LARGE MAMMAL-VEHICLE COLLISIONS:

OVERVIEW OF MITIGATIONS AND ANALYSIS OF COLLISIONS IN YUKON

Prepared for:
Yukon Government's Preventing Wildlife Collisions
Interdepartmental Working Group:

Yukon Department of Environment
Fish and Wildlife Branch

Yukon Department of Highways and Public Works
Transportation Engineering and Transportation Maintenance Branch

Prepared by: EDI Environmental Dynamics Inc.

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Large Mammal-Vehicle Collisions: Overview of Mitigations and Analysis of Collisions in Yukon

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EXECUTIVE SUMMARY

Vehicle collisions with large mammals are a risk to public safety and to Yukon's wildlife populations. Yukon is fortunate to have widely distributed wildlife populations. Collisions with vehicles and hunting are the primary anthropogenic sources of mortality. Minimizing wildlife-vehicle collisions is important both for public safety and for wildlife populations.

The Yukon Government established an interdepartmental working group to address wildlife-vehicle collisions in Yukon with the goal of reducing vehicle collisions with wildlife, in particular large mammals. This working group retained EDI Environmental Dynamics Inc. (EDI) to review mitigation measures used to reduce vehicle collisions with wildlife, develop a database of available collision data in Yukon, and analyze and report on patterns present in the available data.

Between 2003 and 2014, a total of 753 motor vehicle collisions with large mammals were reported on Yukon highways. Other collisions occurred but the information was not available for this report. The Alaska Highway and Klondike Highway account for 69% and 21% of the documented collisions, respectively. Areas where vehicle collisions with large mammals are common include:

- North Klondike Highway/Takhini Hotsprings Road
- Takhini River area (Alaska Highway)
- Jake's Corner (Alaska Highway)
- Judas Creek/Lewes River Bridge area (Alaska Highway)
- Swift River Valley (Alaska Highway)
- Little Rancheria River (Alaska Highway)
- North of Watson Lake (Alaska Highway)
- Lucky Lake area (Alaska Highway).

Caribou, moose, elk and deer account for 82% of all reported large mammal-vehicle collisions in Yukon. Collisions with these species occur predominantly during the fall through late winter, which reflects seasonal wildlife habitat use and typically poor driving conditions. Grizzly and black bears account for 10% of collisions and collisions with these species occur predominantly over the spring and summer months when bears are often observed feeding on vegetation along Yukon highways.

A variety of mitigation measures have been applied to reduce the frequency of wildlife-vehicle collisions in a number of other jurisdictions. In Yukon, mitigation measures are currently being used to attempt to reduce wildlife-vehicle collisions, but further reductions in the number of collisions is possible if additional resources are applied to the problem. Following EDI's review of mitigations used in other jurisdictions, new or alternative mitigations are recommended. The suggested mitigation measures were selected recognizing that Yukon's traffic volumes, population size, length of highway in the territory and resources differ from other jurisdictions. These suggested mitigations include:

- Continued public awareness and education campaigns that target appropriate audiences.
- The installation of additional wildlife warning signage and modification of some existing signage.
- Continued vegetation management along Yukon highways, conducted every three to four years.

- Experimental trials to determine the most effective time of year for vegetation clearing/mowing.
- Use of non-attractive forage species in seed mixes when replanting disturbed areas.
- Reduced vehicle speeds in high collision areas such as Watson Lake, Swift River Valley, near Jake's Corner, and on the North Klondike Highway.
- Modifying snow management to provide escape routes, increased signage and reduced speed limits in the Swift River Valley area.

Based on the review of the existing databases, recommendations were made to improve the quality of the wildlife-vehicle collision data collection system. These recommendations include 1) developing a web-based data management system that user groups (i.e. the agencies that contribute to data input and management) can use to input and access data records; and 2) designing a structured data collection and management system so that data collection is standardized between agencies. This could include the development of a specific wildlife-vehicle collision reporting form.

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TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

BC .... British Columbia

$CaCl_2$ .... Calcium Chloride

EDI .... EDI Environmental Dynamics Inc.

GPS .... Global Positioning System

km .... kilometre

km/h .... kilometre per hour

LED .... light emitting diodes

LiCl .... lithium chloride

m .... metre

$MgCl_2$ .... Magnesium Chloride

n .... number/count

NaCl .... Sodium Chloride

NRCan .... Natural Resources Canada

ROW .... right-of-way

UTM .... Universal Transverse Mercator

Working group .... Preventing Yukon Wildlife Collisions Interdepartmental Working Group

WVC .... wildlife vehicle collisions

YBS .... Yukon Biological Submission

Yukon Environment .... Yukon Government, Department of Environment

Yukon HPW .... Yukon Government, Department of Highways and Public Works

% .... percent

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1 INTRODUCTION

Every year, there are an average of 63 large mammal-vehicle collisions reported on Yukon highways and roads. Wildlife-vehicle collisions (WVCs) are a genuine concern for public safety and for wildlife conservation. Collisions with large wildlife can have devastating consequences to vehicle occupants and can result in substantial property damage. Furthermore, wildlife mortality affects the total population size and population growth for Yukon's wildlife, which can have implications for the long-term sustainability of some large mammal populations. The wildlife population-level effects of wildlife mortalities to vehicle collisions are sometimes considered when estimating sustainable harvest levels.

In Yukon, the majority of collisions are with ungulates in the deer family: caribou, moose and mule deer. Ungulates frequent transportation corridors for a number of reasons. Rea and Rea (2005) provided the following reasons for why ungulates are attracted to road corridors:

- Roadside browsing,
- Seasonal and daily movements,
- Aquatic feeding,
- Insect avoidance,
- Pavement warming,
- Roadside cover,
- Travel (especially in winter),
- Access to highway de-icing compounds,
- Avoidance of hunters and predators,
- Use of forest edges,
- Access to roadside watering holes, and
- Access to sodium-rich pools or licks.

Several factors contribute to WVCs, including traffic volume and speed, visibility, driver awareness, time of day, season, frequency of animal use, and the presence of attractants (Gunson *et al.* 2011; Diaz-Varela *et al.* 2011).

The Yukon Government established an interdepartmental working group (the working group) to assess WVC in the Yukon with the goal of reducing vehicle collisions with wildlife. The working group includes staff from the following Yukon Government Departments:

- Department of Environment: Fish and Wildlife Branch and Conservation Officer Services Branch (herein referred to as Yukon Environment).
- Department of Highways and Public Works: Transportation Engineering Branch and Transportation Maintenance Branch (herein referred to as Yukon HPW).

The working group retained EDI Environmental Dynamics Inc. (EDI) to complete the following tasks:

1. Provide a summary of mitigations used in other jurisdictions;
2. Integrate wildlife collision data from a number of sources into one database; and
3. Analyze and report on WVC recorded on Yukon highways between 2003 and 2014.

2 MITIGATIONS TO PREVENT WILDLIFE COLLISIONS

EDI conducted a literature review to determine possible mitigation measures that could be used in Yukon to reduce WVCs. Although there are many mitigation strategies used in other jurisdictions, not all are applicable to Yukon. Considerations when selecting the most appropriate mitigations were effectiveness, cost (both capital costs and operating/maintenance costs), visual aesthetics, and effects on wildlife if movement through the area is important for migrations or seasonal movements to key habitats.

Huijser *et al.* (2007) were commissioned by the United States Congress to prepare a report on WVCs. This report summarized 36 mitigations that were grouped into four categories:

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

The majority of mitigation measures (28 of 36) were included in the first two categories. Mitigations that are practical for implementation in Yukon also fall under these first two categories. For this reason, only mitigations that attempt to influence driver or animal behaviour are further discussed in this report.

A number of mitigations were reviewed and considered for applicability within Yukon. Table 1 provides a summary of mitigation methods used in other jurisdictions. Not all of the mitigations listed in Table 1 are applicable to Yukon. Unlike many of the jurisdictions where the majority of the research on WVCs and mitigations has been completed, the Yukon differs in that there is a relatively low human population density, and a lower number of vehicles per length of road. All mitigations that are potentially feasible in Yukon are described in greater detail in Sections 2.1 and 2.2. Rationale for inclusions or exclusion is provided in Table 1.

Table 1. Summary of mitigation measures used to reduce WVCs.

Mitigation	Description	Feasible in Yukon	Rationale	References
MITIGATIONS TO MODIFY DRIVER BEHAVIOUR				
Public awareness campaigns	Public education on the potential hazards related to WVCs (risks, locations, time of year) through the use of radio announcements, workshops, flyers, information signs at rest stops, billboards, and school programs.	Yes	This is a very diverse method to mitigate WVCs, and although monitoring the effectiveness of these campaigns is difficult, public awareness and interest is needed to reduce WVCs.	Tardif & Associates 2003; Knapp *et al.* 2004
Reduced vehicle speed	Reducing speed limits in areas of known high wildlife use/presence can reduce the number of WVCs.	Yes	Allows for increased observation and reaction time for both the driver and wildlife. Although feasible in Yukon, changing the speed limit as a mitigation to reduce WVCs requires a change to the Regulations under the *Motor Vehicles Act* (Yukon Highways Speed Limits Order).	Tardif & Associates 2003; Knapp *et al.* 2004; Huijser, and Kociolek 2008
Traffic calming treatments	Traffic calming treatments can include speed bumps/humps; traffic circles; curb extensions; sidewalk extensions; raised medians; and rumble strips.	Yes	In areas known to have high collision rates, or areas known for high wildlife use, the use of rumble strips in conjunction with reduced speed limits and active signage can increase driver awareness and be very effective. However, rumble strips, can also act as a wildlife attractant.	Huijser and Kociolek 2008
Wildlife warning signage: Passive	A fixed sign indicating that wildlife may be present. Warns drivers that wildlife may be on or near the road. They are widely used and are easily interpreted by drivers.	Yes	Relatively inexpensive to install and require low maintenance. Can be effective, particularly for drivers from out of the territory. Unfortunately drivers that frequent an area can be habituated to these signs since they are often present year round.	Huijser and Kociolek 2008
Wildlife warning signage: Seasonal	Passive signs that are installed temporarily (seasonally) when animals are using the area (i.e., during migration or when animals are using key habitats near road).	Yes	These signs are more effective than passive signs that are permanently installed. They are more cost effective than active or variable signs, but are not as noticeable. Require maintenance to install and remove.	Huijser and Kociolek 2008

Table 1. Summary of mitigation measures used to reduce WVCs.

Mitigation	Description	Feasible in Yukon	Rationale	References
Wildlife warning signage: Active	Wildlife signs that are fixed in place but have flashing amber lights, light emitting diodes (LEDs), or brightly coloured flags.	Yes	Active signs are effective because signs can be permanently installed but the lights are only activated during times when wildlife are in the area. This would be most suitable for use in areas with seasonal caribou or moose use. These signs are more expensive than passive signs, require more maintenance and can be prone to vandalism.	Huijser and Kociolek 2008
Wildlife warning signage: Variable	Signs that have illuminated messages that can be changed. Informs drivers of potential hazards. These signs are temporary and can be moved to different areas.	Yes	Variable signs are large and catch the driver's attention. Because they are typically used when there are hazards (i.e., wildlife in area), drivers often pay attention and adhere to warnings more than they would with passive signs. These signs are more expensive than passive signs, require more maintenance and can be prone to vandalism.	Huijser and Kociolek 2008
Increased visibility: Infrared cameras	An infrared camera detects wildlife on or near highways and activates a warning sign to alert drivers that there are animals on the road.	Potentially	Detects wildlife directly and doesn't habituate drivers to signs since it only flashes when wildlife are present. Disadvantage is that this system is costly and covers a relatively small area.	Newhouse 2003
Increased visibility: Highway lighting in high collision areas	Street lighting is installed in areas where WVCs occur frequently.	Potentially	While lighting helps improve visibility at night, it needs to be present in all areas where collisions occur. Many of the areas where WVCs occur frequently in Yukon span a large section of road, making it impractical for the installation of lighting. Many road authorities have not used this mitigation in North America and when it has been used, it has been shown to be ineffective.	Miller 1985; Danielson and Hubbard 1998; Farrell 2002; Tardif & Associates 2003
Roadside vegetation management	Suppressing plant maturation and forest succession to increase visibility for drivers.	Yes	This mitigation increases drivers' abilities to detect wildlife from further away which allows for greater reaction time.	Rea 2003

Table 1. Summary of mitigation measures used to reduce WVCs.

Mitigation	Description	Feasible in Yukon	Rationale	References
MITIGATIONS TO MODIFY ANIMAL BEHAVIOUR				
Roadside vegetation management: Reduce attractive forage species	This vegetation management strategy focuses on reducing the presence of forage species that are favoured by wildlife. In recently disturbed areas, selecting seed mixtures that are less desirable or unpalatable can reduce wildlife browsing along highway right-of-ways (ROWs). Conducting vegetation brushing can also reduce the amount of available forage species.	Yes	This can be a very effective method to reduce WVCs since wildlife are not attracted to highway ROWs to forage, thereby reducing the frequency of wildlife near the road.	Gunson *et al.* 2011; Rea 2003
Roadside vegetation management: Habitat alteration & intercept feeding away from highway ROW	Enhancing vegetation, adding attractants (i.e., salt licks or feeding stations) away from highway ROWs to encourage animals to feed away from roads.	No	This method can reduce use near highways for the short-term but has not proven to be effective over longer periods (for bison). Salt licks and feed stations can also increase the risk of disease /parasite transmission by increasing animal densities at a point location.	Wildlife Collision Prevention Program (2014)
Exclusion fencing	Fences can be used to prevent wildlife from moving onto the highway, particularly in high risk areas.	No	Although fences have proven to be very effective, they have also been noted as unsightly and expensive to install and maintain. In Yukon, this mitigation is likely not feasible because of high cost, high maintenance, and lack of public support. Fences also fragment the landscape interrupting natural movements of wildlife, which may cause them to cross at the ends of the fences. Many species in Yukon migrate seasonally and installing barriers to migration is not recommended.	Bissonette and Rosa 2012; Elmeros *et al.* 2011; Rea 2003

Table 1. Summary of mitigation measures used to reduce WVCs.

