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WILDLIFE-VEHICLE COLLISIONS IN CANADA: A REVIEW OF THE LITERATURE AND A COMPENDIUM OF EXISTING DATA SOURCES

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WILDLIFE-VEHICLE COLLISIONS IN CANADA: A REVIEW OF THE LITERATURE AND A COMPENDIUM OF EXISTING DATA SOURCES

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EXECUTIVE SUMMARY

Wildlife-Vehicle Collisions (WVCs) are a serious burden to our society. The consequences are profound and include significant socio-economic, traffic safety and environmental costs. Not only do WVCs in Canada result in death and serious injuries, but certain species become endangered and are at risk of disappearing altogether, which is a threat to biodiversity in our country. From a monetary perspective, costs have been estimated to be as high as $200 million annually, and while currently available data about WVCs certainly have limitations, there is no doubt that WVCs are on the rise making this a serious cause for concern.

An important limitation of data relates to the level of detail with respect to the location of WVCs. Today, it is often not possible to accurately measure where WVCs actually occur. Also, available data sources are scattered, which makes it more challenging to intimately understand how this problem affects our society at a national and regional level. Of greater concern, data about species involved in WVCs are lacking. Such limitations are problematic because they impede the development and efficient implementation of species-specific and effective measures in problem areas. For example, collisions with moose may require different mitigation strategies than collisions with deer, bears or amphibians. Without detailed knowledge of where and when collisions occur and the species affected it becomes difficult, if not impossible, to properly implement targeted mitigation measures.

In sum, there is an urgent need to establish a national centralized clearinghouse that contains current and accurate data on WVCs. Detailed information such as time of day, season, socio-economic costs, type of roadway, accurate location, and animal type provides invaluable information for researchers and practitioners across disciplines to adequately research and apply effective solutions to the problem. In response to this urgent need, State Farm has provided funding to the Traffic Injury Research Foundation (TIRF) and Eco-Kare International to conduct a study to gauge the feasibility of creating such a clearinghouse; this report is the first deliverable of this project.

The objectives of this report are to lay the foundation for the feasibility study to assess whether and how a centralized clearinghouse on WVCs in Canada can be created. More precisely, the goals of this first deliverable are:

- To provide an overview of the magnitude and characteristics of the problem, including limitations of the existing information, i.e., conducting a literature review (see Section 2 of this report);
- To list and describe the available data sources in Canada about WVCs, i.e., developing a compendium of data sources (see Section 3 of this report);
- To formulate pertinent research questions that have to be answered in order to effectively and efficiently address the problem of WVCs in Canada and ascertain which questions can be answered with the available data today and which ones can only be answered through the creation of the clearinghouse (see Section 4 of this report).

In conclusion, this report serves as the basis for the next step in this project, which is to study the feasibility of creating a centralized clearinghouse and to develop an action plan for the creation of this clearinghouse.

The feasibility study will delineate the confines of today's reality in Canada with respect to making available centralized data about such a topic as WVCs. The action plan will provide a strategy and tactics to realize the creation of the clearinghouse within these confines.

1. INTRODUCTION

1.1 Background

In Canada, the issue of wildlife-vehicle collisions (WVCs) has never been more prevalent in the news than it is today. To illustrate, a Google search with the keywords 'wildlife vehicle collisions in Canada' for the past year yields 53,000 hits. This is not surprising considering statistics from Transport Canada have shown that there is an increasing trend in reported collisions with large ungulate species, such as deer, and moose each year from 1999-2003 (L-P Tardif & Associates 2003, 2006).

Despite this increasing trend, data to inform solutions to the problem are limited. At present in Canada, unlike the U.S. there is no centralized data clearinghouse that can increase understanding of this problem of WVCs or ways it can be addressed (see, e.g., www.deercrash.com for a U.S. example). There are various data sets in Canada that contain some information but they are scattered across federal and provincial agencies such as Transport Canada's Traffic Accident Information Database (TRAID) and the Provincial Ministries of Transportation and Highways or their equivalents and the Provincial Ministries of Natural Resources or Environment. For example, the Ministry of Transportation and Infrastructure in British Columbia has been operating and maintaining its Wildlife Accident Reporting System (WARS) since the late 1970s. In provinces with public insurance coverage (Quebec, Saskatchewan, Manitoba and British Columbia) data are also collated from insurance claims. The Insurance Bureau of Canada (IBC) likely includes information on WVCs in their own statistical reports and database. However, there are discrepancies between counts of WVCs between national and provincial data sets, and the type of data collected between specific agencies (L-P Tardif & Associates 2003).

There are some examples of instances where such databases are used to provide regional or local statistics (e.g., www.wildlifeaccidents.ca), but many of these statistics do not provide the level of detail necessary to assess the significance of the problem at a national or provincial level, or on a species by species basis. This is important information because the degree of injury sustained by a motorist or passenger involved in a WVC varies considerably according to the species due to the variation in the animal's stature and weight. To illustrate, in Vermont, traffic statistics from 2002 to 2005 showed that 33% of all moose-vehicle collisions resulted in an injury or fatality as compared to only 7% with deer-vehicle collisions (Vermont Agency of Transportation; unpublished data).

In addition to the loss of human lives and injuries due to WVCs, there is a serious burden on wildlife and some species have become endangered as a result of this. In Canada, today, several species have been labeled at risk of extirpation due in part to WVCs.

Until the actual socio-economic impacts are known on a per species basis it is difficult to accurately estimate the magnitude of the problem and the resulting impacts on humans and wildlife in regions where specific wildlife populations exist. This lack of knowledge is a barrier to the integration of various species-specific mitigation technologies into mainstream road safety and environmental protocols.

In sum, there is an urgent need to establish a national centralized clearinghouse that contains current and accurate data on WVCs. Detailed information such as time of day, season, socio-economic costs, type of roadway, accurate location, and animal type provides invaluable information for researchers and practitioners across disciplines to adequately research and apply effective solutions to the problem. In response to this urgent need, State Farm has provided funding to the Traffic Injury Research Foundation (TIRF) and Eco-Kare International to conduct a study into the feasibility of creating such a clearinghouse; this report is the first deliverable of this project.

1.2 Objectives

The objectives of this report are to lay the foundation for the feasibility study to assess whether and how a centralized clearinghouse on WVCs in Canada can be created. More precisely, the goals of this first deliverable are:

- To provide an overview of the magnitude and characteristics of the problem, including limitations of the existing information, i.e., conducting a literature review. Based on this literature review it will become clear that the problem of WVCs is not an insignificant one and that better data about WVCs are needed to address it. As such, the conclusion of this literature review will provide the rationale to justify conducting a feasibility study regarding the creation of a WVC clearinghouse whose ultimate goal would be to provide better data and resources about WVCs.
- To list and describe the available data sources in Canada about WVCs, i.e., developing a compendium of data sources – After providing a rationale to justify the feasibility study in the literature review, this compendium will help to avoid redundant work downstream. In other words, in order to efficiently conduct the feasibility study to create a WVC clearinghouse, it is necessary to identify any existing data sources that are relevant to the creation of such a centralized clearinghouse; the compendium will provide this overview.
- To formulate pertinent research questions that have to be answered in order to effectively and efficiently address the problem of WVCs in Canada and ascertain which questions can be answered with the available data today and which ones can only be answered through the creation of the clearinghouse – If the main goal of the clearinghouse is to make accessible better data about WVCs to more efficiently and effectively address this issue, then such a list of research questions will be useful to inform the feasibility study.

1.3 Overview

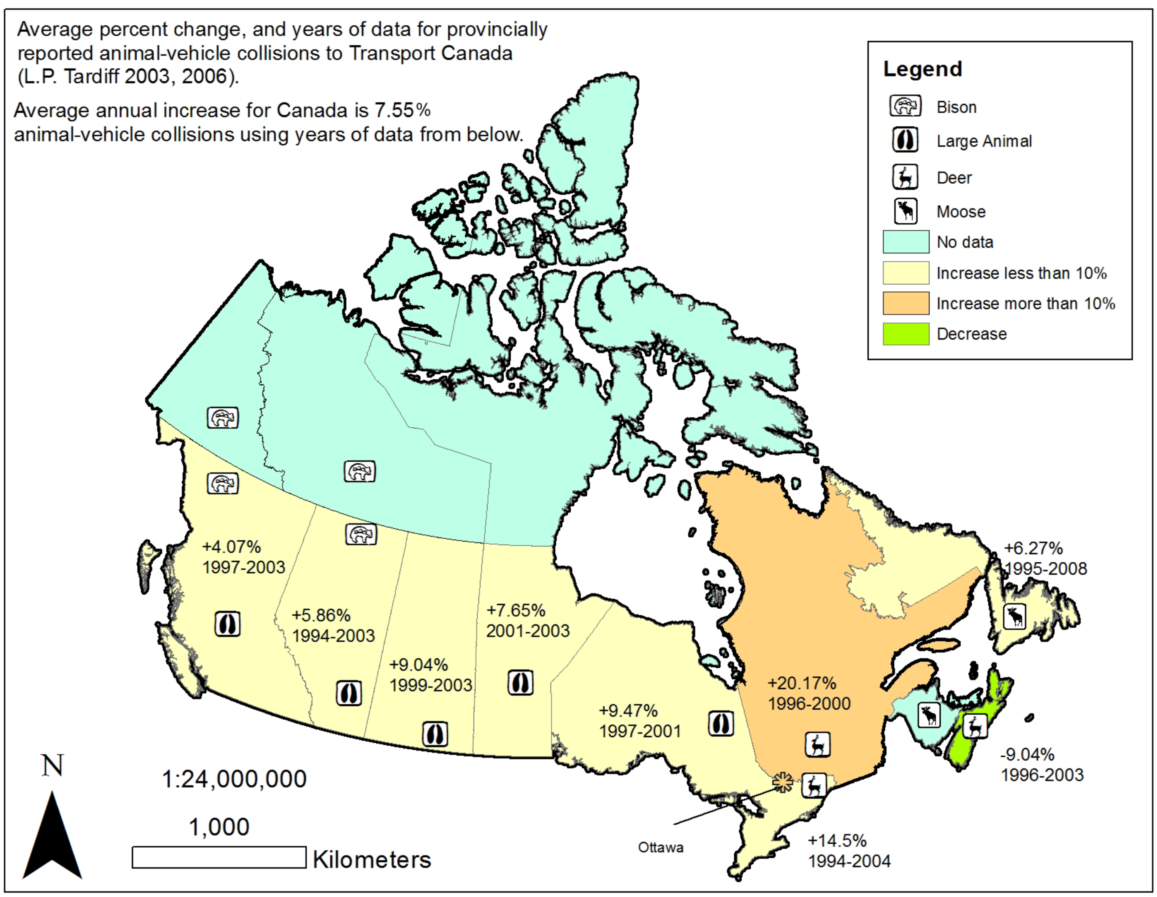
The structure of this report reflects its goals as described in Section 1.2. Following the introduction that describes the background and objectives, the first section is devoted to the literature review and provides an overview of the magnitude and characteristics of the problem (Section 2). The next section (Section 3) contains the compendium of existing data sources. Section 4 addresses the goal regarding research questions, before drawing some conclusions in preparation of the next step of this project, i.e., investigating the feasibility of creating a centralized WVC clearinghouse in Canada.

