	Proven

[1] *Driver*: Measures that attempt to influence driver behaviour; *Animal*: Measures that attempt to influence animal behaviour; *Size*: Measures that seek to reduce wildlife population size; *Separate*: Measures that physically separate animals from the roadway. From Huijser et al. 2007.

[2] *Proven*: Measures that should be implemented (where appropriate); *Promising*: Measures that appear promising, but require further investigation. From Huijser et al. 2007.

[3] Not Available: data or studies on effectiveness.

7. RECOMMENDATIONS

A large amount of information has been gathered specific to each mitigation emphasis site based on site-specific information with regard to mitigation importance, target species, wildlife objectives and mitigation measures recommendations. Instead of reviewing each site, we highlight the most relevant sites with regard to a) regional conservation and connectivity, b) wildlife–vehicle collision reduction and c) immediate mitigation action that Alberta Transportation and British Columbia Ministry of Transportation can undertake. We first review the Alberta section of Highway 3, followed by the British Columbia section. Last, because of the status of badgers in the Highway 3 corridor and their unique mitigation requirements we highlight where transportation agencies should be aware of opportunities to protect this species.

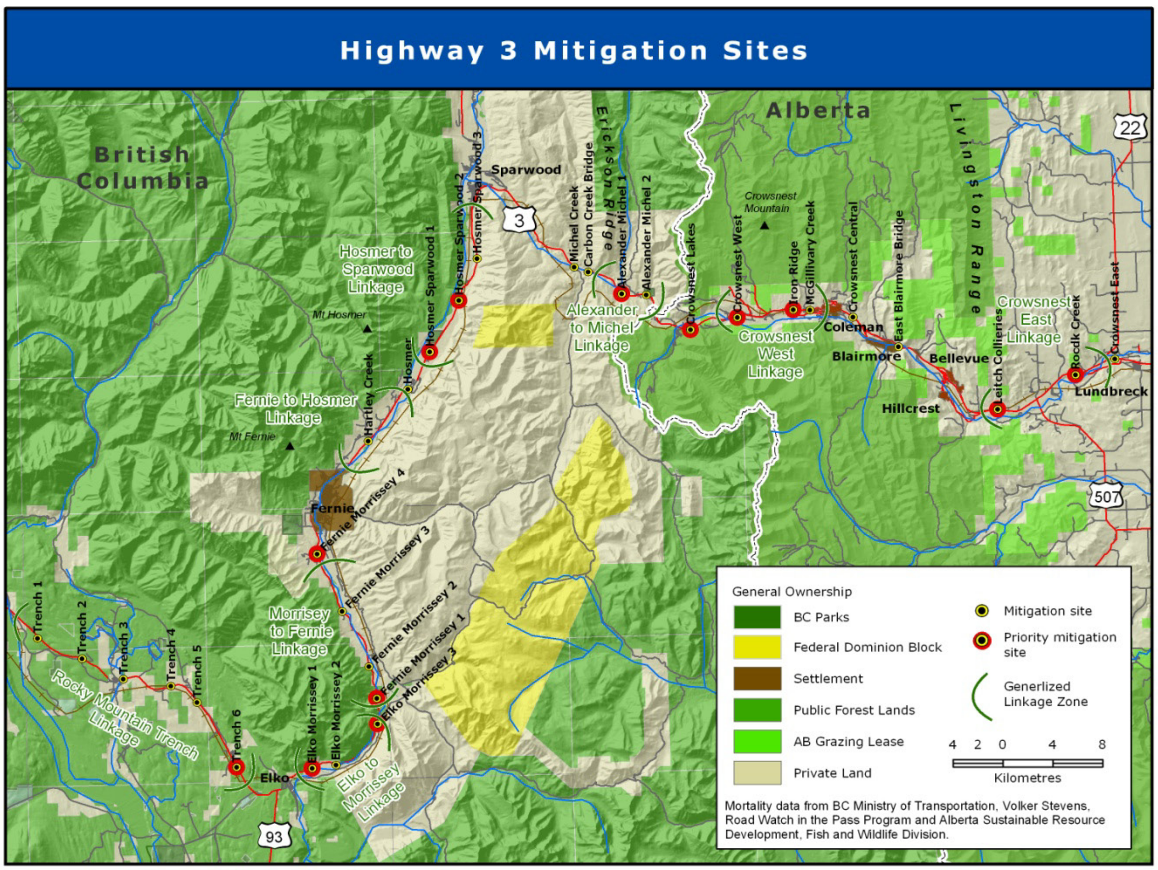

Figure 10: Priority mitigation emphasis sites in Highway 3 study area (highlighted in red).

7.1. British Columbia

The average score for the matrix valuation of the nine sites in British Columbia was 3.27 (see Table 1). Slightly less than half of the 22 sites (n=12) had scores equal to or above the average score. Eight of the 22 sites had scores greater than 3.4.

- Hosmer–Sparwood 1 (4.4)
- Alexander–Michel 1 (3.8)
- Fernie–Morrisey 1 (3.8)
- Elko–Morrisey 1 (3.8)
- Elko–Morrisey 3 (3.8)
- Trench 6 (3.6)
- Fernie–Morrisey 4 (3.6)
- Hosmer–Sparwood 2 (3.6)

We discuss each of these sites and their mitigation recommendations in light of their respective attributes associated with local and regional conservation values and the safety of motorists traveling Highway 3. Specific mitigation techniques are italicized

7.1.1. Hosmer–Sparwood 1

This site has the highest matrix score for the British Columbia sites and the entire study area (4.4). It is particularly important in terms of regional and local conservation (both = 5) and the land-use security is high (=5), as Nature Conservancy of Canada lands abut both sides of the highway. The site has good opportunities for highway mitigation (=4). Twin culverts currently drain wetlands adjacent to the highway.