Mitigation	Description	Feasible in Yukon	Rationale	References
Reflectors	Reflectors along highways startle/scare wildlife when light from vehicles reflects and creates a "light fence". The reflectors are deployed in hopes to "frighten, distract, freeze, and/or alarm animals enough that they will not cross the roadway" (Knapp *et al.* 2004).	No	This method has been tested multiple times in several jurisdictions; however, it has not proven to be effective.	Knapp *et al.* 2004; Tardif & Associates 2003
Wildlife overpasses	Infrastructure developed to allow wildlife to cross over highways with heavy traffic and high rates of WVCs. Overpasses allow connectivity of an otherwise fragmented landscape.	No	Expensive and also requires fencing the highway. Yukon highways do not have the traffic volume required to warrant the installation of overpasses. These features have been used along the Trans-Canada Highway in Canmore and Banff, Alberta, which averages 21,500 vehicles per day. For comparison, the busiest highway in Yukon is the Alaska Highway near Whitehorse, which averages 2,045 vehicles a day.	AMEC 2004; Lee *et al.* 2012; Transportation Engineering Branch 2011
Wildlife underpass	Infrastructure developed to allow wildlife to cross under highways with heavy traffic and high WVCs. They allow connectivity of an otherwise fragmented landscape.	No	Although found to be effective in some areas, they are expensive to construct and require fencing. Some animals still may not use the underpass since many animals avoid enclosed spaces.	Bissonette and Rosa 2012; Lee *et al*. 2012
One-way earthen escape ramps	Earthen escape ramps are created in areas to allow wildlife to more easily move off of roadways in areas with steep terrain or toward exclusion fencing (one–way only).	Yes	These escape ramps can be relatively expensive to construct and maintain. However they have proven to be effective in Yukon for sheep near Sheep Mountain on the Alaska Highway along Kluane Lake.	Bissonette and Rosa 2012; Lee *et al*. 2012

Table 1. Summary of mitigation measures used to reduce WVCs.

Mitigation	Description	Feasible in Yukon	Rationale	References
Bridge specific mitigations: boulder clusters and electrified mats	Prevent wildlife from travelling up a river bank onto the highway where they are very difficult to observe until they are on the highway. Boulder clusters are used to deter large mammals so they avoid the specific area with the obstacles. The electrified mat delivers a shock which deters the animal from crossing and may also condition animals to avoid crossing in that area.	No	Installing boulder clusters is relatively inexpensive, especially when completed when road work is already occurring in the area (i.e., machines and material are present). However, the majority of collisions near bridges are with moose and most collisions occur during the winter when the snow is deep and the boulders would likely be buried. The electrified mat is expensive to implement.	Lee *et al*. 2012
Wildlife hazing	Hazing wildlife using dogs, rubber bullets, noise making devices, horse herding to deter animals from using highway corridor.	Yes	This method can be effective if conducted regularly and professionally managed. However, these operations need to be conducted within the parameter of the Yukon Wildlife Act and with the authorization of Conservation Officers to avoid harassment, a contravention of the *Yukon Wildlife Act*.	Wildlife Collisions Prevention Program 2014; *Yukon Wildlife Act* 2002
Hunting/Harvest	Harvest management can be used to discourage ungulates (e.g., bison, elk) from frequenting highway corridors. Lethal control of a small number of animals (i.e., bison) can also be used by Conservation Officers to reduce the risk of WVCs	Yes	Seasonal harvest management in highway corridors has been useful in keeping Yukon wildlife such as bison out of highway ROWs. Lethal removal of select individuals has also been successfully used in Yukon to discourage animals such as bison from using highway corridors.	Wildlife Collisions Prevention Program 2014; Yukon Environment 2012b
Relocation	Relocating key individuals within a herd (such as bison) which can result in the rest of the herd moving away from the area.	No	This method was used elsewhere on bison. The only feasible wildlife population would be the Nordquist bison herd in southeast Yukon and collisions with these bison have been low.	Wildlife Collisions Prevention Program 2014

Table 1. Summary of mitigation measures used to reduce WVCs.

Mitigation	Description	Feasible in Yukon	Rationale	References
Noise and ultrasound emitters	These devices are typically mounted on to the front of a car, so that when specific speed is reached, the device emits a high pitch noise (above human auditory levels) to scare wildlife.	No	There is no evidence that noise and ultrasound emitters are effective at reducing wildlife collisions. Vehicles travelling in Yukon are commonly from other regions, so implementation of this mitigation would be very difficult.	AMEC 2004; Knapp *et al.* 2004
Chemical deterrents (in road salt): lithium chloride (LiCl)	Wildlife can learn to associate specific foods with aversive consequences such as nausea. LiCl is a gastrointestinal toxin that can be very effective if administered in correct dosages over a specific length of time. During this period, the wildlife would develop a conditional taste aversion.	No	Although the results associated with LiCl use is promising, there are too many uncertainties, including: how to ensure that ungulates ingest sufficient amounts of LiCl for them to feel the effects? What happens if smaller animals ingest the LiCl? How will it affect waterbodies and plants during spring melt? Additionally, LiCl would have to be reapplied after each snowfall, which could be impractical in Yukon where there is snow for six months a year. Additionally, LiCl is administered through the application of salt and in Yukon the use of salt on roads is minimal.	Smits 1997; Brown *et al.* 2000
Repellents/scent-fencing: "Wolfin"	This is an olfactory repellent simulating wolf urine to deter wildlife, particularly ungulates, from frequenting or remaining in an area.	No	It is not effective in deterring animals from highway ROWs. In addition, repellents like this can habituate wildlife to predator scents, increasing the likelihood of predation.	Brown *et al.* 2000
Repellents/scent-fencing: Deer Away Big Game repellent	An olfactory and taste repellent to deter ungulates from feeding or resting in an area.	No	Over a short period of time, this repellent has been found to be effective; however, it does not last long and would have to be reapplied regularly. Additionally, as with Wolfin, there is a risk of decreasing prey fear of predator scents, leading to increased predation.	Brown *et al.* 2000

Table 1. Summary of mitigation measures used to reduce WVCs.

Mitigation	Description	Feasible in Yukon	Rationale	References
Removal of salt pools	Salt pools as a result of melting snow can attract a number of species. Through snow removal in the spring, prior to melt, the salts can be removed from the roadways, reducing the likeliness of salt pools developing.	No	This is a relatively expensive task that is time consuming and not likely feasible in the Yukon given the number of highway kilometres that would need to be cleared. Also, the Yukon uses minimal amounts of salt on roads.	Grosman *et al.* 2009
Salt alternatives: Cryotech CMA chemical formulation from dolomitic lime and acetic acid	A low corrosion, environmental alternative to road salt that is available in solid and liquid forms. It prevents sand from freezing and has been known to repel ungulates from roadways due to its smell.	No	Best performance is above -7°C, so it would not be effective during much of the winter. A salt alternative is likely not required since the Yukon uses minimal amounts of salt on roads.	Cryotech 1998
Salt alternatives: calcium chloride ($CaCl_2$)	Commonly used throughout Canada as an anti-icer, de-icing roads, and controlling dust.	Potentially	Recognized as being relatively environmentally safe within North America, it has greater melt ability, penetrates ice faster and $CaCl_2$ is less toxic than magnesium chloride ($MgCl_2$). With a functional temperature range down to - 32°C, there is potential for further use within the Yukon. However, the Yukon uses minimal amounts of salt on roads so a salt alternative is likely not required.	Government of Canada 2001; General Chemical Industrial Products 2002
Salt and alternative: Sodium chloride (NaCl) mixed with calcium chloride brine	NaCl pre-wetted with calcium chloride brine was recommended for reducing total salt required for road applications in melting ice.	Potentially	As with $CaCl_2$, there are benefits to using the product given it is relatively safe and effective in fairly cold climates. Salt that has been pre-wetted with $CaCl_2$ bounces and scatters less when it is applied to road surfaces, allowing it to stay on the road better than dry salt does. It also tends to stay in the center of the road, where it is most effective at melting ice. A salt alternative is likely not required since the Yukon uses minimal amounts of salt on roads.	Government of Canada 2001; General Chemical Industrial Products 2002

Table 1. Summary of mitigation measures used to reduce WVCs.

Mitigation	Description	Feasible in Yukon	Rationale	References
Salt alternatives: $MgCl_2$	Used as a roadway de-icer.	No	This product is limited to a temperature of -15°C. It is often limited by the presence of magnesium sulfate that can crystallize and can cause sludge in application tanks. The sludge clogs spray nozzles and pumps. In addition, it is relatively hard on concrete resulting in slow deterioration of roadways. A salt alternative is likely not required since the Yukon uses minimal amounts of salt on roads.	Government of Canada 2001; General Chemical Industrial Products 2002
Salt alternatives: mix Mg and NaCl	Combination de-icer comprised of multiple elements.	No	Not used in Canada — very little information available. A salt alternative is likely not required since the Yukon uses minimal amounts of salt on roads.	Government of Canada 2001; General Chemical Industrial Products 2002
Salt alternatives: ferrocyanide	Used to prevent the clumping of chloride salts during storage and de-icing operations.	No	In water, it can be photolysed to release cyanide ions, and "Laboratory tests determined that a 15.5 mg/L solution of ferrocyanide would produce 3.8 mg cyanide/L upon exposure to sunlight for 30 minutes". A salt alternative is likely not required since the Yukon uses minimal amounts of salt on roads.	Government of Canada 2001

2.1 MODIFYING DRIVER BEHAVIOUR

This section summarizes mitigation measures that modify driver behaviour and are applicable in Yukon. Many of these mitigations are already used in Yukon, as discussed in Section 3. These mitigations include:

- Public awareness campaigns,
- Reduced vehicle speed,
- Wildlife warning signage,
- Increasing visibility, and
- Roadside vegetation management.

2.1.1 Public Awareness Campaigns

Public awareness and education is an important component in reducing WVCs. Public awareness campaigns are a proactive approach to reducing WVCs and are aimed at educating drivers about the need to take safety precautions in high wildlife-use zones (Tardif and Associates 2003). Radio announcements, workshops, flyers, signs at rest stops, billboards, and school programs help to inform the public of high wildlife-use areas, critical times of year when wildlife are on the road, and what to do if wildlife and/or wildlife signs are encountered while driving. Although there is no concrete evidence on the effectiveness of public awareness campaigns, it is suspected that this mitigation is helpful at reducing WVCs (Knapp *et al.* 2004).

2.1.2 Reduced Vehicle Speed

Posted Speed Limit — Reducing speed limits in areas of known wildlife presence can reduce the number of WVCs. The benefits provided by additional reaction time and distance (due to vehicle speed reductions) are clear. This method has been effective in highly regulated areas such as parks (Tardif and Associates 2003). Decreasing driver speed can reduce the number of WVCs dramatically; however, this may not be as effective on open rural highways due to non-compliance issues. If speed limits are reduced and obeyed, reduction in vehicle speeds can decrease the frequency of severe crashes involving human injury or fatality (Huijser and Kociolek 2008). Reducing vehicle speed decreases the distance required to stop a vehicle and can help prevent WVCs from occurring, or reduce the severity of the collision. It is "estimated that even a 5 km/h reduction in speed from 80 km/h on undivided roads could lower casualty crashes by 31 to 32%" (Huijser and Kociolek 2008). Driving at a reduced speed can increase driver awareness and increase the reaction time when a driver encounters an animal on or beside the road (Knapp *et al.* 2004). By slowing down, the driver has more time and distance to see the animal and react accordingly. Reduced speed can also provide wildlife the opportunity to move off the road before the vehicle reaches them (i.e., the vehicle does not surprise the animal).

Although feasible in Yukon, implementation of reduced speed zones requires changes to the regulation of the *Motor Vehicles Act* (Yukon Highways Speed Limits Order). Variable speed limits (i.e., dusk to dawn) are not feasible in Yukon since there is no legal mechanism for implementation.

Traffic Calming — Traffic calming has the potential to be effective at reducing WVCs in Yukon. Traffic calming treatments are designed to increase the driver's awareness of potential hazards in an area and to encourage them to reduce their speed to reduce the likelihood of WVCs (Huijser and Kociolek 2008). Although evidence is lacking, it is suspected that increased driver alertness may reduce WVCs for all wildlife species that cross or use roads and could be very effective in areas with high wildlife sightings/crossings.

Disadvantages associated with speed reduction and installation of rumble strips include non-compliance and decreasing speed enough to be effective at reducing WVCs while still maintaining traffic flow. Maintenance of highways with rumble strips can sometimes be challenging when plowing or upgrading sections of the roadway, which would be a concern on Yukon highways. Rumble strips can also act as a wildlife attractant. Loose salt on highways can cake and accumulate within and along the edges of rumble strips, which in effect can essentially create a salt lick and attract wildlife.

2.1.3 Wildlife Warning Signage

Signage to reduce WVCs includes standard passive signs, active and variable signs, and seasonal signs.

Passive Signs — A widely used mitigation measure to reduce WVCs is animal crossing warning signs. The design of this sign is often a diamond-shape, square or rectangle with a black animal silhouette or symbol on a yellow or white background (Knapp *et al.* 2004; Huijser and Kociolek 2008). This sign is widely recognized and easily interpreted by drivers, "alerting drivers to the potential presence of wildlife on or near the road, and urging them to be more alert, to reduce the speed of their vehicle, or a combination of both" (Huijser and Kociolek 2008). These signs attempt to prevent collisions, or to reduce the severity of a collision through lower vehicle speeds at impact.