2. A BRIEF LITERATURE REVIEW OF THE MAGNITUDE AND CHARACTERISTICS OF WILDLIFE-VEHICLE COLLISIONS

2.1 Magnitude and characteristics of the problem

Available Canadian data and research show that there is an increasing trend in collisions with wildlife. To illustrate, in Canada WVCs have increased by approximately 9% from 1996 to 2000 (L-P Tardif & Associates 2003). As can be seen in Figure 1, comparable estimates for the time frame 1994-2004 suggest WVCs have been on the rise at an average of 7.55% per year (Tardif 2003, 2006). Collisions most often reported involve large animals such as deer, moose, elk and bison. With the exception of Nova Scotia, all provinces in Canada have recorded increasing trends in collisions and these can be mainly attributed to both an increase in ungulate abundance, and/or traffic volumes in a region (Gunson et al. 2003; Seiler 2004). Quebec (20%) and the City of Ottawa (14%) have the highest increasing trends of collisions involving deer. To further illustrate this, in the United States (U.S.) collisions with deer resulting in fatalities for motorists have increased by 70% from 131 in 1994 to 223 in 2007 (www.deercrash.com).

Figure 1: Collision rate by Canadian Jurisdictions



The annual road toll from WVCs is substantial in Canada and elsewhere. According to Transport Canada's TRAID database, from 1988 through 2000, there are on average more than 25,000 collisions each year that involve a large animal. More specifically for British Columbia, the Wildlife Collision Prevention Program Website — an initiative administered by the British Columbia Conservation Foundation (see www.wildlifeaccidents.ca) — reports that each year in British Columbia, over 19,500 animals are killed in collisions with vehicles. In addition to the loss of wildlife, every year, four people are killed and 316 people are injured in this type of collision. In Europe (excluding Russia), it is estimated that over 500,000 WVCs occur each year (Groot Bruinderink & Hazebroek 1996). Not surprisingly, the wildlife population also suffers death and serious injuries in these collisions. Romin & Bissonette (1996), for example, estimated that the 1991 national deer road-kill in the U.S. totaled at least 500,000 deer. This figure would be substantially higher today given the increases in WVCs that have been documented and reported here.

Crashes with wildlife are a serious economic burden. For example, the Ontario Ministry of Transportation 2005 statistics state that roughly 6% of all motor vehicle collisions involve wildlife (www.mto.gov.on.ca/english/safety/wildlife.shtml), which corresponds to about 14,000 crashes per year in Ontario alone. With an estimated average vehicle-damage cost of about $2,800 per crash (L-P Tardif & Associates 2003), this equates to a total of $39.2 million just for property damage costs in Ontario. According to Saskatchewan Government Insurance (SGI), WVCs cost $48 million in collision claims in 2010 (CBC News 2011). Manitoba Public Insurance (MPI) has used its claims data as part of a public awareness campaign about the severity of the WVC problem in the province. Not only was a cost estimate provided, but maps of high-risk areas for deer-vehicle collisions were posted on MPI's website (Manitoba Public Insurance 2010). According to the most recent estimates, WVCs cost MPI $31 million in claims annually compared to $33 million for impaired driving, $40 million for speeding and $23 million for non-use of seatbelts (Skerritt 2012). To provide a national perspective, the study by L-P Tardif & Associates estimated the annual minimum direct cost (property damage and loss of wildlife animals) as a result of collisions with wildlife at $200 million in Canada.

Compounding these costs are several indirect costs such as long-term disability, health-care, traffic delays, lost workdays, serious social impacts to road users and communities as well as the loss of a valued natural resource. Often WVCs, especially with large mammals, lead to serious injury or death for the motorist, animal, or both, causing a serious human/wildlife road safety issue and public health concern. In Canada, it was estimated that from a total of 30,000 collisions in the year 2000, approximately 7% involved injury or fatality for the motorist, which translates into 2,100 injury-producing collisions involving wildlife annually (L-P Tardif & Associates 2003).

In conjunction to the socio-economic losses and safety concerns, there is a substantial conservation issue for wildlife populations in Canada associated with WVCs; these impacts are presently not well-understood or documented. All wildlife populations whose seasonal and home range movements overlap with roads are subject to WVCs, and these impacts vary regionally and by species. For the most part, traffic collisions do not significantly impact the population status for deer (Putman 1997) or moose. For example, moose abundance is increasing concurrently with increasing moose-vehicle collisions in Newfoundland and Labrador (Clevenger 2001). However it has been suggested that roads impact the population viability and persistence for other species in North America such as the Florida panther (Foster and Humphrey 1995), grizzly bear (Chruszcz et al. 2003) and freshwater turtle (Gibbs and Shriver 2002).

In Canada, there are several pieces of environmental legislation that are relevant to the documentation and mitigation of WVCs. These include the federal Species at Risk Act (SARA) which was introduced in 2002, and the Provincial Endangered Species Act in Ontario (2007) and Nova Scotia (1999). The Federal Act applies to federal lands (such as Canada's oceans and waterways, national parks, military training areas, and First Nations reserves), all aquatic species and migratory birds listed under SARA that are on federal, provincial, public or private lands. Under these acts, declining wildlife species and their habitat are listed as threatened, endangered or extirpated and have special protection status against harmful development and practices by government agencies, corporations, and individuals. However, better data about WVCs and their impact is useful to guide the application and enforcement of this legislation.

Wildlife road mortality has been listed as a substantial threat for many Species at Risk (SAR), and government agencies are responsible for mitigating the threat for these species. To illustrate, in Ontario, 18 reptile species, three amphibian species, 10 bird species, two small mammal species, and one insect species (monarch butterfly) are all labeled SAR and road mortality has been documented as a threat for these species (Ontario Road Ecology Group 2010).

It is clear from this brief review of the literature that the problem of WVCs is not insignificant with severe socio-economic, safety-related and environmental consequences. Each of these types of consequences needs careful consideration and mitigation solutions. However, the data available today to inform such solutions are limited and this is demonstrated in more detail in the next section. It is explained that to properly address this problem, better data and resources are needed.

2.2 Limitations of the evidence

Gaps in ability to measure

Currently, there are gaps in terms of data collection coverage of WVCs across Canada. Areas where data coverage is lacking include animal-specific data, spatial accuracy, temporal accuracy, and data continuity. Measures of wildlife death tolls by insurance or transportation departments are significantly underestimated for two main reasons. First, not all WVCs are reported. In Canada, WVCs are typically only reported by law enforcement agencies if damages exceed $1,000 or if there is an injury or fatality to a vehicle occupant (L-P Tardif & Associates 2003, 2006). Second, the majority of WVC tallies only include wildlife species that are considered to be a hazard to motorists, e.g., large animals (Hesse 2006), and therefore collisions with other smaller wildlife species are not recorded; while this is not considered problematic from a traffic safety perspective, it obviously is from a conservation perspective.

Fragmentation of available data

Presently in Canada, the only national compilation of data for WVCs is available in two reports commissioned by Transport Canada (L-P Tardif and Associates 2003, 2006) and these reports concentrate primarily on annual tallies of vehicle collisions with animals. In the United States, on the other hand, regional tallies of deer-vehicle collisions for selected states and some national summaries are available at the Deer-Vehicle Crash Information Clearinghouse (DVCIC). This is an internet-based clearinghouse based at the University of Wisconsin (see www.deercrash.org). It hosts research-related projects, data compilation reports, a toolbox of mitigation measures, and annual tallies of deer collisions for 11 states (Knapp 2005a, 2005b; Knapp et al. 2005). A similar clearinghouse exists in British Columbia and is administered by the British Columbia Conservation Foundation (www.wildlifeaccidents.ca). This site has regional summaries for vehicle collisions with deer and moose in Northern British Columbia., resources, and access to research papers.

In the U.S., several peer-reviewed papers are available documenting the deer-collision problem and mitigation solutions (Romin and Bissonette 1996; Bissonette et al. 2008) as well as in Europe (Bruinderink and Hazebroek 1996; Putman 1997). Several regional peer-reviewed studies exist documenting characteristics of collisions with moose in Sweden (Seiler 2005), in Vermont (Mountrakis and Gunson 2009), in Quebec (Dussault et al. 2006), and in Newfoundland and Labrador (Joyce & Mahoney 2001). One study focuses specifically on patterns of collisions with elk and other ungulates (Gunson et al. 2003) in the Central Canadian Rocky Mountains, and one review focuses on WVC data for all wildlife internationally (Gunson et al. 2010).

While there may be many types of WVC summary documents produced in Canada from the 1990s to present, including government annual and special reports, conference proceedings, safety information bulletins and press releases, generally speaking, published and peer-reviewed research studies for WVCs in Canada are not widespread. If available, they are more likely to focus on specific areas such as British Columbia, Alberta, and Quebec. For example, in British Columbia several studies (Rea 2003, 2004, 2006; Hesse et al. 2010) have been completed as a result of funding partnerships between academic institutions and the Insurance Corporation of British Columbia (ICBC). In addition, WVC data are also available from several long-term sources including claims information provided by ICBC, data from WARS, data from the British Columbia Ministry of Environment, and Parks Canada in Mount Revelstoke, Glacier and Kootenay National Parks (Child et al. 2001; Gunson et al. 2003; ICBC 2006; Sielecki 2010; Hesse 2010; Hurley et al. 2007). In Alberta, a long-term WVC and mitigation monitoring study was initiated by Parks Canada in 1997 and is currently funded by a public-private partnership (Ford et al. 2009). In Quebec, a partnership between the Ministry of Transportation and Ministry of Natural Resources has led to several published reports and peer-reviewed documents (e.g., Leblond et al. 2003).

Publications about socio-economic costs are likely to be more readily available for property damage collision insurance claims in British Columbia, Saskatchewan and Manitoba that have provincial insurance carriers than in jurisdictions such as Ontario where data may be collected by 199 insurance agencies (Morrison

Hershfield 2011b). Furthermore, there are no available publications that document or assess the indirect societal costs associated with WVCs in Canada in great detail.