In the <u>short-term</u> it will be most important to conserve and manage the existing network of lands for wildlife habitat and movements through the area and across Highway 3. WVCs are not high in this area, therefore fencing is not recommended.

In the <u>long-term</u>, a *wildlife overpass* and *fencing* are recommended should the highway be upgraded or expanded to four lanes. A wildlife overpass structure is the most suitable design given the high water table in the area. The recommended minimum dimension for a wildlife overpass is 25–30 m wide.

Wing fencing (minimum 200 m) should be used to guide wildlife to the overpass. An *animal detection system* can be placed at fence ends to warn motorists when animals cross the highway. *Boulders between fence* and roadway and *jump-outs* may be required depending on the site-specific situation.

7.1.2. Alexander–Michel 1

This is the most critical habitat linkage in the entire Highway 3 corridor. It is the most important site from a conservation and management standpoint, to preserve for local and regional scale movements of wildlife, particularly fragmentation-sensitive species such as grizzly bears, wolverines and lynx. Alexander–Michel 1 is recognized as a site with high regional and local conservation value (=5). It has moderately high opportunities for highway mitigation (=4).

In the short-term mitigation alternatives should focus on improving the land-use security in the area and managing adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.

Potential opportunities in the long-term consist of bridge reconstruction or highway twinning (bridge construction) project. All bridge construction or reconstruction must be designed with wildlife movement (and hydrologic flow) in mind. Bridges should be designed with a wide span, allowing dry travel sections (7–10 m wide) above high-water mark and more than 4 m vertical clearance. Wing *fencing* (100–200 m depending on terrain) should be accompanied with an *animal detection system* at fence ends.

7.1.3. Fernie–Morrisey 1

This site is one of two sites with the highest score for land-use security (= 5) and is recognized for its importance for carnivore population connectivity across the lower Elk Valley. It has moderately high scores for local and regional conservation values (=4); however, mitigation opportunities are limited.

As indicated, short-term mitigation alternatives are few. Efforts should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.