Roadway warning signs are most effective and result in an alteration of speed and or path choice when they alert the driver to an obvious danger. Wildlife travel routes change over time and can be altered if there is a disturbance in the area. Although these signs give an indication that a particular species is expected to be in an area, they do not indicate when the species is expected to be in the area (i.e., time of day or season). Furthermore drivers who pass through that area on a regular basis may become habituated to the signs and ignore them. The overuse, or misuse by installing them at incorrect locations, reduces their overall effectiveness (Knapp *et al.* 2004). Huijser and Kociolek (2008) found many reports that supported that these signs are considered to be ineffective in reducing WVCs and are therefore not overly useful in preventing WVCs. Passive signage can still be beneficial at increasing driver awareness when installed correctly at appropriate locations.

Seasonal — Seasonal signs are essentially passive wildlife signs that are only in place seasonally, or for shorter time periods. These signs are typically installed when animals are regularly using an area for a short duration, such as during the winter or during migration timing.

Previous studies have shown that drivers are more likely to reduce vehicle speed along road segments where the signs were installed only during the migratory season or when animals use critical habitats in the winter near highways. The decrease in driver speed and the reduction of WVCs as a result of seasonal wildlife warning signs is very positive, however it was noted that "these reductions resulted from the installation of the signs and the fact that the drivers were mostly local commuters and understood the time and impacts" associated with the signs (Knapp *et al*. 2004). Local commuters recognized the collision danger during particular periods of the year, and the signs were a reminder to them to adjust their driving accordingly.

These signs are relatively inexpensive but do require maintenance since these signs need to be installed and removed every year.

Active and Variable Signs — Active wildlife warning signs are fixed in place but may have a permanently activated flashing amber warning light, LEDs, or brightly coloured flags (i.e., red or orange) attached to the sign (Huijser and Kociolek 2008).

Variable wildlife warning signs, or variable message boards, are messages displayed on static or electronic sign boards, which can be moved to different locations as needed. These signs are typically moved depending on seasonal needs and are able to have text input to inform traffic of upcoming hazards (e.g., bison on road). Although there is little evidence to determine the effectiveness of variable wildlife signs, it is suspected that these signs are effective in attracting and holding the drivers' attention. They help remind drivers to be observant and aware of potential wildlife within the area. Drivers are unlikely to become habituated to the signs because they will only be present when wildlife are known to be in an area.

Variable and active wildlife warning signs are designed to attract the attention of the driver and to relay a stronger message than the standard, passive wildlife warning signs (Huijser and Kociolek 2008). Although these signs may be effective in drawing the attention of drivers, a potential downside is that it takes the driver longer to interpret the sign because it is non-standard and often includes a few words or sentences that drivers need to read (as opposed to a familiar image). Another consideration when installing these signs is the initial cost and maintenance from vehicle damage, weather-related damage and vandalism. Although thought to be effective, they are typically substantially more expensive and require more maintenance than standard wildlife warning signs (Huijser and Kociolek 2008).

2.1.4 Increasing Visibility

Infrared Cameras — Infrared cameras can be used in areas of high wildlife use to detect when wildlife are on or near the road. When wildlife are detected, warning signs are activated to alert drivers that wildlife are present. Newhouse (2003) conducted a study to assess the effectiveness of this wildlife protection system. This study 1) tested the ability of the wildlife protection system to detect wildlife and warn motorists; 2) determined if drivers slowed when warning lights were activated; and 3) documented wildlife behavior near highways. The first trial was conducted during the summer of 2002 in Kootenay National Park, BC and found that the infrared cameras were able to detect wildlife, mostly deer, within a 1 km range. Although this study recommended that further trials be conducted, benefits observed from this study included:

- Drivers do not become complacent to the wildlife protection system because it is only activated when wildlife are on the road.
- The wildlife protection system does not affect the natural movement of wildlife.

- The system is highly portable. It can be moved seasonally to high use areas and can respond to changes in wildlife movement patterns.
- The system can also be used to determine the time of day when wildlife are using the road.

2.1.5 Roadside Vegetation Management

Roadside brush-cutting is conducted to increase sight lines and driver visibility by suppressing plant maturation and forest succession (Rea 2003). This method is effective since drivers are able to spot the animal from a greater distance, giving them a longer reaction time. Unfortunately, ungulates increase their foraging activities between dusk and dawn, when driver visibility is reduced (Gunson *et al.* 2011). The risk of ungulate-vehicle collisions also increases near forested areas, rather than open areas such as fields (Rea 2003). One drawback associated with roadside vegetation clearing is that the quality and availability of browse along managed roadsides tend to remain relatively constant as they are frequently cut providing excellent, lush feed (Rea 2003).

2.2 MODIFYING ANIMAL BEHAVIOUR

This section summarizes mitigation measures that modify, or attempt to influence, animal behaviour. These mitigations include:

- Roadside vegetation management,
- One-way earthen escape ramps,
- Wildlife hazing, and
- Hunting/Harvest,
- Salt Alternatives.

2.2.1 Roadside Vegetation Management

In many jurisdictions, vegetation management along highway ROWs is often focused on minimizing encroaching vegetation and increasing driver visibility and road safety. Wildlife such as moose, elk, caribou, bison, deer and bears often use roadside corridors as foraging habitat. Reducing the attractiveness of vegetation for browsing within ROWs is a practical mitigation measure to help reduce WVCs (Rea 2003). Decreasing the attractiveness of roadside vegetation can be accomplished by timing brush cutting activities (both time of year and years between brushing), and planting less palatable plant species in disturbed areas, thereby discouraging feeding within the ROW (Rea 2003).

Rea *et al.* (2010) conducted a three year study near Prince George, BC, to determine the most effective time of year to cut roadside vegetation preferred by moose. They recommended that cutting vegetation, especially in collision hotspots, during early summer is the most effective. During the first winter after cutting, the cut vegetation was typically buried under the snow and was not accessible to moose. During the second and third years following cutting, moose targeted plant species cut in the later part of the growing season

(August and October). Rea (1999) noted that the effectiveness of cutting only lasts three years, therefore brush-cutting will likely be required every three to four years.

2.2.2 One-Way Earthen Escape Ramps

Earthen escape ramps are used in areas bordered by steep terrain or where there is exclusion fencing (one-way only). These ramps are typically constructed of gravel fill and allow wildlife to move off roadways. They generally are costly to construct and maintain. They require fairly regular maintenance to ensure that they are clear of snow/debris so that they are functional for wildlife use, particularly during the winter. An escape ramp was constructed for sheep to escape from the Alaska Highway near Sheep Mountain by Kluane Lake and was proven to work effectively. More information on the escape ramp at Sheep Mountain is provided in Section 3.4. No other one-way earthen escape ramps have been used in Yukon.

2.2.3 Wildlife Hazing

Wildlife hazing can be used to discourage animals from feeding along highway ROWs. This is a short-term mitigation that has been implemented in some jurisdictions. Wildlife hazing focuses on disturbing wildlife feeding in areas along the highway to deter them from using the ROW in the future. Hazing methods can include using dogs, heli-hazing, horses to herd the animals, noise making devices, bean bag rounds, or rubber bullets (Wildlife Collisions Prevention Program 2014). Hazing is mostly used for animals that exhibit herd behaviour, such as bison. Hazing of the Aishihik (Yukon) and Hay Zama (Alberta) bison herds with helicopters and rubber bullets was not effective in keeping bison off highway corridors in the long-term (Wildlife Collisions Prevention Program 2014). Implementation can be costly and must be conducted continually. Another disadvantage of hazing wildlife is that it can be viewed negatively by the public.

2.2.4 Hunting/Harvest

Hunting can be used to reduce the amount of time that wildlife spends along highway ROWs and therefore reduce the number of WVC occurrences. In Yukon, wildlife harvest management of species like elk and bison is considered to increase public safety near highways. Modifying bison behaviour along the Alaska Highway corridor through hunting has been very successful. Initially, attempts were made to discourage bison from congregating within highway ROWs through hazing and this met with limited success. However, the lethal removal of a few select bison by Conservation Officers was very successful in keeping bison away from the highway corridor. Harvest in highway corridors is also allowed during September to March to keep bison off of highways. This management regime has been extremely effective at keeping bison away from the highway corridor. Alberta has had a similar experience in their management of the Hay Zama bison herd. The needs of highway public safety also need to be balanced with opportunities for wildlife viewing and appropriate management will vary depending on the species and area.

2.2.5 Salt Alternatives

Two chemical agents that have been used as de-icers have the potential to be effective in Yukon: $CaCl_2$ and NaCl mixed with $CaCl_2$ brine. The reduction in use of salt can reduce attracting wildlife to the road for access to sources of salt.

Calcium chloride —$CaCl_2$ is commonly used throughout Canada to de-ice roads and control dust. $CaCl_2$ helps to prevent the bond formation between the road surface and snow/ice. It is typically applied to the road as a liquid before or at the start of freezing precipitation (General Chemical Industrial Products 2002). A corrosion inhibitive liquid, $CaCl_2$ is also available which has shown to be 65% to 85% less corrosive than salt. It can work effectively in cold climates and has been shown to work in temperatures as cold as -32°C.

Sodium chloride mixed with calcium chloride brine — Liquid $CaCl_2$ is often used to pre-wet NaCl before application which allows for faster melt time and increase melting ability (i.e., it can melt more ice by volume). $CaCl_2$ also helps salt stay on the road because it bounces and scatters less than salt by itself. Cost reductions of 20% to 30% have been observed since it melts more ice and snow and it remains on the roadways longer (General Chemical Industrial Products 2002).

3 MITIGATIONS USED IN YUKON

A variety of mitigations have been used in Yukon in an effort to reduce WVCs on highways. Mitigations that are currently being implemented in Yukon include:

- Public awareness campaigns,
- Wildlife warning signs,
- Vegetation management,
- Escape ramps, and
- Wildlife underpass.

The effectiveness of these mitigations *in situ* has not been studied (A. Fontaine, pers. comm., March 13, 2014).

3.1 PUBLIC AWARENESS CAMPAIGNS

A variety of public awareness campaigns have been used in Yukon to educate the public on safety issues related to WVCs; where and when to expect animals on the road; and what drivers can do to reduce the potential of a collision with wildlife. Methods of delivery have included radio and news ads, articles in newspapers, and presentations/posters at the Environmental Fair and other public events. Table 2 provides a summary of public awareness campaigns that have been implemented in recent years. An example of a caribou poster used to alert drivers that caribou may be on the road in the Watson Lake region is included in Appendix A.

Table 2. Recent wildlife-vehicle public awareness activities implemented by the Yukon Government.

Public Awareness Type	Date	Yukon Government Department	Additional Information
Radio Interview	February 21, 2014	Yukon HPW Yukon Environment	CBC Radio Interview
Television Interview	February 21, 2014	Yukon HPW Yukon Environment	CBC TV Interview
Exhibit at Environmental Fair	May 10 & 11, 2013	Yukon Environment	Information was presented on wildlife-vehicle collisions and public were asked to identify where they have seen wildlife on the road.
Newspaper Article	March 22, 2013	Yukon Environment	Yukon News
Newspaper Article	March 4, 2013	Yukon Environment	Whitehorse Star
Newspaper Article	January 9, 2013	Yukon Environment	Yukon News
Posters	2013–2014	Yukon Environment	Posters advising that caribou on the roads were displayed at the Watson Lake and Whitehorse weigh scale stations; in local businesses in Watson lake.

3.2 WILDLIFE WARNING SIGNS

A variety of road sign types have been used on Yukon highways to alert drivers that wildlife may be on the road. Sign types include passive, seasonal and variable. The locations of the wildlife warning signs are shown in Figure 1 and on the collision summary figures for each species (caribou, moose, elk and deer) in Section 4. Figure 1 includes an identification number for each sign which corresponds to the information on the target species, signage type, and direction of travel which is provided in Table 3.

There are ten wildlife warning signs targeting caribou on the Alaska Highway (eight passive and two variable signs). The types of signs installed vary by location, but include a caribou silhouette on a yellow diamond, a caribou silhouette on a white rectangle, caribou cut-outs, and variable message boards. Many of these signs are taken down when caribou are not using the area. The caribou warning signs on the Alaska Highway are in the following locations:

- The east and west side of Lucky Lake (two signs; south of Watson Lake).
- East of the junction with the Stewart Cassiar Highway (Hwy 37).
- The east and west side of Little Rancheria River (two signs; west of Watson Lake).
- The west side of Johnson's Crossing.
- Near Summit Lake.
- Between Judas Creek subdivision and Jake's Corner (two signs).

There are two passive signs warning of moose on road. Both signs are located in the Swift River Valley — on the east and west sides of the high collision area. Both moose signs are moose cut-outs.

On the North Klondike Highway, there are seven passive signs advising of elk in the area at five locations. On the Alaska Highway, there are two elk signs along the Takhini River Valley on the east and west sides of the high collision area. The type of signs installed include an elk silhouette on a yellow diamond, an elk silhouette on a white and black square, and an elk cut-out.

There are two passive signs warning of deer, both on the north Klondike Highway north and south of the high collision area. Both of these signs are a yellow diamond with a deer silhouette.

Figure 1. Wildlife warning signage locations by species.

Table 3. Yukon highway wildlife warning sign information.