2.3 Why better data are needed

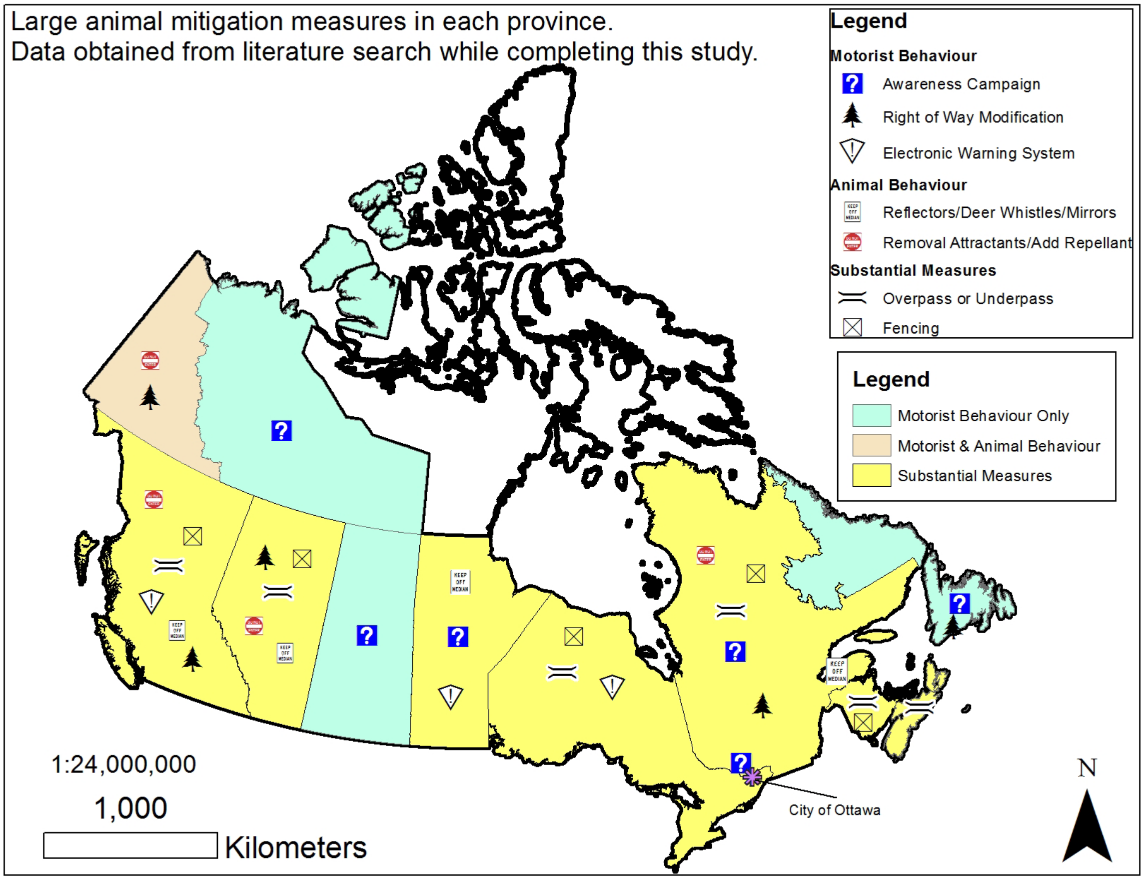
Road-wildlife mitigation solutions aim to reduce negative impacts by changing motorist and/or wildlife behaviour (Huijser et al. 2007a). For example, public awareness campaigns (e.g., Joyce and Mahoney 2011), speed reduction (e.g., Jones 2000), wildlife detection systems (e.g., Huijser et al. 2007a), and wildlife warning signage (e.g., Found and Boyce 2011) are widely used to inform motorists when and where to slow down and be aware of wildlife. These measures are relatively less permanent and less costly than other mitigation measures but there is little conclusive evidence regarding their effectiveness (Huijser et al. 2007a). Strategies that involve changing wildlife behaviour with respect to roads include right-of-way modifications, habitat composition (Rea 2003) and removal of attractants such as salt pools (Grosman et al. 2011). More substantial measures include the use of wildlife fencing with crossing structures such as underpasses or overpasses. The fencing separates wildlife from the road and adjacent roadside habitat and funnels wildlife to safe crossing opportunities over or under the road. Examples in Canada include the Trans-Canada Highway in Banff National Park (Clevenger et al. 2001; Clevenger et al. 2002; Clevenger et al. 2009) and Highway 69 in Ontario (Eco-Kare International 2012).

In Canada, some regions have identified target species for mitigation solutions based on socio-economic, safety or conservation-related considerations. For example, in regions where moose-vehicle collisions are common such as Newfoundland and Labrador, Northern Ontario and Northern British Columbia, mitigation solutions are usually targeted for this species because of the increased risk in injury or fatality for motorists. However, in Southern Ontario, mitigation is often targeted toward amphibians and reptiles because road traffic has been identified as a threat for these species under the 2007 Endangered Species Act (e.g. turtles; Seburn 2007).

Taking all this into account, it is absolutely imperative to have species-specific WVC data to inform where and what type of mitigation is required to solve the problem.

Figure 2 shows where mitigation measures have been used in Canada. Eleven jurisdictions have invested in some type of mitigation measure, and seven jurisdictions have invested in substantial mitigation measures such as overpasses, underpasses, and associated fencing. With the exception of Nova Scotia, all the jurisdictions that use mitigation measures combine substantial measures with other strategies designed to change animal or motorist behaviour.

Figure 2: Overview of Wildlife-Vehicle Collision Mitigation Measures in Canada



In sum, the need for a clearinghouse of data and resources in Canada has never been greater, as road mitigation solutions are more commonly integrated into road upgrades and extensions (Clevenger et al. 2002; Eco-Kare International 2012). Complete, consistent, species-specific, and spatially and temporally accurate WVC data are required to conduct rigorous monitoring programs for wildlife-road mitigation measures (Huijser et al. 2007b). Both British Columbia and Newfoundland and Labrador have stressed the importance for a centralized, standardized, and accessible repository for data to inform mitigation needs (Department of Inland Fish & Wildlife 2005; Hesse et al. 2006; Rea et al. 2006). A survey completed by experts identified the need to standardize WVC data collection as the second highest research priority and fourth highest practice priority for implementing and measuring the success of mitigation solutions in Canada (Cramer & Bissonette 2007). Such a clearinghouse will supply resources to a broad audience, encourage multi-disciplinary (engineering, environmental, and road-safety) and agency (government, non-government, and academic) partnerships and collaborations and provide sound data for complete and rigorous research and monitoring studies.

2.4 Conclusion

It has been demonstrated that WVCs are a serious burden to our society. The consequences are profound and include significant socio-economic, traffic safety and environmental costs. Not only do WVCs in

Canada result in death and serious injuries, but certain species become endangered and are at risk of disappearing altogether, which is a threat to biodiversity in our country. From a monetary perspective, costs have been estimated to be as high as $200 million annually, and while currently available data about WVCs certainly have limitations, there is no doubt that WVCs are on the rise making this a serious cause for concern.

This literature review has demonstrated that the available data about WVCs are indeed limited. For example, the level of detail with respect to the location of WVCs is insufficient to accurately measure where collisions actually occur. Also, available data sources are scattered, which makes it more challenging to intimately understand how this problem affects our society at a national and regional level. Perhaps most importantly, data about species involved in WVCs are lacking. Such limitations are problematic because they impede the development and efficient implementation of species-specific and effective measures in problem areas. For example, collisions with moose may require different mitigation strategies than collisions with deer, bears or amphibians. Without detailed knowledge of where and when collisions occur and species involved it becomes difficult, if not impossible, to properly implement targeted mitigation measures.

In conclusion, there is an urgent need to make available data of better quality about WVCs in Canada. While this becomes abundantly clear when reviewing the literature, it is also one of the main conclusions from a recent expert opinion survey. As such, it is timely to conduct a feasibility study on the development of a centralized clearinghouse of WVCs in Canada. In order to efficiently conduct such a study, knowledge of existing data sources that are relevant to this issue is needed. The next section contains a compendium of such sources; this compendium will serve to inform further steps for the creation of the clearinghouse.

3. COMPENDIUM OF EXISTING DATA SOURCES OF WILDLIFE-VEHICLE COLLISIONS IN CANADA

3.1 Introduction

In order to determine the feasibility of creating and maintaining a centralized WVC clearinghouse in Canada, it is important to determine how data are collected and which data sources already exist and can be used to facilitate this exercise. For this reason, this compendium reviews the current state of WVC data sources and their respective data collection protocols in Canada. Various characteristics that should be included in a comprehensive WVC clearinghouse are also described.

3.2 Method

A literature search was conducted within the TIRF library to locate any reports, articles, or conference papers dealing with WVCs in Canada. More specifically, these sources were reviewed to determine whether there was any reference to data that were used or created. Although the current feasibility study is intended for a Canadian database, the literature search was expanded to include the U.S.A., Sweden, Finland, and Germany. Many regions in these other countries have terrain, wildlife, vegetation, weather and hours of daylight that are similar to Canada.

The literature search dealt with WVCs involving all animal species. Since most of the literature focuses on WVCs with large animals, there is an obvious bias towards this group of animals. In traffic safety literature this bias is due to the greater likelihood that a collision between a larger animal and a motor vehicle will cause death or injury to vehicle occupants, or at least cause substantial damage to the vehicle, compared to collisions with smaller animals. From a road ecology perspective, WVCs with smaller animals often go unnoticed and carcasses quickly disappear from the roadside, therefore WVCs data sets and subsequent summaries are lacking. Nevertheless, an effort was made to identify sources that focus on smaller animals also as it is recognized that WVCs not only affect traffic safety but they have important consequences for all wildlife, notably SAR.

A scan of motor vehicle collision report forms was conducted to determine how animal-vehicle collisions are recorded in each jurisdiction in Canada. Data dictionaries from coroner/medical examiner offices were scrutinized to see if animal involvement in a motor vehicle collision is provided in any of their data sets. Data instruments were also reviewed to determine whether they included any variables that could enable the linking of associated data sets with collision-reported data.

3.3 An ideal wildlife-vehicle collision database

Ideally, a WVC database will have to incorporate many descriptive variables with key characteristics. These include:

- Circumstances of collision (date, time, location, road conditions, lighting, weather);
- Vehicle characteristics (vehicle type, vehicle manoeuvre, damage to vehicle);
- Vehicle occupant characteristics (position, age, gender, safety equipment used, injury severity); and,
- Characteristics of animal struck by vehicle (species, gender, injury severity).

At this stage, there does not appear to be a comprehensive source of data in Canada that includes information on all of the preceding characteristics.

Circumstances of collision

The circumstances of a collision are significant since it is expected that more WVCs will occur in darkness or dusk/dawn than would occur during daylight hours. Inclement weather and reduced visibility are other possible factors leading to a greater frequency of WVCs. Also, it is expected that more WVCs would occur during certain times of the year, particularly in the fall when mammals migrate for the following reasons:

- evasive action during hunting season;
- males travel great distances in search of females during mating season; and,
- crop harvests in farming regions mean more heavy machinery in the fields and less cover for wildlife (Grovenburg et al. 2008).

Another time of year that may see more WVCs than average would be in the spring since among deer, fawns start to move with their mothers (Ng et al. 2008). To illustrate, on Cape Breton Island's Cabot Trail, more cow moose are killed in the summer months (Fudge et al. 2008). Large ungulates may also leave heavily wooded areas in favour of roadways to escape biting insects in the late spring and early summer (Dussault et al. 2006).

The posted speed limit and number of lanes of a roadway are other possible contributing factors. It can be assumed that roads with higher posted speed limits may have more WVCs since drivers have less time to react to animals on the roadway and the animals have less time to avoid an oncoming vehicle. Roads with more lanes would take the animal longer to cross and can also contribute to the likelihood of a crash happening.

A precise collision location is crucial in order to merge these data with other data sets. If an accurate location for a collision is provided in the data, wildlife biologists or traffic engineers could study the relationship between WVCs and physical characteristics of the crash location such as amount of tree cover, prevalent types of vegetation, and predominant human activity (agriculture, forestry, parkland). It is possible that in spite of the best efforts to make drivers aware of animals on roadways, and reduced speed limits to make roads safer, that animals will still congregate in a given location and make WVCs a real danger.

On the one hand, cutting down trees within a road allowance may enable drivers to see animals sooner and be granted more reaction time. On the other hand, new vegetation can grow in its place and provide greater browsing potential for large mammals (SOPAC 2011). As mentioned earlier, increased agricultural activity can cause animals to move out of fields and possibly onto roadways (Grovenburg et al. 2008). Other human activity may play a contributing factor in the likelihood of WVCs occurring in a specific location.

Another important reason to include a precise location in the data is that it could enable researchers to accurately measure the effectiveness of mitigation measures (see also section 2.3). Several potential mitigating measures have been introduced in an effort to reduce the possibility of WVCs. There are means of warning motorists such as installing warning signs or reflectors at 'hotspots' where WVCs are more likely to occur. There are also measures to change animal behaviour such as installing wildlife fencing along roadways, constructing wildlife overpasses or underpasses to keep animals off the road, the removal of salt pools near roadways to reduce animals coming to drink, and the placement of feeding stations away from roadways to keep animals out of the way.