In the long-term, if the highway is reconstructed, there will be opportunities to mitigate the highway to reduce mortality and improve wildlife movement. A *wildlife underpass* could be situated in this area as slopes are gentle and the highway is raised. The recommended minimum dimension for the wildlife underpass is 4 m high x 7 m wide. Wing *fencing* (ca. ≥200 m) should be used with an *animal detection system* at fence ends to warn motorists when animals cross the highway. *Boulders between fence* and roadway should be used to keep ungulates from entering the fenced area. *Jump-outs* also may be required depending on the terrain.

7.1.4. Elko–Morrisey 1

Elko–Morrisey 1 is particularly important in terms of local conservation and highway mitigation opportunities (=4). Similarly, it is an area of very high rates of WVC (= 5), primarily with deer, elk, bears and bighorn sheep. There is an existing 1.2 m-diameter steel culvert at the site. It is uncertain whether Alberta Transportation plans to replace the culvert with a new below-grade structure.

Being an area of high WVCs, short-term recommendations include using *variable message signs* to warn motorists of regular occurrence of wildlife on the highway and use of *de-icing alternatives* by maintenance in winter rather than road salt. Efforts also should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity across Highway 3.

In the long-term, if the highway is reconstructed, this is an opportunity to mitigate the highway to reduce mortality and improve wildlife movement. A *wildlife underpass* could be situated in this area as a culvert is in place and will need to be replaced, likely with a bridge or larger culvert structure. Slopes are gentle and fill below the highway where the culvert lies. The recommended minimum dimension for the wildlife underpass is 4 m high x 7 m wide. Wing *fencing* (ca. ≥200 m) should be used with an *animal detection system* at fence ends to warn motorists when animals cross the highway.

7.1.5. Elko–Morrisey 3

This site has moderately high scores for local conservation, land-use security and mitigation opportunities (all = 4); however, it is a high collision area for bighorn sheep.

In the short-term, efforts should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity. Recommendations for reducing wildlife–vehicle collisions in the area include installing *variable message signs* warning motorists of wildlife on the highway. Also, during winter, replace road salt with other *de-icing agents* to reduce bighorn sheep attraction to the roadway.

In the long-term, if the highway is reconstructed, there will be opportunities to mitigate the highway to reduce mortality and improve wildlife movement. A *wildlife underpass* could be situated in this area as slopes are gentle and the highway is raised. Recommended minimum dimensions for the wildlife underpass is 4 m high x 7 m wide. Wing *fencing* (ca. ≥200 m) should be used and end at the rock cut. If the rock cut isn't suitable for a fence end, an *animal detection system* should be placed at fence ends to warn motorists when animals cross the highway.

7.1.6. Trench 6

Trench 6 has high rates of WVCs, primarily with deer and elk. However, the opportunities for mitigating the highway for large mammals are limited.

Short-term recommendations to reduce WVCs in the area include: (1) use of *de-icing alternatives* rather than road salt in winter, and (2) install *variable message signs* to warn motorists of wildlife on the highway. Grizzly bears are known to move across the highway, therefore efforts should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity. The area is also important for local badger populations and mitigation recommendations for badgers are discussed below.

In the long-term, if the highway is reconstructed this may be an opportunity to mitigate the highway for wildlife movement, including badgers. For large mammals a *wildlife underpass* is recommended and could be placed below the road with some scouring at both ends to provide a suitable approach to the underpass. Recommended minimum dimensions for the wildlife underpass is 4 m high x 7 m wide. Wing *fencing* (ca. ≥200 m) should be used with an *animal detection system* at fence ends to warn motorists when animals cross the highway.

7.1.7. Fernie–Morrisey 4

This site has high scores for regional and local conservation significance (both=5) and moderately high rates of WVCs. The opportunities for highway mitigation are limited however.

In the short-term, efforts should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity. The access road to the ski area is problematic and disturbance along that road likely affects animal movement through the area. Fencing as mitigation for highway mortality is not recommended as it would also affect movement through the area.