Sign ID	Target Species	Sign Type	Direction	Details
1	Caribou	Yellow Diamond	West-bound	Combination diamond and small rectangular sign beneath with "NEXT 25 KM"
2	Caribou	Caribou Cut-out	West-bound	Combination cut-out and 2 rectangular signs beneath with " CAUTION 45 KM" and "Little Rancheria Herd"
3	Caribou	Caribou Cut-out	East-bound	Combination cut-out and 2 rectangular signs beneath with " CAUTION 45 KM" and "Little Rancheria Herd"
4	Caribou	Yellow Diamond	East-bound	Combination diamond and small rectangular sign beneath with "NEXT 25 KM"
5	Caribou	White rectangle, caribou	East-bound	Rectangular with black caribou silhouette, "CAUTION" "NEXT 17 KM"
6	Caribou	White rectangle, caribou	West-bound	Rectangular with black caribou silhouette, "CAUTION" "NEXT 17 KM"
7	Caribou	Yellow Diamond	East-bound	Combination diamond and small rectangular sign beneath with "NEXT 18 KM"
8	Caribou	Yellow Diamond	West-bound	Combination diamond and small rectangular sign beneath with "NEXT 18 KM"
9	Moose	Moose Cut-out	East-bound	Combination cut-out and 1 rectangular sign beneath with " CAUTION 25 KM"
10	Moose	Moose Cut-out	West-bound	Combination cut-out and 1 rectangular sign beneath with " CAUTION 25 KM"
11	Elk	White and black square	South-bound	Elk silhouette; text "Caution - Elk, Next 50 km"
12	Elk	Yellow diamond	South-bound	Elk silhouette
13	Elk	Elk Cut-out	South-bound	White, brown and green; text "Caution 28 km, Braeburn Elk Herd"
14	Deer	Yellow Diamond	South-bound	Deer silhouette
15	Deer	Yellow Diamond	North-bound	Deer silhouette
16	Elk	Yellow Diamond	North-bound	Elk silhouette; text "Next 80 km"
17	Elk	Yellow Diamond	North-bound	Elk silhouette
18	Elk	Elk Cut-out	North-bound	White, brown and green; text "Caution 28 km, Braeburn Elk Herd"
19	Elk	Yellow Diamond	North-bound	Elk silhouette
20	Elk	Elk Cut-out	West-bound	1472KM Elk Silhouette. Large Rectangle. Black and White
21	Elk	Elk Cut-out	East-bound	1500KM Elk Silhouette White, brown and green
22	Caribou	Variable Message Board	East-bound	Seasonal use
23	Caribou	Variable Message Board	West-bound	Seasonal use

3.3 VEGETATION MANAGEMENT

Vegetation is managed on Yukon highways to provide drivers with increased visibility. Vegetation management typically considers traffic volumes, rates of vegetation growth, budget and contractor availability. Current vegetation management practices do not specifically target WVC locations.

The vegetation management area width within the highway ROW depends on the highway, but generally it is 45 m from the centre line for the Alaska Highway and 30 m from the centre line on other highways and some roads. Vegetation maintenance includes shoulder mowing, brushing, and clearing. General shoulder mowing is completed within 2.5 m of the shoulder. Then the extent of clearing depends on the highway "class". The classification system was modified during this study. The most recent system (2013–2014) is as follows:

Class A/Clover	2.5 m from shoulder
Class B	5.0 m from shoulder
Class C	10.0 m from shoulder
Class D	Full width vegetation control

The maintenance schedule is variable. The schedule provided by Yukon HPW showed that some sections of highways have ROWs cleared/brushed every year, while others are completed every three to five years.

3.4 ESCAPE RAMPS

Sheep Mountain in Kluane National Park is an important area for thinhorn sheep. The section of the Alaska Highway along the base of Sheep Mountain has steep terrain on the west side of the highway and Kluane Lake on the east side, which provides little escape routes for sheep when vehicles approach. Escape routes have been cut into the rock face to allow sheep to move off the road. These escape routes were found to be effective, but rock fall and sloughing has reduce the effectiveness of these escape ramps over time (A. Fontaine, pers. comm., March 13, 2014). There are currently no plans to maintain these ramps (S. Taylor, pers. comm., October 7, 2014).

3.5 WILDLIFE UNDERPASS

Two large multi-plate culverts were installed in the Grizzly Valley Subdivision, located at KM 220 on the North Klondike Highway, which are passable to large mammals. These are the only known wildlife underpasses in Yukon. These culverts were installed to allow for "free movement of large mammals along the melt water channel" (YESAB 2006). Both culverts were installed within the 'wildlife travel corridor' that was included as part of the subdivision design. This corridor was established based on terrain and wildlife observations made during 2005 (Inukshuk *et al.* 2006). To the best of our knowledge, these underpasses have not been monitored for effectiveness. Traffic volume on the Grizzly Valley Road is considered to be low.

4 YUKON WILDLIFE-VEHICLE COLLISIONS ANALYSIS

WVCs that occurred on Yukon highways, and within Yukon maintained sections of highway in northern British Columbia (herein referred to as Yukon highways) between May 2003 and February 2014 were recorded. These analyses provide a summary of Yukon Government's WVC database by species, year, and highway.

4.1 OVERVIEW

4.1.1 Data Collection

In Yukon, WVC data is collected by Yukon Environment (Conservation Officer Services) and Yukon HPW.

The WVC data collected varies by organization and location. Not all data were collected for each collision. Data collected by Yukon Environment is typically collected by Conservation Officers or other Yukon Environment staff in each district on a Yukon Biological Submission form (YBS Form). An example of this form is included in Appendix C. All YBS forms are sent to the Whitehorse Yukon Environment office for entry into the YBS database. This database can then be queried to extract the desired information (e.g., WVCs) into an output spreadsheet. The following data were collected by Yukon Environment on the YBS forms for most collisions:

- YBS Number
- Occurrence Report Number
- Species
- Date of collision
- Kill type
- Sex
- Age
- Game Management Subzone
- Description of location
- GPS location (UTM) or nearest landmark
- Comments

Wildlife collision data collected by Yukon HPW are recorded by HPW case number in their database.

4.1.2 Wildlife-Vehicle Collision Data

Data used for this analysis were collected between May 2003 and February 2014 (earlier data are available but not included in this report). The YBS database is maintained by Yukon Environment staff in Whitehorse and includes YBS data that is generated from all Conservation Officer Services district offices.

The majority of WVCs occur in the Whitehorse, Teslin and Watson Lake districts and as a result these offices generate substantially more data than other district offices.

4.1.3 Data Limitations and Assumptions

Limitations associated with the WVC data presented in this report include:

- Not all collisions that occurred in the Yukon between 2003 and 2014 were documented on YBS forms and as a result these were not found in the YBS database. To maximize the number of collision records available for this analysis, a manual search was conducted through the occurrence record logbooks and paper files of the Whitehorse, Teslin, and Watson Lake Conservation Officer Services district offices. Examples of reported WVCs that do not generate YBS forms are when officers attend the scene of a reported collision but are unable to find evidence that a collision occurred or when no officers are available to attend the scene of a collision. Collision data that was not recorded on a YBS form in offices other than the aforementioned district offices were not included in the analysis. However, this represents a very small data gap given that these other districts have few reported WVCs.
- The locations for many of the WVCs were estimated based on the descriptions provided.
- WVCs that occurred on the sections of the Alaska and Stewart-Cassiar highways that are located in BC but are maintained by Yukon HPW and for which we have occurrence records were included in the data consolidation and analysis. However, collisions that occur within BC do not normally generate a YBS form given that they occur in another jurisdiction.

4.2 METHODS

4.2.1 Data Consolidation and Management

Only WVCs that occurred with large mammals were recorded. Wildlife species included in the database and analyses are:

- Caribou (*Rangifer tarandus*)
- Moose (*Alces alces*)
- Wood bison (*Bison bison athabascae*)
- Elk (*Cervus canadensis*)
- Mule deer (*Odocoileus hemionus*)
- Grizzly bear (*Ursus arctos*)
- Black bear (*Ursus americanus*)
- Gray Wolf (*Canus lupus*)
- Cougar (*Puma concolor*)

The data records provided by Yukon Environment and Yukon HPW were consolidated into a single Microsoft Excel database. Most of the descriptions provided a spatial reference or enough information to estimate the location of the collision; however, 29 collisions could not be spatially referenced and were dropped from spatial analyses. For data that were missing spatial locations, but contained a description of the collision site (e.g., Alaska Highway, 5 km north of Jake's Corner), spatial locations were estimated and added to the database. For collisions where only a kilometre post was provided for the location, the spatial location was determined using the kilometre post spatial dataset in Yukon from Geomatics Yukon (Government Yukon 2008). The kilometre post locations in BC were generated in the GIS by creating 1 km station intervals starting from the Yukon/BC border using Yukon kilometre post data.

Quality Assurance/Quality Control was then conducted to ensure that all collision records were complete and that all data were accurate as reported and not replicated. This was done by cross checking data entries; plotting the locations to ensure that there were no anomalies; and preparing table summaries of collision data. Duplicate WVCs were combined into one entry.

An overview of the Yukon highways and roads included in the WVC analysis is provided in Figure 2. A list of highways and roads with their average daily traffic count is provided in Table 4. Some roads included in the analysis are territorial highways while others are high use roads. Herein, all roads included in the analysis are referred to as highways regardless of being labelled a road or highway.

Figure 2. Yukon roads and highways included in the wildlife-vehicle collision analysis.

Table 4. Yukon highways/roads and average traffic volumes.

Road	Yukon Highway No.	Location	2011 Traffic Volume (Average Daily Traffic)[1]
Alaska Highway	1	Watson Lake Weigh Scales (KM 976)	561
		Swift River Grader Station (KM 1137)	542
		Jake's Corner South (KM 1342)	588
		Carcross Cutoff South (KM 1404)	2045
		North Klondike Junction – 2 km south (KM 1435)	4,166
Annie Lake Road	108	n/a	n/a
Atlin Road	7	n/a	n/a
Dempster Highway	5	Dempster Corner (KM 0.1)	108
Klondike Highway	2	Carcross Cutoff (KM 158)	1,188
		Carcross South (KM 106)	821
		Braeburn (KM 280)	460
Mountainview Drive	n/a	n/a	n/a
Nahanni Range Road	10	n/a	n/a
Robert Campbell Highway	4	Watson Lake Airport Rd Junction (KM 10.2)	126
		Tuchitua (KM 110.6)	29
Robert Service Way	n/a	n/a	n/a
Stewart-Cassiar Highway	BC Hwy #37	South of Gas Station (KM 1)	163
South Canol	6	n/a	n/a
Tagish Road	8	Jake's Corner (KM 0.1)	298
Takhini Hotsprings Road	14	n/a	n/a

[1] Yukon Highways and Public Works 2011.

4.2.2 Data Analysis

All mapping and analysis was completed using the ArcGIS 10.2 software platform (Yukon Albers projection system). Point data were analyzed to display WVC locations. During this analysis, the WVCs were assessed by species, year and season. The ArcGIS extension Spatial Analyst geo-processing tool, known as kernel density, was used to calculate the density of collisions to show where high collision areas occur. The number of data points (i.e., collision locations) shown in the figures sometimes do not match the number of collisions listed in the collision summary tables. The reason for this is that some of the collision locations displayed in the figures have occurred in the same spot, and therefore overlap. When there is a discrepancy, the number of WVC listed in the table supersedes that shown in the figures.

4.2.2.1 Kernel Density Analysis

Kernel density estimation was used to assist visualizing concentrations of WVC. The method generates values for all locations representing the density of points within a defined search area, known as the search radius or bandwidth.

Geoprocessing Settings and Preparation — Prior to starting the kernel density analysis, specific geoprocessing settings were input into the GIS workspace to ensure that all analyses were completed using the same geospatial parameters. The geoprocessing settings were as follows:

1. Workspace Projection: North American Datum Canadian Spatial reference System Yukon Albers
2. Output coordinates: North American Datum Canadian Spatial reference System Yukon Albers
3. Raster Resolution: 75 metres
4. Raster Mask: *Merged_Hiways_5kmBuffer.shp* (description below)
5. Processing Extent: *Merged_Hiways_5kmBuffer.shp*

The 727 collisions (with suitable location information) were imported into the GIS for mapping and analysis. Vector files were created for caribou, deer, moose, bear (black and grizzly), cougar, wolf, bison, elk, and for all species combined; nine files were created.

Creation of Layer: Merged_Hiways_5kmBuffer.shp — Major Yukon transportation routes were represented using the National Road Network v.11 (Natural Resources Canada). These data were regarded as the most suitable and current at the time of the analysis. Roads included in the analyses are (Figure 2):

- All major highways within Yukon
- Takhini Hot Springs Road
- Haines Road through BC
- South Klondike through BC
- Atlin Road through BC
- On the Alaska Highway in BC from the Yukon Border, south to where BC takes over highway maintenance

A 5 km buffer was applied to the roads. The buffer was used to constrain the kernel density layers created during the analysis and it was also considered a suitable extent for visualizing and mapping the data.

Kernel Density Estimates — Using ModelBuilder in ArcGIS for Desktop, a series of operations were created to derive kernel densities from the point data by species; processing was completed using ESRI ArcGIS Spatial Analyst extension. The kernel density was calculated using a 5 km bandwidth and the output units were set to density of points per 1 km^2. A total of nine density estimates were created, including one layer that contained all combined point data. The overall process produced nine raster files representing density estimates for each species and a layer for all species combined.

Reclassification of Layers — Once the densities estimates were completed, the values were reclassified first from the layer containing the kernel density estimates for all species. This layer contained the entire range of possible density values and so it was used to create the categories for which all other layers would be based. Reclassifying using the same method means comparisons can be made among the species. The values were classified from a numerical value of 0 to 0.892 which were divided into five categories based on a Natural Jenks classification system (Low, Low to Moderate, Moderate, Moderate to High, High).

4.3 RESULTS AND DISCUSSION

4.3.1 All Species

Between 2003 and 2014, a minimum of 753 animals were hit by motor vehicles on Yukon highways. The majority of these collisions (69%) occurred on the Alaska Highway. The Klondike Highway also had a number of WVCs, representing 21% of the total collisions. Table 5 summarizes the WVCs for each highway/road by year.