Vehicle characteristics

Ideally, characteristics of the vehicle involved in a WVC should be included in a database. Vehicle type may be a contributing factor in the severity of the collision for the vehicle occupants. It would be expected that occupants of heavy trucks would be less likely to be injured than occupants of an automobile or a motorcycle. More specifically, a certain make of vehicle with superior roof reinforcement may be more capable of withstanding contact from a collision with a moose. This species has a relatively high centre of gravity and as it falls into the vehicle that strikes it, significant roof intrusion can result. It would also be beneficial to have information on the degree of the damage severity of the vehicle involved in the collision. Another consideration is that larger vehicles may have their headlights mounted higher which could enable the driver to recognize a large animal in the middle of the road at night.

Vehicle occupant characteristics

Information on vehicle occupant characteristics would be useful to include in a WVC database, especially for the purpose of devising motorist-behaviour based mitigation solutions. For example, the degree of vehicle occupant injury severity could be dependent upon one's seating position (e.g., driver versus passenger, front row versus back row). A Swedish study of moose-vehicle collisions (Björnstig et al. 1984) found that in casualty crashes, the mortality rate was higher for drivers (72%) than front seat passengers (57%) and rear seat passengers (29%). The age of a driver may be a contributing factor in a WVC. It is possible that younger drivers have greater exposure to this type of mishap since they may be more inclined to drive after dark than older drivers. Also, younger drivers may have less practical experience avoiding WVCs. It is also possible that male drivers may be more inclined to be involved in WVCs than female drivers since they may drive more at night (Khattak 2003).

Other meaningful contributing factors include alcohol/drug use, fatigue, distraction, or excessive speed that would make it more difficult for the driver to avoid colliding with an animal on the roadway. In addition, the use or non-use of safety equipment would be worth including in a WVC database as a means of examining to what extent seatbelts and helmets mitigate deaths and injuries.

Lastly, the degree of injury severity would be an important variable to determine how serious WVCs are to vehicle occupants. And the type of injury would be useful to include, given that it is believed that moose-vehicle collisions result in a disproportionately high number of head and neck injuries to vehicle occupants (Garrett and Conway 1999).

Characteristics of animal struck by vehicle

A WVC data set should identify the species of animal that was involved in a WVC. Since moose are heavier than deer, it should be expected that moose-vehicle collisions will result in greater vehicle damage and a greater likelihood of injury or death to vehicle occupants than deer-vehicle collisions. Cost comparisons have shown the average cost of moose-vehicle collisions to be $30,760 (US) compared to $17,483 for elk-vehicle collisions and $6,617 for deer-vehicle collisions (Huijser et al. 2009). It has been reported that in casualty WVCs, 33% of moose-vehicle collisions resulted in a fatality compared to 7% of deer-vehicle collisions (Gunson and Mountrakis 2009). Moose are more difficult to see at night since their coats are dark in colour and their eyes are higher than most headlight beams so there is no reflected eye shine to alert drivers of their presence (British Columbia Conservation Foundation 2010).

The animal's gender and age may be a contributing factor in the potential for WVCs. Although there are limitations to data on the exact age of animals involved in WVCs, this could be measured from an animal's size and/or dental records. Large male mammals in search of mates in the fall may be more likely to be struck by vehicles than their female counterparts. Some studies, including one conducted among the elk population in the Canadian Rockies, suggests that younger animals have a higher mortality rate in WVCs (Gunson et al. 2003).

Animals that have been introduced to a new environment may also be more vulnerable to being struck by motor vehicles. For example, less than one year after being introduced to northeastern British Columbia, three out of 15 bison in the Etthithun Lake herd were killed in vehicle collisions (British Columbia Conservation Foundation 2011). Likewise, animal populations at risk can be jeopardized by a high incidence of WVCs. The A La Peche woodland caribou herd in Alberta lost 10% of their herd numbers (estimated 150-200) in 1991 and 1992 (Alberta Woodland Caribou Recovery Team 2005).

3.4 Types of existing sources of data

Six principal sources of WVC data are included in the compendium. These data originate from the following sources:

- Police-reported motor vehicle collisions;
- Coroner/medical examiner records;
- Insurance claims;
- Records compiled by maintenance contractors, conservation officers, and park wardens;
- Observations by citizen scientists; and,

- Projects conducted by research biologists.

Data derived from police-reported motor vehicle collisions, coroner/medical examiner records, and insurance claims have a greater emphasis on characteristics of vehicles and their occupants. On the other hand, the latter three data sources deal more specifically with WVCs and are often based on records of animals killed in motor vehicle collisions or observations of animals (dead or alive) on or near roadways.

Police-reported motor vehicle collision data

The most universally available and comprehensive source of data are based on police-reported motor vehicle collisions. These data are then entered into a jurisdiction's collision database. Each Canadian jurisdiction collects these collision data. Details of animal involvement, collision location, other collision information, vehicle information and driver/person information are included in Table 3-1. Twelve of 13 jurisdictions in Canada report animal involvement on their collision report forms. A collision-related variable such as 'sequence of events' often includes a value that allows the investigating officer to indicate whether an animal was involved in the collision. Also, most jurisdictions have an animal involvement category in the variable dealing with contributing factors, which is a driver/vehicle-based variable. Some jurisdictions list 'animal involvement' as a contributing factor, others differentiate between domestic and wild animals, and New Brunswick has categories for deer, moose, and other animals.

Provincial data may yield more precise information since data recoded by Transport Canada into either the TRAID database or the National Collision Database (NCDB) will be generalized. No distinction is made between domestic and wild animals in either of the Transport Canada data sets.

Table 3-1 Data Derived from Police-Reported Collision Report Forms (Canada)

Jurisdiction	Animal Involvement on Collision Form	Collision Location	Other Collision Info	Vehicle Info	Driver/Person Info
BC	Type of Incident Collision (Animal)	municipality, hwy number, hwy control section	date, time, police file number, police dept, land use	vehicle type, make, year, style	contributing factors, age, gender, injury, injury type
	Apparent Contributing Factors (70- Domestic Animal; 71- Wild Animal)				
AB	Object (Animal)	municipality, hwy number	date, time, police service, police file number	vehicle type, year, make, model	contributing factors, age, gender, injury
	Object Identification (Animal)				
SK	Major Contributing Factors (60- Animal Action (Wild); 61- Animal Action (Domestic))	municipality, hwy control section, km marker	date, time, police file number	vehicle icle type, year	contributing factors, age, gender, injury
MB	Sequence of Events (44- Animal)	municipality	date, time, police force	vehicle type, year	contributing factors, age, gender, injury
	Major Contributing Factors (401- Animal Action (Wild); 402- Animal Action (Domestic))				

Jurisdiction	Animal Involvement on Collision Form	Collision Location	Other Collision Info	Vehicle Info	Driver/Person Info
ON	Sequence of Events (08- Animal(Domestic); 09- Animal (Wild))	municipality, hwy number, km marker	date, time, police force, severity	vehicle type, make, year, style	contributing factors, age, gender, injury
QC	Facteurs contributifs à l'accident (73- Animaux sur la route)	municipality, hwy number	date, time	vehicle type, make, year	contributing factors, age, gender, injury
NB	Sequence of Events (02- Animal)	municipality, hwy number, km marker	date, time, police dept, police file number	vehicle type, year, make, model	contributing factors, age, gender, injury
	Major Contributing Factors (60- Animal Action (Deer); 61- Animal Action (Moose); 62- Animal Action (Other))				
NS	Sequence of Events (02- Animal)	GPS coordinates, municipality, hwy number	date, time, police file number	vehicle type, year, make, model	contributing factors, age, gender, injury
	Major Contributing Factors (60- Animal Action (Deer); 61- Animal Action (Other Wild); 62- Animal Action (Domestic))				
PE	Sequence of Events (02- Animal)	municipality, hwy number, km marker	date, time, police dept, police file number	vehicle icle icle type, year, make, model	contributing factors, age, gender, injury
	Major Contributing Factors (60- Animal Action (Deer); 61- Animal Action (Other Wild); 62- Animal Action (Domestic))				
NL	Sequence of Events (02- Animal)	municipality, hwy number	date, time, police dept, police file number	vehicle icle type, year, make, model	contributing factors, age, gender, injury
	Major Contributing Factors (43- Avoiding Animals)				
YK	Sequence of Events (11- Animal)	municipality, location code	date, time, police dept, police file number	vehicle type, year, make, style	contributing factors, age, gender, injury
	Major Contributing Factors (D1- Animal Action (Wild); D2- Animal Action (Domestic))				
NT	Moveable Objects (07- Animal-domestic; 08- Animal-wild)	municipality, km marker	date, time, police file number	vehicle type, year, make, model	contributing factors, age, gender, injury
	Environmental (72- Animal action)				
NU	unknown				
Transport Canada	Sequence of Events (14- Animal)		date, time	vehicle type, year	contributing factors, age, gender, injury
	Major Contributing Factors (51- Animal in Roadway)				

Although not included in Table 3-1, another potential source of police-reported motor vehicle collision data may be available from municipalities. For example, in the City of Ottawa, data on deer-vehicle collisions from 1995 to 2003 were made available to researchers studying the relationship between deer population and wildlife collisions (Widenmaier and Fahrig 2006). Collision data from Hamilton were used from 1988 to 2006 to review trends in deer-vehicle collisions (Timmerman 2010).

Coroner/medical examiner records

Among coroner/medical examiner offices across Canada, only British Columbia, Alberta, Saskatchewan and Manitoba include a specific variable in their data sets that identifies WVCs as a contributing factor in a person's death. The mention of a WVC as a value in a data set, collision location, other collision information, vehicle information, and driver/person information is provided in Table 3-2.

Table 3-2 Wildlife-Vehicle Collision Information in Coroner/Medical Examiner Data

Jurisdiction	Variable and Value in Data Set	Collision Location	Other Collision Info	Vehicle Info	Driver/Person Info
BC	Environmental Factors (animal in roadway)	GPS coordinates	weather conditions, lighting, road type	vehicle type, make, model, year	file number, position, safety equipment, driver condition
AB	Circumstance Description (MV Animal)	address of incident	incident date, date found dead		file number, age, gender, position, type of injury
SK	Vehicle Impacted with Moveable Objects (Animal) Environment Conditions (Animal Action (Wild); Animal Action (Domestic))	hwy number	collision date, time, weather conditions, lighting	vehicle type, make, model, year	file number, age, gender, position, safety equipment, human condition, human action
MB	Accident Type (98-Animal/ Vehicle)	place of collision	date of death, police file number		file number, age, gender, position, type of injury

Since 2010, the British Columbia Coroner's Service has provided GPS coordinates for collision location. The only possible instance where data on a WVC-related fatality will show up in a coroner/medical examiner data set and not be reported in the TIRF Fatality Database would occur when the victim died more than 365 days after the collision.

Another possible source of data for WVCs with an emphasis on human victims would be hospital data. In Sweden, for example, data on victims in moose-vehicle collisions were used in an ongoing evaluation of vehicle windshields, A-pillars (i.e., support that frames and surrounds windshield) and roofs in protecting vehicle occupants (Löfling et al. 1988). Data provided from the National Electronic Injury Surveillance System - All Injury Program (NEISS-AIP) were used in an analysis of the number and percentage of persons treated in emergency departments for non-fatal WVCs in the United States during 2001-2002 (Conn et al. 2004).