In the long-term, if the highway is reconstructed and a new highway interchange is built for the ski area, this may be an opportunity to mitigate the highway to reduce mortality and improve wildlife movement.

7.1.1. Hosmer–Sparwood 2

Hosmer–Sparwood 2 has moderately high scores for regional conservation and land-use security (both = 4). It is an area with good potential for highway mitigation (=4).

In the short-term there are three recommendations to reduce WVCs in area: (1) Remove the existing carcass pit to keep bears and other carnivores away from the highway, (2) use *de-icing alternatives* rather than road salt in winter, and (3) install *variable message signs* warning motorists of wildlife on highway. Efforts also should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.

In the long-term, if the highway is reconstructed, this is an opportunity to mitigate the highway to reduce mortality and improve wildlife movement. A *wildlife underpass* is recommended with minimum dimensions of 4 m high x 7 m wide. Wing *fencing* (ca. ≥200 m) should be used with an *animal detection system* at fence ends to warn motorists when animals cross the highway.

7.2. Alberta

The average score for the matrix valuation of the nine sites in Alberta was 3.2 (see Table 2). Six of the nine sites (66 percent) had scores equal to or above the average score:

- Rock Creek (4.2)
- Leitch Collieries (3.8)
- Crowsnest West (3.6)
- Crowsnest Lakes (3.4)
- Crowsnest East (3.4)
- Iron Ridge (3.2)

We discuss each of these sites and their mitigation recommendations in light of their respective attributes associated with local and regional conservation values and the safety of motorists traveling Highway 3. Specific mitigation techniques are italicized.

7.2.1. Rock Creek

Rock Creek has the highest matrix score for the Alberta sites (4.2). It is particularly important in terms of local conservation, land-use security and highway mitigation opportunities. Similarly, it is an area of very high rates of WVC (= 5), due to incorporation of high WVC rates on both sides of site. There is an existing 3 m-diameter steel culvert at the site, which Alberta Transportation plans to replace with a new below-grade structure in the near future.

In the short-term there are few mitigation alternatives other than improving the land-use security in the area and managing adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity across Highway 3. Since this is an area with high WVCs, recommendations include *variable message signs* installed to warn motorists of the regular occurrence of wildlife on the highway and use of *de-icing alternatives* in winter rather than road salt.

If the existing fill is removed and the culvert is replaced with a new bridge structure, this is an excellent opportunity to improve terrestrial hydrologic flows in the area. A new bridge structure should be designed to maximize wildlife movement under Highway 3, allowing adequate space (≥3 m wide) and substrate for wildlife travel. Wing *fencing* (minimum 200 m) should be used to guide wildlife to the bridge. An *animal detection system* can be placed at fence ends to warn motorists when animals cross the highway. *Boulders between fence* and roadway and *jump-outs* may be required depending on the situation. As indicated, this work could be done as a culvert reconstruction project or major highway reconstruction project.

7.2.2. Leitch Collieries

Leitch Collieries along with Iron Ridge and Crowsnest West all have moderately high scores (= 4) for regional conservation significance. Similarly the Leitch Collieries site (with Crowsnest East and Iron Ridge) has moderately high rates of WVCs and opportunities for highway mitigation (=4).

In the short-term mitigation alternatives should focus on improving the land-use security in the area and managing adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity across Highway 3. To reduce wildlife–vehicle collisions in this area *de-icing alternatives* are recommended in winter.

In the long-term, a *multi-use wildlife overpass* (Appendix B, Sheet H) and *fencing* (Appendix B, Sheet D) are recommended should the highway be upgraded or expanded to four lanes. An overpass structure is most suitable given a suitable location east of the colliery where terrain bordering the highway is elevated on both sides, thus facilitating overpass construction. Recommended minimum dimensions are 15–20 m wide. Wing *fencing* (minimum 200 m) should be used to guide wildlife to the overpass. An *animal detection system* can be placed at fence ends to warn motorists when animals cross the highway. *Boulders between fence* and roadway and *jump-outs* may be required depending on the situation.