Caribou were the most frequently hit species, representing 27% of the total WVCs. Other species most commonly involved in WVC were deer (24%), moose (23%), and black bear (10%). On the Alaska Highway, mortality clusters, or moderate to high collision areas (Figure 3; shown in red and orange), occurred both north and south of Watson Lake; near the Little Rancheria River crossing; along the Swift River Valley; between Jake's Corner and Judas Creek; and northwest of Whitehorse. There was also a mortality cluster north of Whitehorse on the North Klondike Highway and on the Takhini Hotsprings Road.

Table 5. Vehicle collisions by year and road for all species (2003 – 2014).

Road	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Alaska Hwy	8	40	43	45	48	43	40	44	53	81	57	20	522
Annie Lake Road	-	-	-	-	-	1	1	-	-	-	-	-	2
Atlin Road	1	-	-	-	2	1	-	-	-	-	-	-	4
Dempster Hwy	-	-	-	-	-	-	-	-	-	1	-	-	1
Klondike Hwy	15	12	12	24	17	7	12	7	15	18	12	4	155
Mountainview Drive	-	1	-	-	-	-	-	-	-	1	-	-	2
Nahanni Range Road	-	-	-	-	-	1	2	-	-	-	1	-	4
Robert Campbell Hwy	-	-	1	2	1	-	-	2	4	-	4	1	15
Robert Service Way	-	-	-	-	-	-	-	1	-	1	-	-	2
South Canol Hwy	-	-	1	-	-	-	-	-	-	-	-	-	1
Stewart-Cassiar Hwy	-	-	-	-	1	-	-	-	-	-	-	-	1
Tagish Road	1	1	1	2	5	4	1	-	4	2	3	-	24
Takhini Hotsprings Road	-	-	2	2	1	3	1	-	3	6	2	-	20
Total	25	54	60	75	75	60	57	54	79	110	79	25	753

Figure 3. Vehicle collision distribution and density for all species.

4.3.2 Caribou

Two subspecies of caribou occur in Yukon: woodland caribou (*Rangifer tarandus caribou*) and barren-ground caribou (*Rangifer tarandus grantii*). Woodland caribou occupy most of the central to southern Yukon. Barren-ground caribou occupy most of northern Yukon, from about Dawson City north. Caribou assessed in this analysis are woodland caribou, since all the reported collisions are located south of Whitehorse. The Yukon population of woodland caribou is estimated at 25,000 animals (Yukon Environment 2014), and is listed as 'Special Concern' by the federal government's *Species at Risk Act*.

The most frequent large mammals involved in WVCs in the Yukon between 2003 and 2014 are caribou, representing 27% of the total WVCs. A total of 203 collisions occurred during this period and 91% of those occurred on the Alaska Highway (n=185; Table 6). The largest number of collisions involving caribou occurred in 2012 (n=34) and 2013 (n=29). All but one caribou collision occurred between October and May, with the majority occurring between November and March (82%; Figure B2 in Appendix B).

A number of moderate/high to high collision areas are identified in Figure 4. Figure 5 shows the specific caribou collision locations. The areas with the highest collision density are Lucky Lake area south of Watson Lake and near Jake's Corner south of Whitehorse. Both of these sites are on the Alaska Highway.

In the Lucky Lake area, 24 reported caribou collisions have occurred within a 7 km stretch of highway. The collisions that have occurred in this section of road by kilometre and by year are illustrated in Figure 6. Most of the collisions in the Lucky Lake area have occurred along a 3 km stretch of highway between KM 969 and KM 972 (n=18; 75%) and all reported collisions have occurred between 2010 and 2013. The majority (88%) of these collisions occurred in 2012 and 2013. Many of these collisions are with caribou from the Little Rancheria or Horseranch caribou herds. In 2009, these herds were estimated at 1,000–1,200 and 600–800 animals respectively and were considered to be stable or increasing (Yukon Environment 2012a).

Near Jake's Corner, 39 caribou collisions have occurred between KM 1342 and 1362. Figure 7 shows the distribution of caribou collisions by year. The highest collision area is between KM 1345 and 1355. Caribou have been hit in this area every year between 2004 and 2014, with the highest collision years being 2004 (n=6), 2005 (n=5), and 2007 (n=6). The caribou using the Jake's Corner area are likely with the Carcross herd, which in 2008 was estimated at 800 animals and was considered to be stable (Yukon Environment 2012a).

Table 6. Caribou vehicle collisions by year and road (2003 – 2014).

Road	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Alaska Hwy	-	13	17	10	14	17	11	21	21	32	27	2	185
Atlin Road	-	-	-	-	2	-	-	-	-	-	-	-	2
Klondike Hwy	-	1	1	-	-	1	2	-	-	1	-	-	6
Robert Campbell Hwy	-	-	-	-	-	-	-	-	-	-	1	-	1
Stewart Cassiar Hwy	-	-	-	-	1	-	-	-	-	-	-	-	1
Tagish Road	-	1	-	1	1	-	-	-	3	1	1	-	8
Total	-	15	18	11	18	18	13	21	24	34	29	2	203

Figure 4. Vehicle collision distribution and density for caribou.

Figure 5. Locations of caribou-vehicle collisions, 2003 – 2014.

Figure 6. Caribou-vehicle collisions in the Lucky Lake area, 2003 – 2014.

Figure 7. Caribou-vehicle collisions in the Jake's Corner area, 2003 – 2014.

4.3.3 Moose

Moose (*Alces alces*) occur throughout the Yukon, with the exception of the St. Elias Mountains. Moose are the largest ungulate in Yukon. The Yukon moose population was last estimated to be approximately 70,000 animals (Yukon Environment 2014). Because of their large size, WVCs with moose are a serious safety concern that can often result in both human and moose mortality.

Between 2003 and 2014 there were 173 WVCs with moose, representing 23% of the total WVCs. The majority of these collisions (73%) occurred on the Alaska Highway (Table 7). The Klondike Highway also had a number of moose collisions (n=25). The highest number of moose collisions occurred in 2011 (n=26) although moose collisions occurred in all years (Table 7; Figure B3 in Appendix B). Moose collisions occurred year round, but the highest number of collisions occurs through the winter months, with 57% of moose collisions occurring between December and February (Figure B4; Appendix A).

The locations of high collision areas for moose are illustrated in Figure 8. The actual locations of moose collisions are shown in Figure 9. The most significant collision area is in the Swift River Valley between the Continental Divide Lodge (Upper Rancheria River Bridge; ~ KM 1119) and Partridge Creek (KM 1142). The distribution of moose collisions in the Swift River Valley, by year, is illustrated in Figure 10. All of the reported moose collisions in this area have occurred since 2006 (n=25). The highest collision area has been between KM 1120 to KM 1130. The highest year for collisions in the Swift River Valley occurred in 2008 (n=11) and no moose were hit by motor vehicles in 2010 or 2012. The snow accumulation in the Swift River Valley can be significant and there are local reports of moose not attempting to move off the road because of high snow banks (B. Schonewille, pers. comm., October 2, 2014). Other low/moderate to moderate collision areas occur along the Alaska Highway from Watson Lake to Whitehorse. The Klondike Highway and Tagish Road also have numerous collisions. One moose was killed on the BC/Yukon border in 2007, but no location was documented.

Table 7. Moose vehicle collisions by year and road (2003 – 2014).

Road	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Alaska Hwy y	-	10	5	11	15	12	12	8	19	14	9	11	126
Annie Lake Road	-	-	-	-	-	1	1	-	-	-	-	-	2
Atlin Road	-	-	-	-		1	-	-	-	-	-	-	1
Klondike Hwy	-	-	1	3	3	1	3	2	5	5	1	1	25
Mountainview Drive	-	1	-	-	-	-	-	-	-	1	-	-	2
Nahanni Range Road	-	-	-	-	-	1	1	-	-	-	1	-	3
Robert Campbell Hwy	-	-	-	-	-	-	-	1	2	-	1	1	5
South Canol Hwy	-	-	1	-	-	-	-	-	-	-	-	-	1
Tagish Road	-	-	1	-	2	3	-	-	-	-	2	-	8
Total	-	11	8	14	20	19	17	11	26	20	14	13	173

Figure 8. Vehicle collision distribution and density for moose.

Figure 9. Locations of moose-vehicle collisions, 2003 – 2014.

Figure 10. Moose-vehicle collisions in the Swift River area, 2003 – 2014.

4.3.4 Wood Bison

The re-introduction of wood bison (*Bison bison athabascae*) to Yukon started in 1986 with the release of 170 bison into the Nisling River Valley between 1988 and 1992. That herd of wood bison now ranges north to the Nisling River, east to the North Klondike Highway, south to the Dezadeash River and west to the Ruby Range (Yukon Environment 2012b). Bison also occur in the Liard region (Nordquist herd) in northern BC, where their range overlaps with the Alaska Highway. Like moose, WVCs with bison are also a serious safety concern because of their large body size.

Twenty bison have been killed by motor vehicles since 2003, all on the Alaska Highway. These collisions occurred south of Watson Lake and mostly in BC. The highest number of WVCs with bison occurred in 2014 (n=7; Table 8). All of the collisions in 2014 occurred in January and it appears there were two collisions where multiple bison were killed. One collision involved two bison and the other involved three bison. Collisions with bison occurred during the months of January (n=9), May (n=1), August (n=7), September (n=1) and October (n=1).

The kernel density analysis identified one moderate collision density area and four low to moderate collision density areas (Figure 11). The locations of the actual collision sites are shown in Figure 12.

Table 8. Bison vehicle collisions by year and road (2007 – 2014; no collisions from 2003–2006).

Road	2007	2008	2009	2010	2011	2012	2013	2014	Total
Alaska Hwy	3	-	1	-	1	6	2	7	20
Total	3	-	1	-	1	6	2	7	20

Figure 11. Vehicle collision distribution and density for bison.

Figure 12. Locations of bison-vehicle collisions, 2003 – 2014.

4.3.5 Elk

Two populations of elk (*Cervus canadensis*) occur in Yukon: the Braeburn and Takhini Valley herds. The Braeburn herd ranges along the North Klondike Highway, between Fox Lake and Carmacks. The Takhini Valley herd mainly occurs in the Takhini River Valley, west of Whitehorse extending to approximately the Aishihik River. Although elk historically occupied Yukon, the recent populations were re-introduced in the 1940s by a local hunting association (Yukon Environment 2008). The current elk population is thought to be around 300 animals (Yukon Environment 2014).

Between 2003 and 2014, 61 elk were hit by vehicles, representing 8% of the total WVCs during this period. All of those collisions occurred on the Alaska (n=46) and North Klondike (n=15) highways (Table 9). The highest number of collisions with elk occurred in 2005 (Table 9; Figure B5 in Appendix B). The majority of elk collisions occurred between August and January, with peak collisions occurring in October (Figure B6; Appendix B).

The kernel density analysis identified two high collision areas (Figure 13). The area on the Alaska Highway at KM 1470 to 1490 is a moderate to moderate/high collision density area. There is also a low/moderate to moderate collision density area on the North Klondike Highway near Braeburn. The locations of WVCs with elk are shown in Figure 14.

Table 9. Elk Vehicle collisions by year and road (2003 – 2014; no collisions in 2014).

Road	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Alaska Hwy	1	5	8	3	4	2	6	4	3	6	4	46
Klondike Hwy	4	3	1	3	1	-	-	-	2	-	1	15
Total	5	8	9	6	5	2	6	4	5	6	5	61

Figure 13. Vehicle collision distribution and density for elk.

Figure 14. Locations of elk-vehicle collisions, 2003 – 2014.

4.3.6 Deer

Both mule deer (*Odocoileus hemionus*) and white-tailed deer (*Odocoileus virginianus)* have been reported in Yukon, though mule deer are much more common than white-tailed deer. Their Yukon range extends from the BC-Yukon border north to about Dawson City, although the majority of deer are observed along highways and large river valleys in southern Yukon (Yukon Environment 2014). For the purposes of the WVC analysis, the two deer species are not differentiated.

WVCs with deer represent 24% of the total collisions that have occurred in Yukon between 2003 and 2014. The total number of collisions with deer during this period was 183. Most of the collisions with deer have occurred on the Alaska (n=66) and Klondike (n=89) highways (Table 10). One deer was killed in 2006, but no location was given, therefore it was not included in the analysis. The year with the highest deer WVCs was 2006 (n=31; Table 10 and Figure B7 in Appendix B). Collisions with deer have occurred year round, with the highest collisions occurring between September and December (61%; Figure B8 in Appendix B).

The kernel density analysis identified high collision areas north of Whitehorse on the North Klondike Highway and Takhini Hotsprings Road (Figure 15). Collisions have occurred in this region every year within the study period. The most significant years for collisions in this area are 2006, 2007, 2011 and 2012.

Other moderate to moderate/high collision areas include the Alaska Highway, south of Whitehorse near the Lewes River Bridge, and the South Klondike Highway (between KM 120 and 130). The collisions near the Lewes River Bridge mostly occurred between 2003 and 2007, although one collision occurred there in both 2012 and 2013. Collisions with deer between KM 120 and 130 on the South Klondike Highway have occurred in all years except 2007, 2008 and 2014. The locations of WVCs with deer are illustrated in Figure 16.

Table 10. Deer vehicle collisions by year and road (2003 – 2014).

Road	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Alaska Hwy	2	7	9	14	5	8	1	4	5	7	4	-	66
Klondike Hwy	10	6	8	12	10	5	6	4	8	9	8	3	89
Robert Campbell Hwy	-	-	-	2	1	-	-	-	-	-	-	-	3
Robert Service Way	-	-	-	-	-	-	-	1	-	1	-	-	2
Tagish Road	1	-	-	1	1	1	-	-	1	-	-	-	5
Takhini Hotsprings Road	-	-	2	2	1	1	1	-	3	6	2	-	18
Total	13	13	19	31	18	15	8	9	17	23	14	3	183

Figure 15. Vehicle collision distribution and density for deer.