Insurance claims

Some insurance companies collect data based on claims made for WVCs. They may have dedicated data sets for these incidents or at least they may be able to select data for the presence of wildlife involvement in motor vehicle collisions. These data will be claims-based with each record representing either an injury claim or a vehicle damage claim. Details on contact information, availability of the data to the public, funding agency, temporal span, structure and collection methods, characteristics (strengths/limitations), collision location, other collision information, vehicle information, driver/person info, and animal information are provided in Table 3-3.

One important aspect to keep in mind when using insurance data to study WVCs is that a single incident may result in several claims depending upon the number of vehicles involved and the number of persons killed and injured in a collision. Furthermore, the Insurance Corporation of British Columbia (ICBC) estimates that its collision claims account for only 75% of wildlife-vehicle collisions in British Columbia (Hesse 2006), attributing unclaimed WVCs to those involving out of province vehicles (10%), vehicles with less than $100 damage (10%), and vehicles insured with other carriers (5%).

Since provincial insurance companies in British Columbia, Saskatchewan, Manitoba, and Quebec handle police-reported fatality and injury data on an annual basis, it could be assumed that it is possible to link collision data with claims data for those jurisdictions. However, the variables included in the claims data sets do not appear to be readily available in the public domain and this is a barrier to linking these data.

In the literature dealing with WVCs, several general references are made to dollar amounts to illustrate the severity of the problem (see literature review in Section 2 of the report). However, there does not appear to be any detailed reporting of what variables are included in an insurance company's data set. In an Ontario study that monitored mitigation measures for large mammal collisions on Highway 69, researchers requested WVC data from 199 major automobile insurance companies and at the time of publication of the report they had not received any response (Morrison Hershfield Ltd. 2011). The need for insurance companies to protect client confidentiality may be a factor.

Insurance claim data may contain some information on long-term aftercare issues that are not present in motor vehicle collision data but that are relevant to the issue of WVCs (Bissonette et al. 2008).

Table 3-3 Wildlife-Vehicle Collision Insurance Claims Data

Data Source and Contact Information	Available to Public	Funding Agency	Temporal Span	Structure & Collection Methods	Characteristics (Strengths & Limitations)	Collision Location	Other Collision Info	Vehicle Info	Driver/ Person Info	Animal Info
Insurance Corporation of British Columbia (ICBC)	Unkown	ICBC	2001-2005?	records of vehicle insurance, human injury claims	swerve to miss claims included as well as direct collision claims; claims data exclude 25% of WVCs; animal species info less accurate; one WVC could result in several claims		date, time	amount of damage		
Saskatchewan Government Insurance (SGI)	Unkown	SGI		collision claims data			date	amount of damage		species
Manitoba Public Insurance (MPI)	Unkown	MPI	2006-2009	deer-vehicle collision data	claims data for deer-vehicle collisions; potential for under-reporting as only WVCs resulting in collision claims are reported	town	date	amount of damage	injury severity	
Société de l'assurance automobile du Québec (SAAQ)	Unkown	SAAQ								

Data provided by maintenance contractors, conservation officers, and park wardens

Some data sets exist that deal exclusively with WVCs. They not only provide information relevant to the collision but also information on the animal that was struck by the vehicle. Table 3-4 provides the following information on data sets that deal specifically with WVCs in Canada: data source and contact information, availability of the data to the to the public, funding agency, temporal span, structure and collection methods, characteristics of the data (strengths/limitations), collision location, other collision information, vehicle information, driver/person information, and animal information.

Among Canadian jurisdictions, there are four known ongoing data sets that deal specifically with WVCs in British Columbia, Ontario, New Brunswick and the Northwest Territories.

Table 3-4 Data Provided by Maintenance Contractors, Conservation Officers, and Park Wardens

Access to Public	Funding Agency	Temporal Span	Structure & Collection Methods	Characteristics (Strengths & Limitations)	Collision Location	Other Collision Info	Vehicle Info	Driver/ Person Info	Animal Info
Wildlife Accident Reporting System (WARS) **BC Ministry of Transportation, Victoria, BC** http://www.th.gov.bc.ca/publications/eng_publications/environment/WARS_reports.htm									
Unkown	BC Min. of Trans..	1978 -	incident-based; recorded by contractors, compiled by district hwy offices, sent monthly to WARS	over 109,000 records include numbered hwys; exclude Alaska Hwy, municipal, secondary & forestry roads, Nat Parks; includes 25-35% of animals killed in WVCs	highway, town, landmark kilometre index	date, signage			species, gender, age
Road Animal Fatality Information Application (RAFIA) **AB Transportation, Hwy Operations** http://www.transportation.alberta.ca/Content/docType256/Production/Marchfin2010TSBNewsletter.pdf									
Unkown	Alberta Trans.	2008 -2009	data collected by hwy maintenance contractors; pilot project in Lamont & Vermilion	GPS technology used for location; data collection may have to be included in future contracts	town	date, time			species, gender, age
AB Sustainable Resource Development Enforcement Database (ENFOR)									
Unkown			tracks responses of AB Fish & Wildlife officers to WVCs	includes injured wildlife	location	date, time			species
NE Division Wildlife Collision data **Ontario Ministry of Transportation (MTO)**									
Unkown	MTO	2006-2010	collected by hwy maint. contractors, entered onto Wildlife Collision Datasheet for AMC Contractors, data sent to MTO every 2 wks	data mapped, combined with data obtained from OPP collision reports; include data not available from police reports but helpful in selecting mitigation techniques	highway, town, GPS	date, time			species, gender, age

Access to Public	Funding Agency	Temporal Span	Structure & Collection Methods	Characteristics (Strengths & Limitations)	Collision Location	Other Collision Info	Vehicle Info	Driver/ Person Info	Animal Info
Toronto Animal Services Emergency and Mobile Response Unit									
Unkown	City of Toronto		mobile response unit collects dead or injured animals in response to calls from public	data collected for animals killed on city and private property, excluding provincial highways and expressways	municipal ward				species, injury severity
NB Department of Natural Resources Dead Game Reporting System									
Unkown	NB Dept of Natural Resources		data collected on big game (deer, moose, bear) mammals killed		data collected on big game (deer, moose, bear) mammals killed	date			species
NL Wildlife Division									
Unkown	NL Dept of Environment and Lands	1983 - 2001		moose-specific; usually restricted to crashes resulting in $1000+ damage or human injury		date, time	vehicle type, speed	gender, position, injury type, severity	species, gender, age
Northwest Territories Department of Transportation Wildlife-Vehicle Collision Report Form **NT Dept of Transportation** **http://www.wildlifeaccidents.ca/docs/08-09bisonvehiclecollisionprotocolv12oct31-09.pdf**									
Unkown	NT Dept of Transp.		data collected and entered onto NWT Wildlife-Vehicle Collision Report Form		GPS, latitude, longitude, highway, km post	RCMP file number, date, time	vehicle type, damage, licence plate	driver age, sex	species, gender, age, injury severity
Edmonton Bylaw Services									
Unkown	City of Edmonton	2002 - 2004			nearest intersection	date, speed limit			

The British Columbia Ministry of Transportation maintains WARS. WARS is an incident-based data set which primarily contains data on the animal involved. There are some collision-based variables dealing with crash date, highway, and town of crash. Among the strengths of WARS are that it is the most extensive source of WVC data in Canada (109,000 records). It includes information on the animals involved (species, gender, maturity), and the data set provides information on mitigation measures in place at the collision site (warning signs, fencing). The British Columbia Ministry of Transportation also produces a "road kill identification" guide. This reference tool is for ministry staff and private maintenance contractors charged with wildlife carcass removal. The guide is intended to assist these persons in their identification of animal characteristics so that data integrity can be improved (Sielecki 2008b).

From an ecological point of view, one could argue that one of the limitations of WARS is that it only includes data on animals considered to be a hazard to motorists, i.e., larger mammals. Also, data collection is limited to numbered highways in British Columbia and excludes collisions occurring on municipal roads, secondary roads, forestry roads, the Alaska Highway, and national parks. According to the British Columbia Ministry of Transportation, WARS captures only 25-35% of animals killed in MVCs (Hesse 2006).

Similar to British Columbia, in Northeastern Ontario, wildlife collision data are collected by highway maintenance contractors and sent to the Ontario Ministry of Transportation every two weeks. Information is gathered on approximate and, if possible, accurate GPS location as well as date and time of collection. In addition, species, gender and approximate age of the animal involved in the collision is also collected. Unfortunately, there does not appear to be a guide or protocol for maintenance contractors to use as a reference tool in data collection, which can jeopardize the consistency of data collection.

The New Brunswick Department of Natural Resources has implemented a Dead Game Reporting System that collects data on big game mammals (deer, moose, bears) killed along the province's roadways. Spatial data are provided in terms of GPS coordinates, latitude, longitude, and highway number.

The Northwest Territories Department of Transportation collects data on WVCs and has produced a specific report form. Data collected on this form include information on collision location, vehicle occupant, vehicle/weather information and wildlife information. Since one of the variables is a RCMP file number, this data set could be linked with police-reported collision data collected in the Northwest Territories. The territorial government produced a bison-vehicle collision protocol to assist renewal resource officers dealing with bison-vehicle collisions. Included in the document were directions on how to report such collisions (Government of Northwest Territories 2008).

There are other sources of data that were provided by contractors, conservation officers, and park wardens on a temporary basis. In Newfoundland and Labrador, data on moose-vehicle collisions from 1983-1990 were published by that province's Wildlife Division in a study outlining management considerations of the moose population (Oosenbrug et al. 1991).

In Alberta, a pilot project has been initiated that is relevant to WVCs. Launched in 2008 and maintained by Alberta Transportation, the Road Animal Fatality Information Application (RAFIA) reports on WVC data tabulated by highway maintenance employees in the Lamont and Vermilion areas. Employees used GPS units to identify collision sites and the data were correlated with police-reported WVC data (Imran 2010).

Another initiative based in Alberta is the Alberta Sustainable Resource Development Enforcement Database (ENFOR). This data set tracks responses of Alberta Fish and Wildlife officers to human-animal conflicts. Included among these cases are officer responses to WVCs (Clevenger et al. 2010).

Among municipalities, the City of Edmonton Bylaw Services provided a data set to researchers studying the role of landscape and traffic factors in deer-vehicle collisions from 2002-2004 (Ng et al. 2008). And in Toronto, the Animal Services Emergency and Mobile Response Unit responds to calls from the public as they collect wounded and dead animals from both city and private property (Winsa 2012).

In the U.S., the Wisconsin Department of Transportation founded DVCIC, which has representatives from Wisconsin, Illinois, Iowa, Michigan and Minnesota on its technical advisory committee. One of DVCIC's goals has been to complete regional and statewide trend analyses of deer-vehicle-collision data (Knapp 2005a).

Data provided by citizen scientists

In some jurisdictions, estimates of WVC counts are supplemented with reports of animal carcasses that are seen by motorists at roadsides. These sources of data are animal-based, stand-alone data sets that differ from those mentioned in Table 3-4 since they are based on observations of animals on the road or in the case of carcasses, are the result of unwitnessed WVCs. Data sets based on animals killed in motor vehicle collisions or animals observed along roadsides are highlighted in Table 3-5, which provides contact information, availability of the data sets to the public, funding agency, temporal span, structure and collection methods, characteristics (strengths and limitations), collision location, other collision information, and animal information.