7.2.3. Crowsnest West

Crowsnest West is a site with high local conservation value (=5) along with Rock Creek. Crowsnest West, in addition to Iron Ridge and Leitch Collieries, has moderately high scores (= 4) for regional conservation significance. The Crowsnest West site has moderately high opportunities for highway mitigation (=4).

In the short-term, mitigation alternatives should focus on improving the land-use security in the area and managing adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity across Highway 3. Given the local conservation value it will be critical to retain vegetative cover and riparian habitat along the Crowsnest River.

Long-term solutions will depend on the extent of highway reconstruction and alignment. If Highway 3 is twinned and bypasses Coleman, the existing highway will remain two-lane, but with considerably reduced traffic volumes. The existing bridge may provide movement for some wildlife. But given the sloping bridge abutments and lack of level substrate, the underpass is suboptimal for moving most wildlife species.

If the existing highway alignment is twinned, a new bridge structure will be added and the existing bridge span can be reconstructed to allow for greater wildlife passage (and hydrologic flow). All bridge construction or reconstruction must be designed to enhance and improve wildlife movement (and hydrologic flow). Bridges should be designed with a wider span, allowing dry travel sections (≥3 m wide) above the high-water mark. Wing *fencing* (minimum 200 m depending on terrain) should be accompanied with *animal detection systems* at fence ends.

7.2.4. Crowsnest Lakes

This site is one of two sites with the highest rates of WVC (= 5), primarily due to vehicle collisions with bighorn sheep. Sheep come down to the highway to lick road salt. The area is moderately important for regional conservation, while the local conservation significance is mostly due to the local bighorn sheep population.

There are three recommendations in the short-term to reduce wildlife–vehicle collisions in area:

- Install *variable message signage* warning motorists of wildlife on the highway.
- During winter, replace road salt with other *de-icing agents* to reduce bighorn sheep attraction to roadway.
- Install *fencing* to funnel bighorn sheep movement towards Emerald Lake. On the south side of the highway, installing *fencing* and the placement of Jersey barriers, and the use of boulders to funnel bighorn sheep to the Emerald Lake undercrossing are recommended. On the north side of the highway, install fencing that borders the highway and lake.

In the long-term, if the highway is reconstructed, fencing and construction of a *wildlife underpass* is recommended west of the site near the quarry. Recommended minimum dimensions for the underpass is 4 m high x 7 m wide. Wing *fencing* (100–300 m) should be used and end at rock cuts or steep slopes.

7.2.5. Crowsnest East

Of all sites in Alberta, Crowsnest East has the best opportunity for highway mitigation (=5). It also has a moderately high rate of WVCs, primarily deer (=4). The Crowsnest River flows under the highway through a large span bridge. Alberta Transportation has no plans to replace the bridge without being part of a highway reconstruction project.

Short-term mitigation solutions consist of *fencing* part of the highway, directing wildlife to the bridge to keep animals from crossing at-grade. It is important that adequate wing-fencing is used. Fence length should be long enough to encompass the most problematic WVC locations in the area.

In the long-term, if the bridge is reconstructed it is an opportunity to lengthen the bridge span, install more suitable substrate and provide room for wildlife movement (≥3-m-wide section) above the high-water mark. This work could be done as a bridge reconstruction project or highway twinning project. Wing *fencing* (minimum 200 m) should be used to guide wildlife to the bridge with *animal detection systems* situated at fence ends.

7.2.6. Iron Ridge

Iron Ridge has moderately high scores (= 4) for local conservation and regional conservation significance. It is a high collision area for deer and elk. Land use security is low (=2) compared to the high conservation value of the area.

In the short-term it will be most important to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.