Figure 16. Locations of deer-vehicle collisions, 2003 – 2014.

4.3.7 Bear

Bear species found in the Yukon include grizzly bear, black bear and polar bear. Grizzly bear (*Ursus arctos*) and black bear (*Ursus americanus*) occur throughout the majority of Yukon, while polar bear (*Ursus maritimus*) only occur on the northern coast (Yukon Environment 2014).

Since 2003, a total of 100 bears were hit by vehicles on Yukon highways, representing 13% of the total WVCs. Fifteen of those collisions occurred with grizzly bears (Table 11); 76 with black bears (Table 12); and nine with unidentified bear species (Table 13). No collisions with polar bears have been recorded.

Like most species, the majority of the collisions with both grizzly and black bears (75%) occurred on the Alaska Highway. The kernel density analysis (Figure 17) identified moderate collision areas, which occur mostly on the Alaska Highway between Teslin and Whitehorse. Not only does this area see a higher volume of traffic, but there is also higher quality black bear habitat in this area (B. Schonewille, pers. comm., October 2, 2014). Three areas on the South Klondike Highway (south of Whitehorse) were also identified as a moderate collision area. Thirteen bears (four grizzly, eight black and one unknown bear species) were killed or injured by vehicles on the Klondike Highway. Five of the six collisions with bears on the Robert Campbell Highway were with black bear and the other collision record was with an unknown bear species. The location for WVCs with bears is shown in Figure 18.

The highest number of collisions with grizzly bear occurred in 2007 and 2010 (n=3 for both years; Figure B9 in Appendix B). The highest number of collisions with black bear occurred in 2012 (n=12; Figure B11 in Appendix B). All recorded bear collisions occurred between April and October, with 93% occurring between May and September (Figure B10 and Figure B12; Appendix B). Bears in Yukon typically hibernate throughout the winter so it is expected that there were no WVCs with bears during the winter months.

Table 11. Grizzly bear vehicle collisions by year and road (2003 – 2014).

Road	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Alaska Hwy	-	-	-	-	2	1	1	2	-	2	1	-	9
Klondike Hwy	-	-	1	2	-	-	-	1	-	-	-	-	4
Nahanni Range Road	-	-	-	-	-	-	1	-	-	-	-	-	1
Tagish Road	-	-	-	-	1	-	-	-	-	-	-	-	1
Total	-	-	1	2	3	1	2	3	-	2	1	-	15

Table 12. Black bear vehicle collisions by year and road (2003 – 2014).

Road	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Alaska Hwy	5	5	4	5	5	4	7	5	2	11	8	-	61
Atlin Road	1	-	-	-	-	-	-	-	-	-	-	-	1
Klondike Hwy	1	1	-	2	2	-	1	-	-	-	1	-	8
Robert Campbell Hwy	-	-	1	-	-	-	-	1	2	-	1	-	5
Tagish Road	-	-	-	-	-	-	-	-	-	1	-	-	1
Total	7	6	5	7	7	4	8	6	4	12	10	-	76

Table 13. Vehicle collisions with unknown bear species by year and road (2003 – 2014).

Road	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Alaska Hwy	-	-	-	-	-	-	1	-	1	2	1	-	5
Dempster Hwy	-	-	-	-	-	-	-	-	-	1	-	-	1
Klondike Hwy	-	-	-	-	-	-	-	-	-	1	-	-	1
Robert Campbell Hwy	-	-	-	-	-	-	-	-	-	-	1	-	1
Tagish Road	-	-	-	-	-	-	1	-	-	-	-	-	1
Total	-	-	-	-	-	-	2	-	1	4	2	-	9

Figure 17. Vehicle collision distribution and density for bear.

Figure 18. Locations of bear-vehicle collisions, 2003 – 2014.

4.3.8 Gray Wolf

Wolves (*Canis lupus*) occur throughout most of Yukon. Six gray wolves were struck by vehicles since 2003 (Table 14). Three of those collisions occurred on the North and South Klondike highways; two on the Alaska Highway south of Whitehorse and one on the Takhini Hotsprings Road (Figure 19). One of the wolf collisions on the Klondike Highway did not have specific location information. Five (83%) of the collisions occurred between October and December.

Table 14. Gray wolf vehicle collisions by year and road (2003 – 2014; no collisions from 2003–2006).

Road	2007	2008	2009	2010	2011	2012	2013	2014	Total
Alaska Hwy	-	-	-	-	1	-	1	-	2
Klondike Hwy	1	-	-	-	-	1	1	-	3
Takhini Hotsprings Road	-	1	-	-	-	-	-	-	1
Total	1	1	-	-	1	1	2	-	6

4.3.9 Cougar

Cougars (*Puma concolor*) have only recently expanded into Yukon and their range shift is thought to be linked to the expansion of the mule deer range. Few cougar observations have been recorded in Yukon with most occurring in southern Yukon or near the Braeburn elk herd (Yukon Environment 2014). Cougar-vehicle collisions are within the known cougar distribution in Yukon. The two reported WVCs with cougars occurred in 2006 (Table 15). One collision occurred on the Alaska Highway south of Watson Lake and the other occurred on the North Klondike Highway, just north of Lake Laberge (Figure 19).

Table 15. Cougar vehicle collisions by year and road (2003 – 2014; no collisions from 2003 to 2005).

Road	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Alaska Hwy	1	-	-	-	-	-	-	-	-	1
Klondike Hwy	1	-	-	-	-	-	-	-	-	1
Total	2	-	-	-	-	-	-	-	-	2

4.3.10 Unknown Wildlife

Since 2004, there were five reported collisions with unknown species. Three of those collisions occurred on the Klondike Highway and two on the Alaska Highway. Three of the incidents were thought to be deer or caribou.

Figure 19. Locations of wolf and cougar-vehicle collisions, 2003 – 2014.

5 RECOMMENDATIONS

5.1 MITIGATIONS TO REDUCE WILDLIFE-VEHICLE COLLISIONS

Following a review of mitigations used in other jurisdictions, a review of mitigation practices currently being used in Yukon and an analysis of Yukon WVC records since 2003, EDI recommends that the mitigations listed below are considered, or existing mitigations be modified, to further assist in reducing the number of Yukon WVCs. It should be noted that the efficacy of locally applied mitigations needs to be determined through additional studies and ongoing monitoring efforts.

Eight sections of highway are identified as areas with high WVCs. From north to south, these sections are:

- North Klondike Highway/Takhini Hotsprings Road
- Takhini River area (Alaska Highway)
- Jake's Corner (Alaska Highway)
- Judas Creek/Lewes River Bridge area (Alaska Highway)
- Swift River Valley (Alaska Highway)
- Little Rancheria River (Alaska Highway)
- North of Watson Lake (Alaska Highway)
- Lucky Lake area (Alaska Highway).

Mitigation specific to these areas are referred to in the relevant sections below.

5.1.1 Public Awareness Campaigns

Public awareness campaigns have been implemented by the Yukon Government, both Yukon Environment and Yukon HPW. Continued public awareness programs, such as local radio and news advertisements and signs/advertisements at locations frequented by vehicle drivers, are recommended. Locations frequented by drivers include rest stops, gas stations, card lock stations, and weigh stations. The majority of WVCs have occurred between Watson Lake and just north and west of Whitehorse. Based on the collision location data, it is recommended that public awareness initiatives be focused on targeting audiences in Whitehorse, Teslin and Watson Lake.

The data analyzed in this report shows that information on the type of vehicle involved in the collision is rarely recorded. Of the 753 collision entries, vehicle information was only collected for 69, representing only 9% of collisions. By collecting more detailed information on the vehicle type involved in the collision, the target audience for public awareness campaigns could be determined. For example, Yukon Environment has noted that the majority of collisions that have occurred with caribou in the Watson Lake area involve transportation vehicles; therefore public awareness efforts in this region should target areas frequented by transportation truck drivers (i.e., truck stops, card lock gas stations, weigh stations) and potentially major transportation truck companies. By contrast, local residents living just outside of Whitehorse are involved in the majority of collisions near Whitehorse (A. Fontaine, pers. comm., March 13, 2014). By collecting more detailed data on vehicle type and driver type (i.e., local resident or visitor), public awareness efforts can target the most appropriate demographic, which would help increase effectiveness and decrease effort in areas where effort is not required.

5.1.2 Wildlife Warning Signs

If used properly, wildlife warning signs are an effective way to alert drivers that they are travelling through a high wildlife collision zone and that they may encounter wildlife on the road. Many of the high collision wildlife zones already have wildlife warning signs in use. Recommendations on the installation, or modification to existing wildlife warning signs, are provided for each of the high collision areas listed below.

A potentially effective system not currently used in Yukon is the Wildlife Protection System. This system uses infrared cameras to detect when wildlife is on, or near the road and then activates flashing lights (active wildlife warning signs) to alert drivers. For effective implementation, this system should be installed where collisions occur frequently along relatively short sections of road between dusk and dawn. If future WVC data collected includes the time of day that collisions occur, trials for this system could be implemented in areas with high collision rates that occur during darkness.

North Klondike Highway/Takhini Hotsprings Road — There are a number of collisions north and west of Whitehorse on the Alaska Highway, North Klondike Highway and Takhini Hotsprings Road. There are very few mitigations currently being implemented in this area. Two wildlife warning signs targeting deer are located on the North Klondike Highway north of the Takhini Hotsprings Road (Figure 1 and Figure 15).

- Additional seasonal signage (active or variable) should be installed targeting the time of year when most collisions occur (September to December).
- There are currently no signs on the Takhini Hotsprings Road despite the number of WVCs in that area. Seasonal signage should be installed in this area.
- Sign 14, as shown in Figure 1, should be moved south, closer to the start of the high collision zone.

Takhini River area — There are currently two passive elk warning signs in the Takhini River area on the Alaska Highway (Figure 1). These signs appear to be placed in appropriate locations but are permanently installed. The majority of elk collisions have occurred between August and January (Figure B6, Appendix B). The addition of active, variable or seasonal wildlife warning signs may help better alert drivers when elk are using the highway ROW, as drivers can be habituated to permanent wildlife warning signs.

Judas Creek/Lewes River Bridge area — A high number of WVCs have occurred in the Judas Creek/Lewes River Bridge area on the Alaska Highway, mostly with deer. There are no signs currently being used in this area and the installation of appropriate signage should be considered in the high collision zones.

Jake's Corner area — A high number of collisions have occurred in the Jake's Corner area. Collisions have included mostly caribou, but collisions with moose, deer and bear have also occurred. There are currently seasonal wildlife warning signs in the area which have been installed on the north and south ends of the high WVC area. The addition of active or variable signs during the winter could be beneficial in catching a driver's attention.

Swift River area — The Swift River Valley is a high collision area, particularly for moose. The majority of the WVCs along this section of highway have occurred in the winter and snow depth in this area is reported to be high. The highest collision area is located between KM 1120 and KM 1130. There are currently two moose cut-out signs with warning signs saying "Caution next 25 km" (Figure 1 and Figure 8). The east-bound sign is located just to the west of the high collision zone which alerts drivers to the high WVC area, but the west-bound sign is placed after the high collision area. EDI recommends that the west-bound sign is moved to the east of the high collision area (between KM 1115 and 1120).

Since the majority of moose collisions have occurred here during the winter (December to February), the use of active or variable signs may better alert drivers to the high probability of moose on the road during the winter.

Little Rancheria area — Passive caribou warning signs are currently installed in the Little Rancheria area. These signs appear to be appropriately located on either side of the high collision areas. If additional mitigation is required, seasonal, active or variable signs would be beneficial.

North of Watson Lake — Two passive caribou warning signs are located just north of Watson Lake (Figure 4). The west-bound sign appears to be appropriately located on the east side of the high WVC area. The east-bound sign should be relocated to the west side of the high collision area. An additional sign should also be installed on the Stewart-Cassiar Highway to the south of the high collision area. Like with other high WVC areas, if additional mitigation is required, seasonal, active or variable signs may help reduce WVCs by better alerting drivers to potential hazards.

Lucky Lake area — Variable message boards are used in the Lucky Lake area on the north and south side of the high WVC are. These appear to be in the correct locations. The seasonal use of these signs should continue and collision locations should be monitored to determine if signs are placed in the most effective locations in the future (i.e., if the collision locations shift over time).

5.1.3 Vegetation Management

Vegetation management can play an important role in reducing WVCs, particularly if clearing and brushing activities are conducted in key locations. The following vegetation management mitigations are recommended:

- Vegetation mowing and clearing to increase driver site lines is currently being implemented on most highways, and should be continued. High WVC zones, such as the North Klondike Highway/ Takhini Hotsprings road, and Jake's Corner, Swift River area and Lucky Lake area on the Alaska Highway should be assessed to determine if appropriate vegetation maintenance is being conducted.
- Vegetation management trials, such as those conducted by Rea *et al.* (2010), should be undertaken to determine the most effective time of year to cut brush and reduce the quantity of desirable forage

species. In other jurisdictions, the most beneficial time of year for mowing/brush cutting was June, which could be applicable in Yukon, or could vary slightly due to different growing conditions. Vegetation maintenance trials could assist in determining when the most effective time for vegetation clearing is to reduce forage potential and attractiveness.

- Roadside vegetation management should be undertaken every three to four years to reduce the availability of forage species, as recommended by Rea *et al.* (2010).
- Areas where re-vegetation is required should be planted with vegetation species that are not attractive as forage for ungulates (i.e., less palatable).