There are two data sets based in British Columbia that are maintained by the Biodiversity Centre for Wildlife Studies. For the first data set, Road Watch, citizens are able to submit their data findings by email or mail. Citizens can provide information on the collision, types of road barriers (e.g., fencing) vehicles involved, location, the number of animals involved, animal species, gender, age, and mortality. The second data set, RoadTrip, enables citizens to provide data based upon their observations when they are driving. The data forms require citizens to provide a description of the road trip they are taking. Information is also provided on animals observed (species, gender, age, total number, mortality) and the odometer reading for the vehicle being driven.

Table 3-5 Data Provided by Citizen Scientists

Access to Public	Funding Agency	Temporal Span	Structure & Collection Methods	Characteristics (Strengths & Limitations)	Collision Location	Other Collision Info	Vehicle Info	Driver/ Person Info	Animal Info
RoadWatch BC **Biodiversity Centre for Wildlife Studies Wildlife Data Centre, Victoria, BC** www.wildlifebc.org									
Upon request	Biodiversity Centre for Wildlife Studies	2004-	citizens provide data via mail or email to RoadWatch	data can be sent directly to centre; some fields provided; location subject to accuracy of citizen	location based on citizen input	date, time, road barriers	type of vehicle		number, species, gender, age, mortality

Access to Public	Funding Agency	Temporal Span	Structure & Collection Methods	Characteristics (Strengths & Limitations)	Collision Location	Other Collision Info	Vehicle Info	Driver/ Person Info	Animal Info
RoadTrip BC **Biodiversity Centre for Wildlife Studies Wildlife Data Centre, Victoria, BC** www.wildlifebc.org									
Upon request	Biodiversity Centre for Wildlife Studies	2004-	citizens provide observational data via mail or email to RoadTrip based on their driving	data can be sent directly to centre; some fields provided; location subject to accuracy of citizen	citizen notes start, finish pts of trip, odometer reading at sighting of animal	date, time			number of animals, species, gender, age, mortality
University of Northern British Columbia data on animal roadside occurrences									
Unkown	ICBC; RoadHealth Task Force	2006	truckers depress button on road safety device when they observe deer/ moose	GPS gives exact location, can be uploaded for peer to peer real-time usage	GPS coordinates	date, time			species, mortality
Miistakis Institute Road Watch observation and mortality data www.rockies.ca/roadwatch									
Upon request	University of Calgary	2004-	citizens report wildlife observations on Hwy 3 in SW Alberta (over 4,000 observations) via web, phone, or wildlife surveys	citizens can access tutorials, maps; cross-referenced with mortality data collected by hwy contractors; sightings may be limited to 'opportunistic' events	open-end variable entered by observer	date, time			species, age
Ontario Road Ecology Group http://www.torontozoo.com/conservation/RoadEcologyGroup.asp									
Unkown	Toronto Zoo		citizens monitor and report wildlife-road interactions	citizens submit findings via email	latitude, longitude, road name	date, time			species

A 2006 project introduced by the University of Northern British Columbia utilized professional truckers and a road safety device to indicate when they spotted moose or deer. GPS technology provided date, time and location. Drivers were also able to indicate whether the observed animal was dead or alive. Twice per month dispatchers from participating companies emailed data to the university's research team (Rea et al. 2006).

A 44-kilometre stretch of Highway 3, which passes through the Crowsnest Pass in southwestern Alberta, is the study area for Road Watch, founded by the Miistakis Institute (see Table 3-5). In this particular project, citizens recruited from the public provide data on live or dead animals that they have observed along the highway. These citizens use an interactive web-based mapping tool. The Road Watch website enables participants to enter observations, access tutorials that assist in interactive mapping and species identification, and view cumulative results. In order to review data quality, comparisons are made between participants' entries and data collected by highway maintenance contractors (Lee et al. 2006). It should be noted that Road Watch participants are not required to drive the full length of Highway 3 that is under study. Thus, data observations can be considered 'opportunistic wildlife observations' (Paul 2007).

The Ontario Road Ecology Group (OREG), which is affiliated with the Toronto Zoo, requests citizen input on wild animals (dead or alive) that are sighted along roads. Data collection is used to monitor species at risk and to augment research being conducted in Ontario to deal with the interaction of roads and biodiversity. Citizens provide location, time and species information and send it by email to OREG (Table 3-5; Ontario Road Ecology Group 2010).

Although not shown in Table 3-5, a study of WVCs in Washington State concluded that fewer collisions occurred in mountainous areas. One possible explanation was that reduced cell phone coverage in such surroundings may have compromised the ability of observers to report an animal carcass on the roadway (Lao et al. 2011).

An additional source of information is autopsy data collected from veterinarians that assess the condition of large carnivores and ungulates that are involved in WVCs. Banff National Park collected this information (1990-1998) for a sample of large mammals in the park and the percent marrow fat was used to assess whether weaker individuals were involved in WVCs (Gunson et al. 2003).

Data provided by research biologists

Data collection on moose-vehicle collisions has been performed for fixed periods of time in selected regions as part of research studies. For example, in Quebec, Transports Québec and Ministère des Ressources Naturelles et de la Faune du Québec collected data from 1990 to 2002 for a study on moose-vehicle collisions in Laurentides Wildlife Reserve (Dussault et al. 2006). Another study was performed by the same researchers that measured the abundance of moose near roadways in the same region. In an effort to reduce moose-vehicle collisions, the Quebec government removed several roadside salt pools that attract these animals. Using GPS technology, an audit of moose movement and roadside crossing was performed (Grosman et al. 2009).

In Nova Scotia, data collected by the Department of Natural Resources on moose-vehicle collisions along Highways 3 and 103 were analyzed in an effort to determine the frequency of such incidents from 1989 to 2000 (AMEC Earth and Environmental 2004).

Several research projects involving accurate data collection have been conducted by Parks Canada. An ungulate-vehicle collision location study was performed in the Central Canadian Rocky Mountains from 1999 to 2003. All parties responsible for collecting and reporting WVC data in Banff, Kootenay and Yoho National Parks (national park wardens, provincial park rangers, and highway maintenance contractors) were asked to place pin-flags at the location where road-killed wildlife had been collected so that the research team could collect accurate locations using GPS coordinates.

In addition, Parks Canada has a data set of animal carcasses collected from motor vehicle collisions in Banff, Yoho and Kootenay National Parks. For Kootenay National Park, data exist for large mammals killed on Highway 93 in the park (1951-2005) but data collection for all three parks commenced in 1979. Data are also available on the number of bighorn sheep killed on Mile Hill (near the park) from 1997 to 2005

(Preston et al. 2006). And in 2010, a report for Parks Canada provided results of a study conducted to track WVCs in 2008-2009 in the Vermilion and Kootenay valleys (Huijser 2010).

Table 3-6 Data Provided by Research Biologists

Access to Public	Funding Agency	Temporal Span	Structure & Collection Methods	Characteristics (Strengths & Limitations)	Collision Location	Other Collision Info	Vehicle Info	Driver/ Person Info	Animal Info
Transports Québec									
Ministère des Ressources Naturelles et de la Faune du Québec, Quebec, QC									
Unkown	Transports Québec	1990-2002	study of moose-vehicle collisions in Laurentides Wildlife Reserve	Transports Québec used provincial police data as complementary source of information	km marker	date, time, road design, visibility			habitat
Transports Québec									
Unkown	Transports Québec; Min des Ressources naturelles et de la Faune du Québec; UQAR	2 years	observational study of moose movement in Laurentides Wildlife Reserve using GPS telemetry program to determine effectiveness of removing roadside salt pools	proposes efficacy of roadside salt pool removal as highway safety measure vs installation of wildlife fences	km marker	date, time			age, gender, distance travelled from previous location
Nova Scotia Department of Natural Resources									
Unkown	Nova Scotia Dept of Natural Resources	1989-2000	moose-vehicle collision data collected in study of Chebucto Peninsula; pellet group inventory conducted every 3 yrs for moose; aerial surveys conducted of moose	study area restricted to hwy construction corridor (for Highways 3 and 103), limited by visibility, dependent upon weather conditions	km marker	date			species, gender, age
Kootenay, Yoho, Banff National Parks; nearby provincial parks mortality data and observational data									
Unkown	Parks Canada	1979-2009	rangers use pin-flags to mark location of carcass removal	11,000 mortality records (hwys/rail, etc.); collaborators report carcass removal in 48 hrs	GPS	date, land use, terrain, vegetation			species, gender, age

3.5 Findings regarding strengths and limitations of existing databases

This section summarizes and discusses the key findings regarding strengths and limitations of existing databases described in the compendium.

In a report prepared for the Transportation Research Board (TRB), representatives from departments of transportation (DOTs) and departments of natural resources (DNRs) in the U.S.A. and Canada were surveyed on WVC collision data reporting practices (Huijser et al. 2007a). Huijser et al. (2007b) report that among respondents, most agencies record the date of the crash (DOTs 100%; DNRs 91%), the road or route number (DOTs 100%; DNRs 73%), and the species of the animal involved (DOTs 89%; DNRs 100%). However, there are obstacles to implementing or improving data collection of WVCs. These include:

- Lack of demonstrated need;
- Underreporting; and,
- Shortcomings in data quality in terms of consistency, accuracy, completeness, and timeliness (Huijser et al. 2007b).

Lack of demonstrated need

It is possible that the general public perceives other collision factors to be of greater importance. The magnitude, trends and contributing factors of issues such as impaired driving, speeding, fatigue and distracted driving are probably more easily quantified because more data are available about these traffic safety issues. This makes the problem of WVCs more intangible, and may have the undesirable consequence that less emphasis is placed on conducting research on WVCs. This vicious cycle probably perpetuates the notion that the need to collect complete, timely data on WVCs is a low priority.

Under- and over-reporting

Data on WVCs appear to be incomplete as it is believed that reported collisions do not capture all of those which involve an animal being struck. For example, in Kentucky, it was estimated that only 46% of motor vehicle collisions in which a deer was killed was reported (Weir 2002). In a study in and near three Iowa cities (Cedar Rapids, Dubuque and Iowa City), it was concluded that more deer carcasses were being removed from state roadways than there were deer-vehicle collisions being reported (Gkritza et al. 2010).

As mentioned previously, even WARS from British Columbia, acknowledged to be one of most complete WVC data sets in the world, includes data for only 25-35% of wild animals killed in that province. Reasons for under-reporting are numerous and include animal remains being obscured by subsequent vehicles, larger mammal carcasses being removed by passing motorists, animal carcasses being removed or consumed by predators and scavengers, and animals struck by vehicles leaving the roadway to die elsewhere (Hesse 2006).

A case study has been conducted to determine differences in counts of WVC reports (assumed large animal-vehicle collisions) obtained from the Alberta Collision Information System (ACIS), and an estimated 'true count' of WVC collisions along the same road and time period (Trans-Canada Highway (TCH), Banff Park East Gate to Highway 40 intersection, year 2000). The 'true count' was obtained from a WVC database that recorded most if not all large wild animal vehicle collisions that occurred along the road, i.e., systematic surveys were being conducted along the TCH approximately 2-3 times per week (see methods in Clevenger et al. 2003; Gunson et al. 2009) in 2000. The only reports that would be missing from the 'true count' would be if there was no obvious trace that a WVC occurred, i.e., no carcass, animal parts, blood stain, or animal hair. The ACIS received WVC reports for this same road stretch from the RCMP. By law, motorists are required to report a collision to the RCMP if damages exceed $1,000 or there is an injury or fatality.