Long-term solutions will depend on the extent of highway reconstruction and realignment. If Highway 3 is twinned and bypasses Coleman, the highway will remain two-lane, but with reduced traffic volumes. Thus, transportation conflicts with wildlife will become less of a conservation and motorist safety issue. If the existing alignment is twinned, two locations are suitable for mitigation with the following measures:

- *Multi-use wildlife overpass* with *fencing*. A suitable location exists where the highway passes through a ridge-cut, resulting in raised embankments (elevated terrain) on both sides of the highway, facilitating the construction of an overpass structure. Recommended minimum dimension is 15–20 m wide.
- *Wildlife underpass*. Remove fill at a location west of the road cut and replace with an open-span bridge structure designed to allow adequate space (≥3 m wide, ≥3 m high) and substrate for wildlife travel. Wing *fencing* (minimum 500 m) should be used to guide wildlife to the open-span bridge structure. Recommended minimum dimensions are 4 m high x 7 m wide. Wing *fencing* (minimum 200 m depending on terrain) should be accompanied with *animal detection systems* at fence ends.

7.3. Highway Mitigation for Badgers

American badgers (*Taxidea taxus*) are "red-listed" in British Columbia (Cannings et al. 1999) and the subspecies (*T.t. jeffersonii*) is listed as an endangered species in Canada (COSEWIC 2006). Mortality of badgers from collisions with vehicles is significant and in some locations the main source of mortality (Weir et al. 2004, Packham and Hoodicoff 2007, Kinley and Newhouse 2008). Badgers often prefer to use habitats near roads and other open habitats associated with linear infrastructure, thus increasing risks of mortality (Apps et al. 2002). Reducing road-related mortality is a key action in the Canadian recovery strategy for this subspecies of badger. More culverts or badger tunnels appropriately placed along Highway 3 within their range would aid badger recovery and help maintain less-threatened badger populations in Alberta.

Recommendations provided by Kinley and Newhouse (2009) to increase the effectiveness of existing culverts and aid in the placement and design of new culverts has direct implications for mitigation work on Highway 3 in British Columbia and Alberta. The Trench 1, Trench 2, and Trench 6 sites were identified as locations to improve highway permeability and reduce mortality of badgers. Mitigation solutions should be considered in these areas in the short-term as opportunities arise, or in the long-term (see below). The Kinley and Newhouse (2009) recommendations consist of the following:

1. *Passable culverts* – Existing culverts need to be passable by badgers. Crushed and blocked culverts should be repaired and hanging culverts should have fill or boulders placed under the ends to allow badgers access. If culverts are replaced with larger culverts, dry platforms or walkways can be constructed on the lateral interior walls of the culvert and above the high-water mark.
2. *Culvert visibility* – Badgers need to be able to find suitable culverts and many are blocked by dense roadside vegetation. Clearing the vegetation around the entrances would increase visibility.
3. *Install more culverts* – Where data indicates there are high levels of road-related mortality, badger activity and preferred habitats, efforts should be made to install more culverts as part of highway upgrade or reconstruction projects. Installing badger culverts during the latter is the most cost-effective, with little incremental cost to a project. Opportunities to bore under existing highways with new boring technology should be explored.
4. *Drift fencing* – Drift fencing is typically used to guide badgers to culverts to increase their use. Fencing should be considered where opportunities exist. Permanent badger-proof fencing over long areas may be needed where road-related mortality is high; however, fencing requirements may vary for each locale.

7.4. Monitoring and Research

Monitoring and research are needed to inform agencies by providing the most current data and site-specific information to help prioritize and guide decisions regarding planning and design on Highway 3. These recommendations are limited to the scale of the transportation corridor and do not address the regional scale (outside corridor) research and monitoring needs for conservation and management of wide-ranging species and their requirements for landscape connectivity (see Apps et al. 2007).