5.1.4 Reduced Vehicle Speed

Reducing vehicle speed in high collision areas could help reduce the number of WVCs. In Yukon, implementation of a reduced speed zone requires changes to the regulation of the *Motor Vehicles Act* (Yukon Highways Speed Limits Order). Variable speed limits (i.e., dusk to dawn) are not feasible in Yukon since there is no legal mechanism for implementation. Although the majority of the high WVC areas occur seasonally, implementation of reduced vehicle speeds could still be beneficial in areas with high collision rates. These areas would include both north and south of Watson Lake, the Swift River Valley, near Jake's Corner, and the North Klondike Highway area.

5.1.5 Snow Management

Proper snow management practices in areas with particularly high snowfall, such as the Swift River Valley, could help provide better escape routes for wildlife and help reduce the number of WVCs in this area. The Swift River Valley is a high collision area, particularly for moose. The majority of the WVCs along this section of highway have occurred in the winter and snow depth in this area is reported to be high. The highest collision area is located between KM 1120 and 1130. Effective snow management practices may include plowing snow so that there is not a large steep snow bank that is difficult for wildlife to cross, or providing escape routes through high snow banks so moose can move off of the highway. It would be beneficial for wildlife managers and Yukon HPW representatives to assess this area during the winter and see if movement barriers (i.e., high snow banks) are evident and what specific snow management options are feasible.

5.1.6 Monitoring

Future implementation of the techniques described above should consider an effectiveness monitoring component. Effectiveness monitoring will likely be necessary to support the decision to provide the resources to implement techniques such as using a variable message board at a high collision area, or changing snow management practices in the Swift River area. Results of effectiveness monitoring and conclusions regarding the technique's usefulness in reducing WVCs will be important to justify the continued use of the methods.

5.2 DATA COLLECTION

When collected consistently, WVC data are a valuable source of information to identify high collision areas (both spatially and temporally). WVCs are typically not random; they are spatially clustered. Through regular and structured data collection and mapping areas of high WVCs, trends or changes over time can be determined (Gunson *et al.* 2011). Tracking collision details and recording the costs associated with each WVC can provide concrete information for decision makers to conduct cost-benefit analyses prior to implementing a mitigation strategy (Lee *et al.* 2012).

For the data to be useful, specific and consistent information should be collected and be easily accessible and ready for analysis. Much of the data collected for this report was provided in a variety of formats and substantial data compilation and cleaning had to be completed before an analysis could be conducted. This included gathering the information from the various agencies, reviewing each item for consistency, interpreting the information where details were lacking or in a different formats, merging all data into one database, and checking data quality.

To make future WVC data readily available for analysis, we recommend developing a web-based data management system where user groups (i.e. the agencies that contribute to data input and management) can enter and access the WVC data online. If this is not feasible, at minimum a structured data collection and management system is recommended. An example of this would be a consistent data form that is used by all agencies. The YBS form used by Yukon Environment is not specific to just WVCs and is used to collect information from hunters and other user groups. Because the number of data fields on the YBS form is more than is needed for WVCs, compliance in filling out the form in its entirety would likely be lower than if the form only contained relevant WVC data fields. A form specific to WVCs that includes only the required information would likely prove to be more useful for this application. The YBS form could also be modified to include a section specific to WVC.

We recognize that not all data are available for every collision. For instance, if a driver hits a brown ungulate at night that runs off into the bush, the driver might not be able to properly identify the animal or the location. However, it would be useful if the front line people collecting WVC data from drivers, such as conservation officers, were familiar with the recommended data requirements so that they can ask appropriate questions to gather relevant information. The most pertinent data fields for future WVC analysis are:

- Date and Time
- Species/sex
- Was animal injured or killed?
- Property damage
- Vehicle type
- Driver residency (e.g., local resident, visitor)
- Highway/road
- Specific location (KM post with a description or geo-referenced location).

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Ben Schonewille, Professional Biologist, EDI Environmental Dynamics Inc., and Teslin Resident. Communications with EDI on October 2, 2014.

Shawn Taylor, Kluane Regional Biologist, Kluane Region, Fish and Wildlife Branch, Department of Environment. Communications with EDI on October 7, 2014.

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APPENDIX A EXAMPLE OF PUBLIC AWARENESS POSTER

APPENDIX B ANNUAL AND SEASONAL VARIATION OF WILDLIFE COLLISIONS

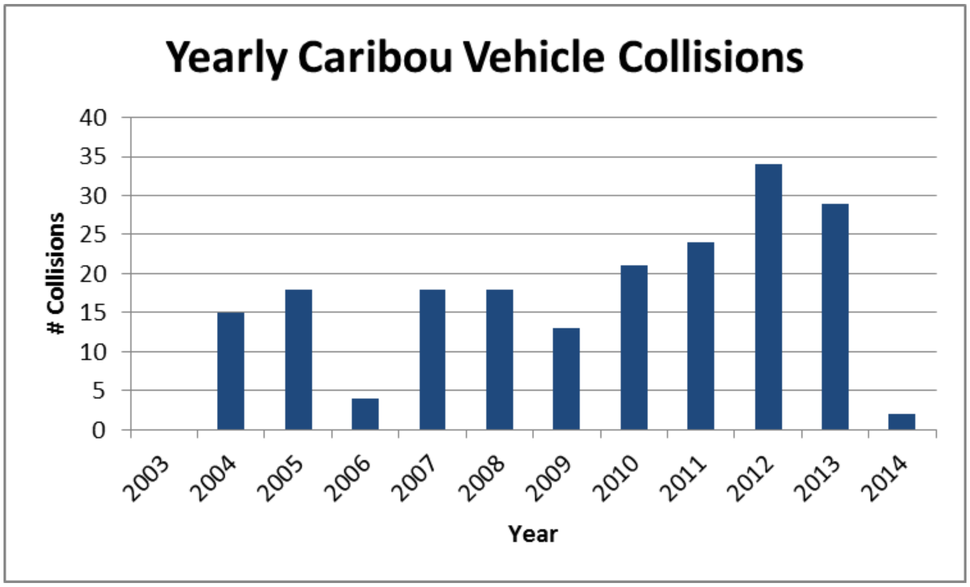

Figure B1. **Count of caribou-vehicle collisions by year, 2003 – 2014.**

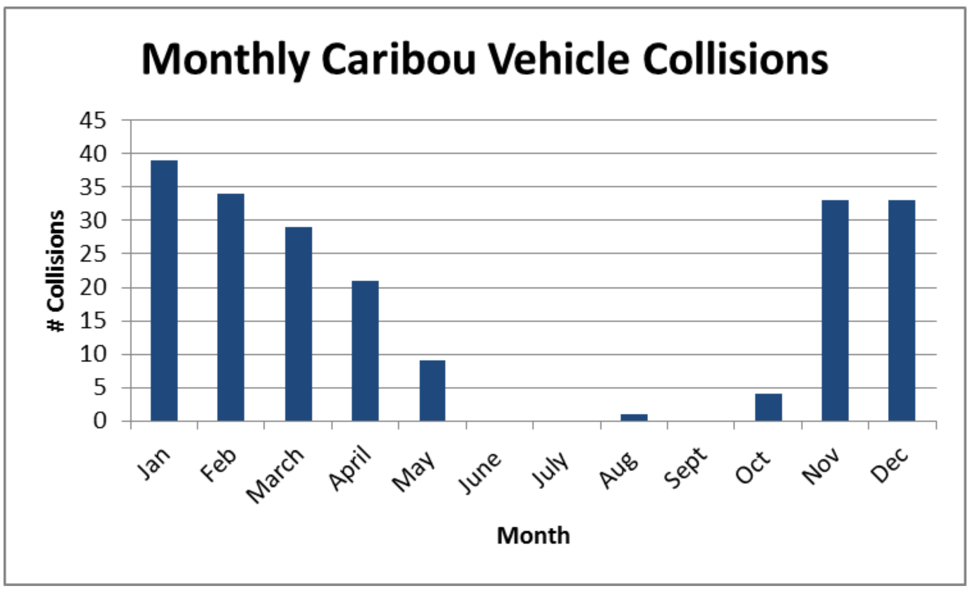

Figure B2. **Variation by month in caribou-vehicle collisions, 2003 – 2014.**

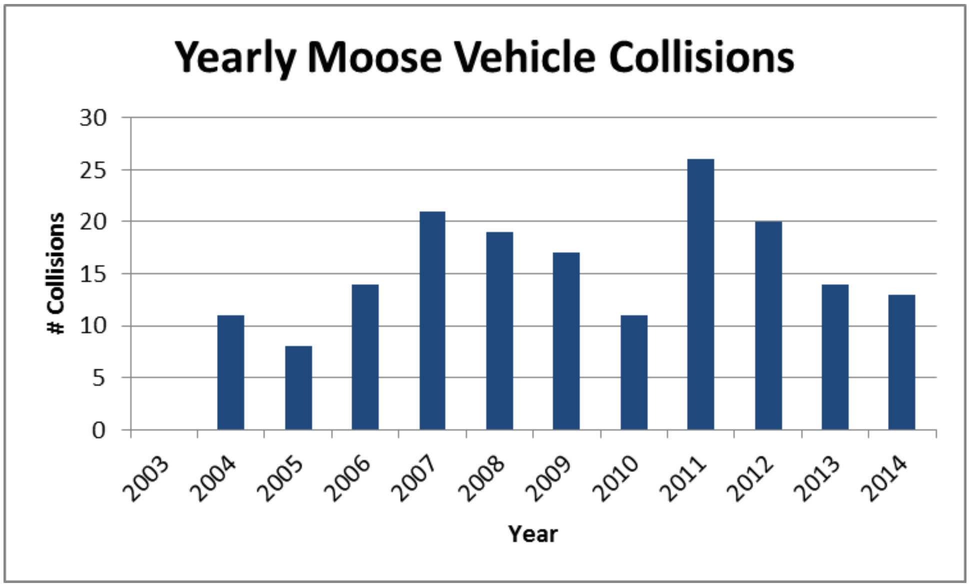

Figure B3. Count of moose-vehicle collisions by year, 2003 – 2014.

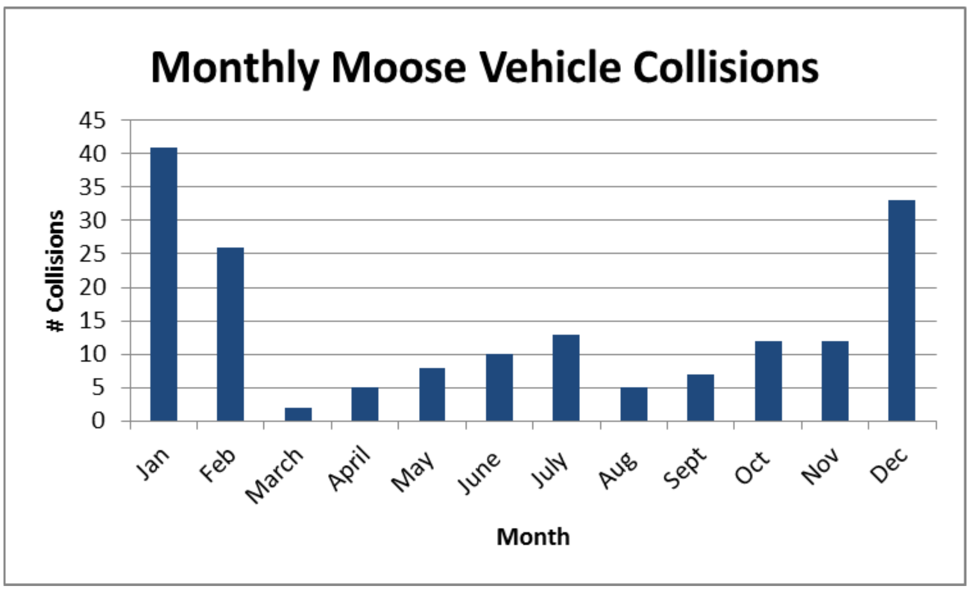

Figure B4. Variation by month in moose-vehicle collisions, 2003 – 2014.