The 'true count' WVC database had 75 records, 29 white-tailed deer, 26 elk, 10 mule deer, eight deer, one cougar, and one wolf (Clevenger et al. 2003). The ACIS data had a total of 52 reported records, 31% fewer reported records for the same time period on the same section of road. This discrepancy can most likely be attributed to the lack of WVC reports obtained by the RCMP from motorists because the damage to the vehicle was not substantial (i.e. less than $1,000). In addition, the animal may not have been severely injured and may have been able to move off the road after the collision. A previous report (Romin and Bissonette 1996) estimated that approximately 50% of deer collisions are not accounted for because of incomplete reporting.

Another potential problem that could undermine data quality is that of duplication or over-reporting. For example, it has been mentioned previously that in ICBC's collision claims data, one WVC could result in multiple claims on behalf of several vehicle owners or persons injured (Hesse 2006).

In a Michigan study with deer-vehicle collisions, it was suggested that in some instances such events may be overestimated since drivers could tell a police officer they were involved in a deer-related crash to cover their own negligence. The possibility was also discussed that some deer reported as killed by vehicles may have been killed by other means, yet filing a collision report allows motorists to take and use the deer legally (Hansen and Wolfe 1983).

There are other factors that may bias WVC data collection. For example, citizens involved with observational data collection may be more likely to report unique or rare animal species than other animals observed as these animals are easier to remember or can be perceived as more important to report (Paul 2007). Or more than one citizen scientist can report a WVC to the same database, especially if the carcass remains on the road for a long period of time. Another bias is a higher incidence of WVCs on suburban roads than rural roads; this may be due to a higher traffic volume on suburban roads (du Toit 2008). Data quality and data checks are an essential component to the integrity of citizen scientist data.

Lack of temporal and spatial accuracy

The temporal accuracy of WVC data collection is often questioned for many WVC data sets. For example, the date and time of occurrence of a WVC is more often correct for data collected by a law enforcement agency than data collected by maintenance workers. This is because it can be assumed that a law enforcer called to the collision site is often there within a few hours of the collision, whereas a maintenance worker may not arrive until a day or two afterwards (Gunson et al. 2003).

The spatial accuracy of WVC data collection is also heavily scrutinized. To illustrate gaps with respect to spatial accuracy, the literature has reported that with the exception of special research studies, locations where WVCs occur are often not assessed at a sufficiently accurate scale for mitigation planning. There is often a large discrepancy between the 'true WVC location' as measured using a spatially accurate (± 10 meters) GPS and the reported location by wildlife carcass collectors or accident enforcement agencies. This discrepancy is dependent on the reporting method used. Gunson et al. (2009) found that the spatial error was higher for WVC data referenced to a nearby landmark (mean distance of 516 meters ± 808 meters) than for data referenced to the closest highway distance marker (mean distance of 401 meters ± 219 meters). The average distance reporting error between WVCs reported by RCMP officers that are transcribed into provincial transportation geodetic systems and accurate GPS locations (calculated from 26 paired reports) was also high and variable: average distance of 2,154 meters ± 1,620 meters (Clevenger et al. 2002). This data deficiency has an impact on both safety for motorists as well as environmental concerns because more effective mitigation measures such as overpasses and underpasses cannot be adequately placed to alleviate the impacts on motorists and wildlife without precisely knowing where most of the WVCs take place.

Lack of species-specific information

One limitation in particular stands out: often provincial and national WVC statistics are summarized under one label, 'wildlife' or 'animal' (L-P Tardif & Associates 2003, 2006). However, in order to inform effective solutions, it is essential to collect species-specific WVC data because mitigation strategies are often specific to a region and target species and one solution does not necessarilty fit all (Lesbarreres 2012). For example, a wildlife warning sign placed on a road would more than likely be more effective if designed according to the species involved in WVCs on a road than a general 'Wildlife crossing' sign.

3.6 Conclusions

As illustrated in this section, many data sources about WVCs already exist in Canada. While these data sources have their limitations, notably because they are not centralized, it is still important to consider them in this feasibility study. Indeed, such existing data sources do have particular strengths and they can help avoid overlap when developing a plan for a centralized clearinghouse. Also, given their strengths and weaknesses, they help increase our understanding of the challenges and limitations involved in the development of a WVC database. While Section 2 provided the rationale for developing a centralized clearinghouse, Section 3 provided some of the building blocks for the clearinghouse as well as important aspects to consider when pursuing this undertaking. A detailed table containing a compilation of WVC summaries for each province and territory in Canada is available in Appendix 3 of this report.

With this in mind, the next section, Section 4, investigates opportunities and limitations of existing data to identify social, economic and environmental impacts of WVCs and to inform mitigation solutions for dealing with WVCs. More precisely, based on the information discussed in Sections 2 and 3, research questions relevant to the development of effective solutions to overcome the problem of WVCs are formulated. A distinction is made between research questions that we can answer with data that are readily available today versus research questions that we cannot answer today unless more data become available. Such a list of research questions, notably the ones that we cannot answer today, is crucial to develop the next steps of the feasibility study.

4. OPPORTUNITIES AND LIMITATIONS OF EXISTING DATA

4.1 Introduction

This section elaborates on opportunities and limitations of existing data to measure the impacts resulting from WVCs and to inform mitigation solutions to prevent them. First, some of the greatest limitations of the currently available data are summarized. This is followed by the formulation of research questions that we can answer today, as well research questions that are difficult or impossible to answer today with the available data. These questions are considered equally important to identifying impacts and to the development of effective solutions. Finally, this section draws conclusions that are especially relevant in light of the next steps of this feasibility study.

4.2 Summary of greatest limitations of current data sources

Some of the intricate problems associated with WVC data collection and subsequent WVC summaries nationally and regionally in Canada are listed below.

- Species-specific information is virtually non-existent with the exception of studies completed by research biologists;
- Data for large animals are under-reported, i.e., generally only collected when there is a claim and/or a police report;
- WVC data for small animals are lacking or non-existent;
- There is a severe time lag between provincial and national reporting;
- There is an overlap of efforts and different data inputs from police agencies, insurance companies, and natural resource conservation data sets;
- Data are not spatially accurate (using GPS technology) and limited to major roads;
- WVC data are lacking on rural, county and municipal roads, and few summaries, mostly general, less detailed ones are available for these roads;
- The true date and time of occurrence of a WVC is often not known;
- Some summaries of data are too general;
- There are few measureable impact summaries on wildlife species;
- Summaries produced by provincial government departments are not always accessible and may be out-of-date; and,
- The true (direct and indirect) cost of WVC collisions is not known.

4.3 Relevant research questions

Table 4-1 below lists a description of questions commonly asked when completing research about WVCs. The table is divided into three major areas of WVC research: socio-economic, safety and environmental research.

From a socio-economic perspective, questions that are commonly asked relate to the societal costs (both direct and indirect costs) associated with WVCs. At this time, it is possible to gather some estimates of direct costs of property damage caused by WVCs, but this information can only currently be assessed in provinces that compile insurance data in a centralized clearinghouse (e.g., British Columbia).

With regard to questions regarding the indirect costs or total societal costs of WVCs, only vague estimates can be identified from the literature. For example, an unpublished report by the Ontario Ministry of Transportation estimated the true cost ($1.1 billion) by extrapolating from an average cost per WVC collision in combination with an annual estimate of 14,000 WVCs. However, there is little information regarding how these costs were derived, which makes it challenging to determine the extent to which these estimates are reliable. Hence it is not possible to accurately answer questions regarding the true total costs of WVCs.

From a safety perspective, it is possible to answer questions regarding the number of WVCs that cause motorist fatalities and serious injuries. This is probably the most extensively reported information in this field of research. However, it is not possible to correctly measure the total extent of injuries, as it appears that only WVCs that involve serious injuries are accurately reported. Other injury-related WVCs may go unreported, for example if the motorist does not report the crash and only later admits themselves into a clinic for medical care.

By far, environmental research questions are the most difficult to answer because environmental information is least likely to be available with regard to WVCs. As it stands today, specific with regard to WVCs involving large animals, research questions involving the species, age, gender, accurate location, time of collision, and impacts on species abundance cannot be adequately addressed across entire road systems within specific jurisdictions. Typically, these questions can only be addressed if specific research projects or additional resources and training are initiated, and these initiatives are generally only available within a localized area. At this point only research questions that address WVC occurrence by road type, or road segment can be adequately addressed across large jurisdictions. For the large part, accurate (GPS recorded) locations are not available to effectively design and place location-specific wildlife mitigation measures along roads (Gunson et al. 2009).

An important barrier to the collection of these data is the lack of adequate training among maintenance contractors that are often tasked with picking up carcasses and collecting data. These contractors are often unable to collect data according to the necessary data fields (e.g., identify a specific species of turtle or obtain an accurate location using a GPS). Another impediment to answering environmental questions is that available WVC data sets initiated by provincial jurisdictions and collected by maintenance contractors only include WVCs on major roads and highways. Data about WVCs on municipal, rural, city, and county roads are typically fragmented across multiple by-law and enforcement agencies, making them difficult to identify, access and compare to provincial data sets to create a complete picture of the problem.

Environmental research questions involving small animals are even more challenging to answer as data can only be addressed on a crude scale, typically using citizen science data. There are some data sets produced as a result of special research projects that have facilitated answers to more rigorous and detailed questions. And, while limited data are available in this regard, what is known is that WVCs clearly pose a significant concern from a conservation point of view for some smaller animals (e.g., turtles). Unfortunately it is not possible to adequately assess population-level impacts or design effective mitigation measures until more accurate and complete data are generated, making better data on this topic a critical need.

In order to provide adequate answers for many of the relevant and commonly asked research questions identified above, and to create opportunities to more adequately address impacts of WVCs on populations (i.e., large and small animals), more long-term and supplementary data sets are required. To illustrate, accurate data can be used to evaluate the effectiveness of mitigation measures for a particular community of wildlife (e.g., adjacent to a road) by assessing population trends. On a larger scale, the collection of long-term WVC data can also be compared to data that measures population or abundance fluctuations for a species near and far from roads. These data sources could then be compared to determine if WVCs are the cause of these population fluctuations for a particular species.

To summarize, increased efforts to consistently gather data are essential to begin to address these questions. And, there are clearly mutual benefits to improving the collection of data regarding WVCs. Data that are often collected to address safety issues with WVCs can also be used to address environmental issues. For example, it is necessary to know both when and where collisions occur to deploy appropriate and effective mitigation measures that both improve road safety for motorists and wildlife. Hence, efforts to address this issue through better data collection have tremendous potential to mitigate socials costs relating to traffic safety and the environment.