7.4.1. Wildlife Mortality along Highway 3

Continue with Road Watch in the Pass in Alberta and coordinated activities aimed at collecting reliable and accurate information on wildlife–vehicle collisions and wildlife movement within the Highway 3 corridor. The development of a project to better track wildlife mortality on the British Columbia section of Highway 3 is advisable; this could include a citizen science approach. Information on wildlife–vehicle collisions is essential for helping identify key locations for evaluating the rate of wildlife–vehicle collisions, their severity, and for prioritizing mitigation efforts. Building on the existing data will provide sound information for agencies responsible for future highway mitigation along the Highway 3 study area.

7.4.2. Existing Below-grade Passage Structures

Wildlife may be able to safely cross Highway 3 using existing below-grade passage structures (i.e., culverts, creek bridge structures). Little is known regarding wildlife use of the structures and their potential for passing wildlife safely across the highway. Structures along Highway 3 should be identified and monitored to determine their efficacy for different wildlife species and species-specific responses to different structure design types. This information will be useful to agencies developing mitigation plans by identifying where wildlife are able to cross the highway and attributes of the structures that might facilitate wildlife passage. As part of this work, tracking wildlife movement in the snow, in and around the structures, will provide important information to agencies on individual behaviours associated with each passage structure type.

7.4.3. At-grade Highway Crossings by Wildlife

An effective, low-cost and non-invasive means of identifying key highway crossing locations of wildlife during winter is to carry out road surveys along Highway 3. Snowtracking wildlife from a moving vehicle will provide information on species occurrence and specific crossing locations in winter. Surveys conducted with vehicles allow large areas to be surveyed in a relatively short period of time, particularly after each snowfall event. This information will assist agencies in planning and designing mitigation along Highway 3.

7.4.4. Realignment of Highway 3 from Blairmore to Sentinel

The upgrade of Highway 3 may result in realignment from Blairmore to Sentinel, Alberta. Understanding wildlife movement and habitat preferences along the preferred route is important for Alberta Transportation and Alberta Sustainable Resource Development, Fish and Wildlife Division in the development of strategies to mitigate for human safety and wildlife conservation.

7.4.5. Aquatic Passage Assessment

Aquatic ecosystems are often severely fragmented due to improperly designed or maintained culverts and other structures that allow water to flow under the road. In special cases, aquatic barriers may be advisable to keep populations separate; for example, to protect imperiled native trout species from introgressive hybridization with non-native species. A review and analysis of existing Highway 3 infrastructure is needed to determine the impacts of the highway to aquatic connectivity, species movement and conservation.

7.4.6. Canadian Pacific Railway Strike Zone Assessment

A railway line runs parallel to Highway 3 for most of the study area. Recent increases in train volume and anecdotal feedback from wildlife professionals indicate wildlife train strikes are occurring on the railway. However, little is known about the frequency and location of wildlife mortality on the railway. Understanding how often and where strikes are occurring will help identify areas of concern and inform highway mitigation strategies. In addition, carcasses may be acting as an attractant to carnivore species, drawing them down to the transportation corridor and increasing the risks of wildlife mortality from strikes with trains or vehicles on Highway 3. As a response to this issue, CPR and Miistakis Institute have developed a research project to interview train engineers, maintenance staff and wildlife officers to identify through local knowledge where strike zones are common. The results of this project can be used to inform the development of a systematic survey aimed at understanding key problem areas along the railway.

7.4.7. Technology Transfer

Keeping current and informed about the most up-to-date and effective means of mitigating highways for wildlife will be important for agencies managing the Highway 3 infrastructure. Recent advances in road ecology and specifically mitigating highways for wildlife have shown that many techniques used by transportation agencies are proven ineffective, thus a waste of agency funding. We recommend that workshops and training courses be provided on a regular basis to transportation and resource management agencies working in the Highway 3 study area.

8. AUTHORS NOTE

This shorter version of the final report has omitted two appendices from the full report. Appendix A describes 10 common highway mitigation techniques for wildlife used in the recommendations section of this report. Appendix B contains summaries of the 31 mitigation emphasis sites and the recommendations for their short- and long-term mitigation. For the full report and other information about Highway 3 and wildlife in the study area please go to: www.rockies.ca/crossroads.

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