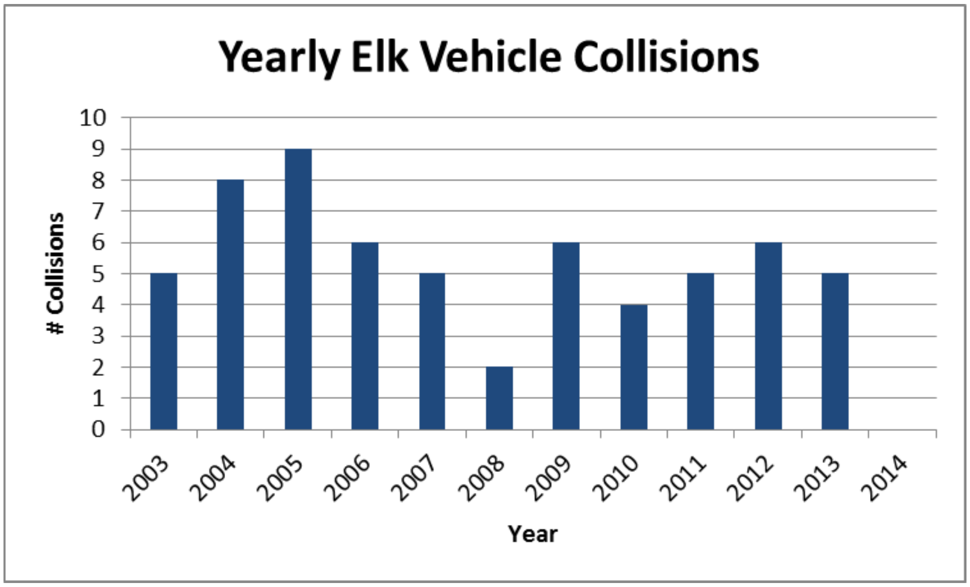

Figure B5. **Count of elk-vehicle collisions by year, 2003 – 2014.**

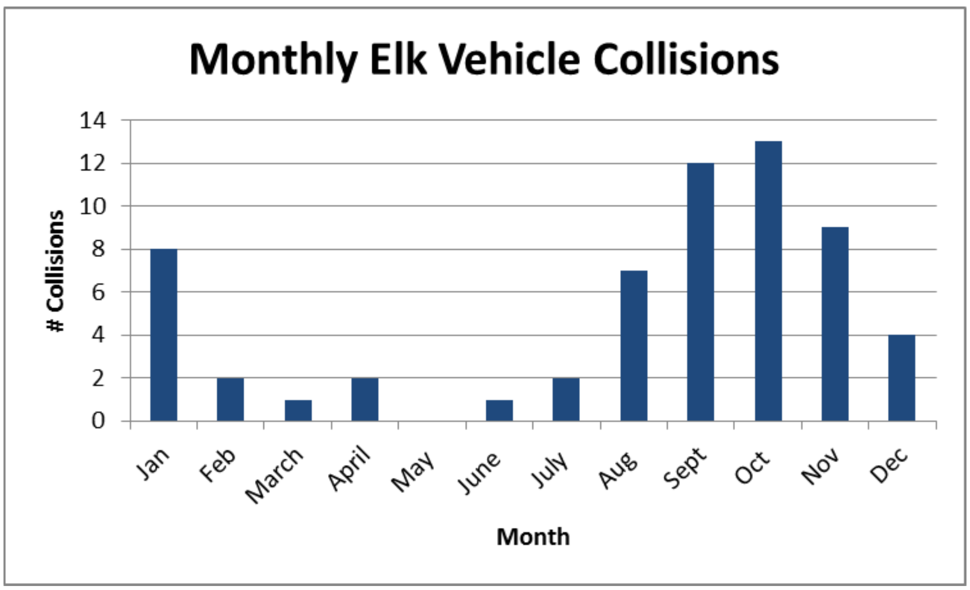

Figure B6. **Variation by month in elk-vehicle collisions, 2003 – 2014.**

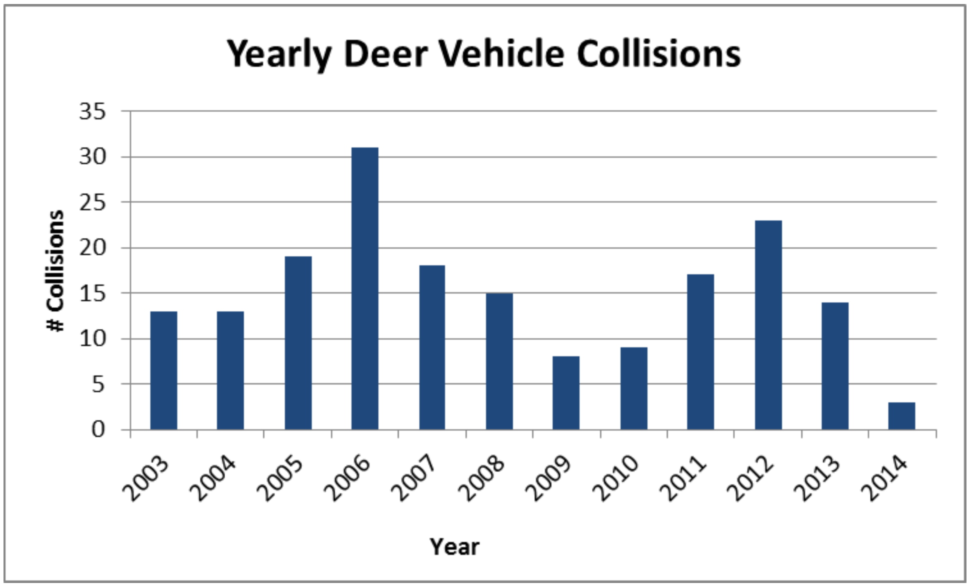

Figure B7. Count of deer-vehicle collisions by year, 2003 – 2014.

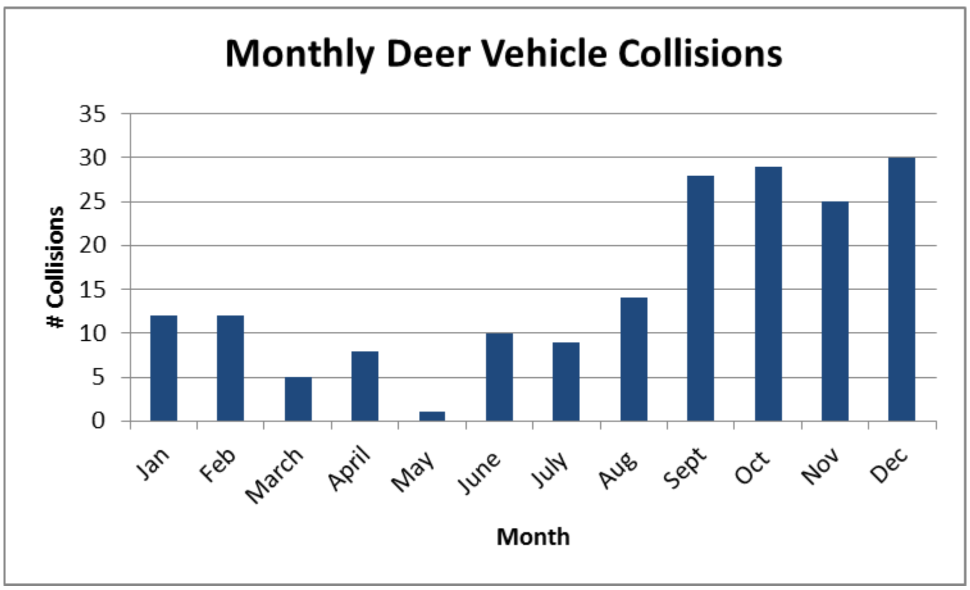

Figure B8. Variation by month in deer-vehicle collisions, 2003 – 2014.

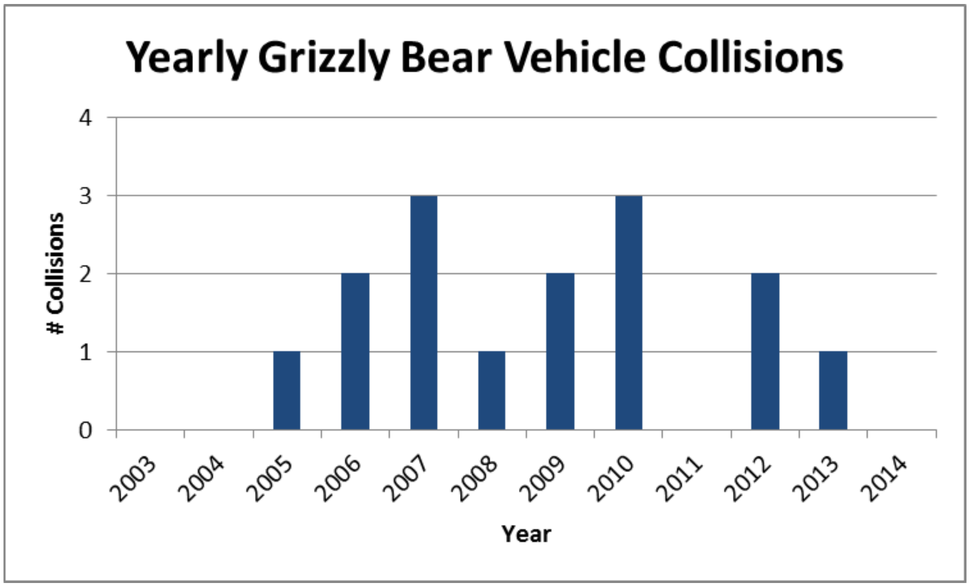

Figure B9. **Count of grizzly bear-vehicle collisions by year, 2003 – 2014.**

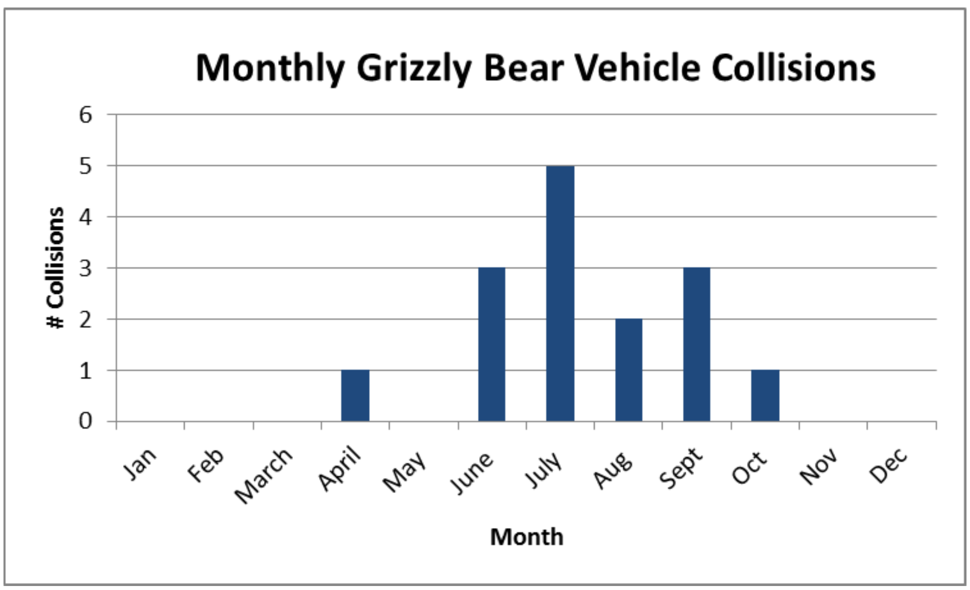

Figure B10. **Variation by month in grizzly bear-vehicle collisions, 2003 – 2014.**

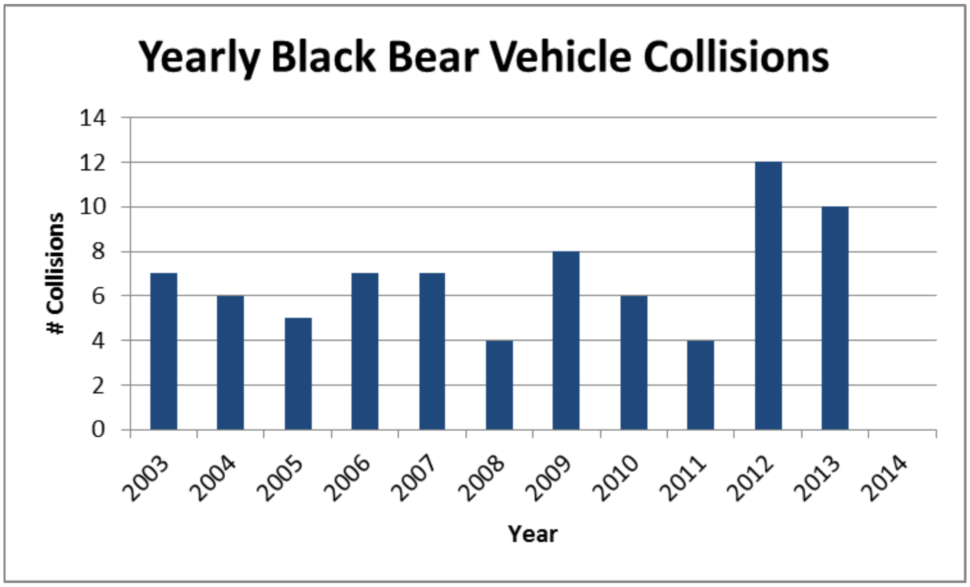

Figure B11. Count of black bear-vehicle collisions by year, 2003 – 2014.

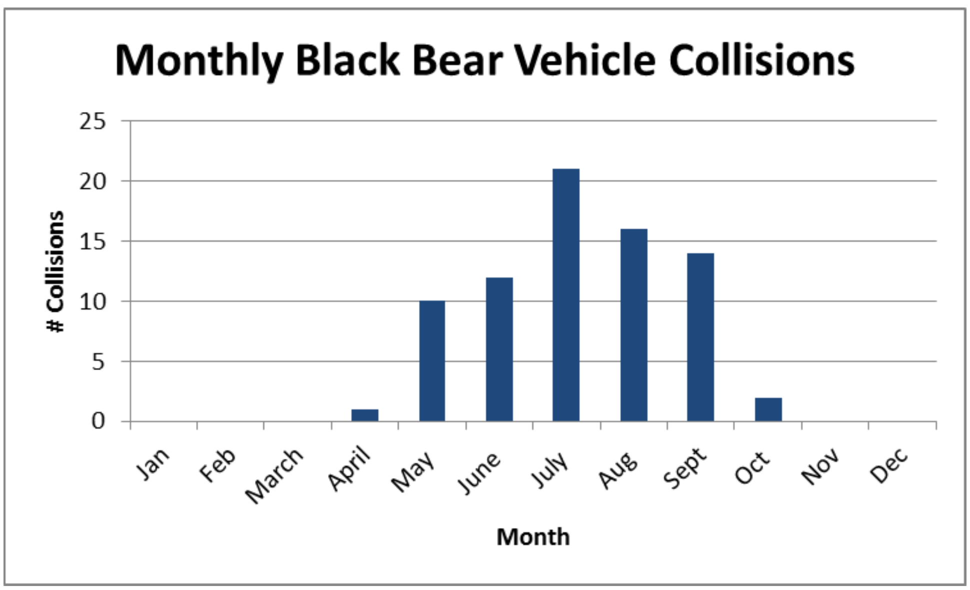

Figure B12. Variation by month in black bear vehicle collisions, 2003 – 2014.

APPENDIX C EXAMPLE OF YBS FORM

ADD YBS Form