Table 4-1. Description of questions commonly asked when completing research for safety, socio-economic and environmental concerns with wildlife-vehicle collisions.*

Question	Data Field(s)	Measurement	Best Data Source	Reference	Comments
Socio-economic					
Direct property damage cost	Claim amount	$	Insurance Claims	L.P. Tardif 2003, 2006	Car insurance costs to assess problem; provincial basis
Indirect societal costs	N/A	N/A	Coroner, Insurance claims	N/A	Usually extrapolated from estimates
Safety					
Injury/Fatality of motorist	Injury/Fatality	N/A	Enforcement Agency	Joyce & Mahoney 2001; L.P. Tardif 2003, 2006	Only severe injuries properly measured; Identify and assess conditions causing no injury, injury vs. fatality for motorist
Environmental					
Injury/Fatality of wildlife	Collision vs. Carcass	-	Natural Resource Agency	None	Identify and assess conditions causing injury vs. fatality for wildlife
Condition of wildlife	Percent marrow fat	-	Natural Resource Agency	Gunson et al. (2003)	Animal population impacts; types of wildlife involved in collision
Wildlife demographic involved	Gender, age	Male, female, age class	Natural Resource Agency	Gunson et al. (2003)	Animal population impacts; types of wildlife involved in collision
Species involved	Species	Genus species	Natural Resource Agency	Fudge et al. 2007	Animal population impacts, e.g. declines; Determine mitigation design & prioritization
Safety and Environmental					
Time of Year	Date	Month	Enforcement agency	Elzohairy et al. 2004	Mitigation planning e.g. timing awareness & prevention campaign or bulletin; Trends in collisions; Mitigation effectiveness
Time of Day	Time	Hour	Enforcement agency	Elzohairy et al. 2004	Mitigation planning e.g. timing awareness & prevention campaign or bulletins; Trends in collisions; Mitigation effectiveness
Location	Location description	2000 m	Enforcement agency	Zabolotny 2009	Mitigation placement, e.g. rural, urban, road-type, road segment
Location	Geographic coordinates	±10 m	Road Maintenance Contractor; Special Research Studies	Sielecki 2010; Gunson et al. 2009	Spatially explicit mitigation placement & design, e.g. overpass
Location	Highway marker	400 m	Transportation agencies	Dussault et al. 2006	Spatially explicit mitigation placement & design, e.g. warning detection systems, fencing
Conditions of collision	Weather, vehicle type, speed, traffic volume	N/A	Enforcement agency	Gunson et al. 2003	Mitigation planning & prevention for motorist and wildlife

*Shaded rows are not currently adequately addressed due to incomplete data.

5. CONCLUSIONS

This report is the first deliverable of a feasibility study to create a centralized WVC clearinghouse in Canada. Its goals were to justify the creation of such a clearinghouse by describing the magnitude of the problem. As such, a literature review was conducted in Section 2 of this report. From the literature review it became clear that the problem of WVCs is not an insignificant one as there are considerable socio-economic, traffic safety and environmental consequences. The literature review also made clear that the available data today are too limited to accurately measure the impact of WVCs and to properly inform mitigation measures.

A second goal of this report was to provide an overview of existing data sources in Canada in preparation of the creation of a centralized clearinghouse. For this purpose, a compendium of existing data sources was created in Section 3 of this report. This compendium illustrates the many data sources about WVCs that are available in Canada. Each of these sources has strengths and weaknesses. Perhaps one of the most important limitations is that they are not centralized, making it impossible to measure the magnitude and characteristics of WVCs at a national and/or regional level. The resulting compendium can serve as a resource to inform the creation of a centralized clearinghouse on WVCs in Canada.

Finally, a third goal of this report was to formulate pertinent research questions to more intimately understand the problem and potential solutions. In Section 4 of this report, a distinction was made between questions that can be answered today with the available data versus questions that can only answered if more complete and accurate quality data become available. Emphasizing this distinction further accommodates informing the development of the clearinghouse as it poignantly illustrates where data are lacking.

In conclusion, this report serves as the basis for the next step in this project, which will be to conduct a feasibility study and to develop an action plan for the creation of a centralized clearinghouse. The feasibility study will delineate the confines of today's reality in Canada with respect to making available centralized data about such a topic as WVCs. The action plan will provide a strategy and tactics to realize the creation of the clearinghouse within these confines.

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APPENDIX 1

COLLISION REPORT FORMS FOR CUSTOMIZED WILDLIFE-VEHICLE COLLISION DATA SOURCES

British Columbia - Wildlife Accident Reporting System Monthly Wildlife Accident Report Form

British Columbia DOT

BRITISH COLUMBIA

Ministry of Transportation

MONTHLY WILDLIFE ACCIDENT REPORT

Enter the day of the month (e.g. 1, 2, 3, ... etc.) in the "Day" column below.

MONTH *(Please Circle)* **Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec** **YEAR** ________

REGION *(Please Circle)* **1 2 3 4 5 6** **DISTRICT**________________________ **DISTRICT NO.**______

Location of Killed Animal: RFI = Road Features Inventory (optional); **LKI = Landmark Kilometre Index (must be completed)**

Time of Kill: 1 = Dawn, 2 = Day, 3 = Dusk, 4 = Dark

Animal Type: Please Specify Sex (Male / Female / Unknown); Please Use "Y" to indicate if Yearling or Younger; **(Other: Sheep, Caribou, Coyote, Porcupine, etc)**

Day	Time of Kill	Hwy No.	RFI Landmark	RFI Offset	LKI Segment	LKI Km	Nearest Town	Deer Sign within 100m Y/N	Deer Rflctr Y/N	# Killed	Deer M	Deer F	Deer U	Moose M	Moose F	Moose U	Elk M	Elk F	Elk U	Bear M	Bear F	Bear U	Other (please specify)	Comments

Please provide the following information to assist in report follow-ups:

_______________________ Maintenance Contractor Contact (Please Print) _______________ Telephone

_______________________ Ministry District Contact (Please Print) _______________ Telephone

Within 30 days of completion, please send this form to:
Leonard E. Sielecki, WARS Manager
Environmental Management Branch
BC Ministry of Transportation
4B - 940 Blanshard Street
P.O. Box 9850 STN PROV GOVT
Victoria, B.C. V8W 9T5 Phone: (250) 356-2255

Note: If you suspect that an animal has been the target of poachers, please contact your local Conservation Officer or call the ORR (Observe, Record, Report) Line at 1-800-663-9453.

H0107 (2001/06) Page____ of ____

NWT Wildlife Collision Report Form

NWT Wildlife - Vehicle Collision Report Form

Station:	RCMP File #:	Occurrence #:	Date:	Time:
Location of Incident (Hwy #):			Km Post:	
Latitude / Longitude (Use GPS & fill out on scene):			Officer Responding:	
Informant Name:		Phone #:	Address:	

Occupant Information

Name of Driver:	Licence #:		Age:	Sex:
Address:	Phone #:		Occupants: Y / N	Number of Occupants:
Occupant(s) Name:		Address:		Phone #:
Occupant(s) Name:		Address:		Phone #:
Describe any Injuries to Driver or Occupants:				

Vehicle / Weather Information

Vehicle Description (Licence Plate #):	Date:	Time of Accident (24h):
☐ Passenger Car ☐ Light or Heavy duty Truck ☐ Bus ☐ RV ☐ Semi-Trailer ☐ Other:		Ambient Temperature (°C):
Estimate of Damage: ☐ Minimal ☐ Extensive ☐ Wrecked	Light Conditions ☐ Dawn ☐ Day ☐ Dusk ☐ Night	
Road Surface Type: ☐ Asphalt ☐ Gravel ☐ Dirt	Surface Conditions: ☐ Dry ☐ Wet ☐ Icy ☐ Loose Snow ☐ Packed Snow	
Weather Conditions: ☐ Raining ☐ Cloudy ☐ Clear ☐ Snowing ☐ Fog ☐ Sunny ☐ Windy Other ☐		
Road Description: ☐ Turn ☐ Dip ☐ Rise ☐ Straight - Away	Photos of Vehicle Taken: Y / N	

Wildlife Information

Wildlife Species:		Was Animal(s) Killed on Impact: Y / N	Did Animal(s) Have To Be Destroyed: Y / N Number:	
Total Number of Animals Involved:		Males: _____ Calf _____ Yearling _____ Sub-Adult _____ Adult _____ Unknown		
		Females: _____ Calf _____ Yearling _____ Sub-Adult _____ Adult _____ Unknown		
Dominant Vegetation along Roadside Right-of Way:				Photos taken: Y / N
Describe any Injuries to Wildlife:				
Method of Carcass Disposal:				
Hide Salvaged: Y /N	Skull Salvaged: Y /N	Meat Salvaged: Y /N	Biological Samples Collected: Y / N	Sample ID#
Lymph Nodes: Y /N	Fecal: Y /N	Teeth(Middle Incisors): Y / N	Ear(DNA): Y / N	Blood: Y / N
Full Girth (CM):	Half Girth (CM):	Nose - Tail Length (CM):		

Date:	Time:	Other Comments:

APPENDIX 2

FORMS FOR DATA BASED ON ANIMAL CARCASS ROADSIDE COLLECTION AND/OR OBSERVATIONS

RoadWatch BC On-Line Data Entry Form

RoadWatch BC

ON-LINE DATA ENTRY FORM

Print Form | Submit by Email

Biodiversity Centre for Wildlife Studies
P.O. Box 32128
3651 Shelbourne Street
Victoria, British Columbia
V8P 5S2
phone/fax 250-477-0465
www.wildlifebc.org / editor@wildlifebc.org

Name (full) John E. Smith

Address 123 - 987 Wildlife Lane
Beautiful, British Columbia
V1V 1V1

Phone 250-555-5555 **e-mail** abcdef@abcdef.abc

Add Record — Some fields are required. This will prevent saving incomplete records**

	Date	Species*	Sex/Age	How many	Animal Status
X	05-Sep-2006	Black-capped Chickadee	Adult Sex Unknown	1	Dead on Roadside

Location 15.2 km west of Hope on Highway 1, westbound

Time since death: Fresh (1-2 days)
Road Location: Roadside/Shoulder
Time of collision: Unknown
Road Type: Divided highway
Type of Vehicle: Unknown

Road Barriers (click all that apply
- [ ] Fencing (one side)
- [ ] Fencing (both sides)
- [x] Fencing (none)
- [ ] Centre Barrier (no gaps/solid)
- [ ] Centre Barrier (with gaps/arches)
- [ ] Roadside barriers (no gaps/solid)
- [ ] Roadside barriers (gaps/arches)

Additional comments:

	Date	Species*	Sex/Age	How many	Animal Status
X	12-Sep-2006	Common Raccoon	Adult Sex Unknown	1	Dead in Centre of Road

Location Junction of Jenkins Road and Hwy 14, Langford

Time since death: Recent (3 - 10 days)
Road Location: Roadside/Shoulder
Time of collision: Unknown
Road Type: 1 Lane each way
Type of Vehicle: Unknown

Road Barriers (click all that apply
- [ ] Fencing (one side)
- [ ] Fencing (both sides)
- [x] Fencing (none)
- [x] Centre Barrier (no gaps/solid)
- [ ] Centre Barrier (with gaps/arches)
- [ ] Roadside barriers (no gaps/solid)
- [ ] Roadside barriers (gaps/arches)

Additional comments: in a residential area

*Please use complete species names when possible
** To avoid a "Required Field" message when submitting or saving forms, be sure to delete blank records using the X in that record.

RoadTripBC On-Line Data Entry Form

RoadTrip BC

ON-LINE DATA ENTRY FORM

Print Form | Submit by Email

Biodiversity Centre for Wildlife Studies
P.O. Box 32128
3651 Shelbourne Street
Victoria, British Columbia
V8P 5S2
phone/fax 250-477-0465
www.wildlifebc.org / editor@wildlifebc.org

Name (full) John E. Smith

Address 123 - 987 Wildlife Lane
Beautiful, British Columbia
V1V 1V1

Phone 250-555-5555 **e-mail** abcdef@abcdef.abc

RoadTrip Description Jct Hwy 1 and MacKenzie Ave in Victoria, north to Jct Hwy 1 and 19 near Nanaimo

RoadTrip Date 28-Sep-2006

Start Odometer Reading (kms) 0
End odometer reading (kms) 96.5

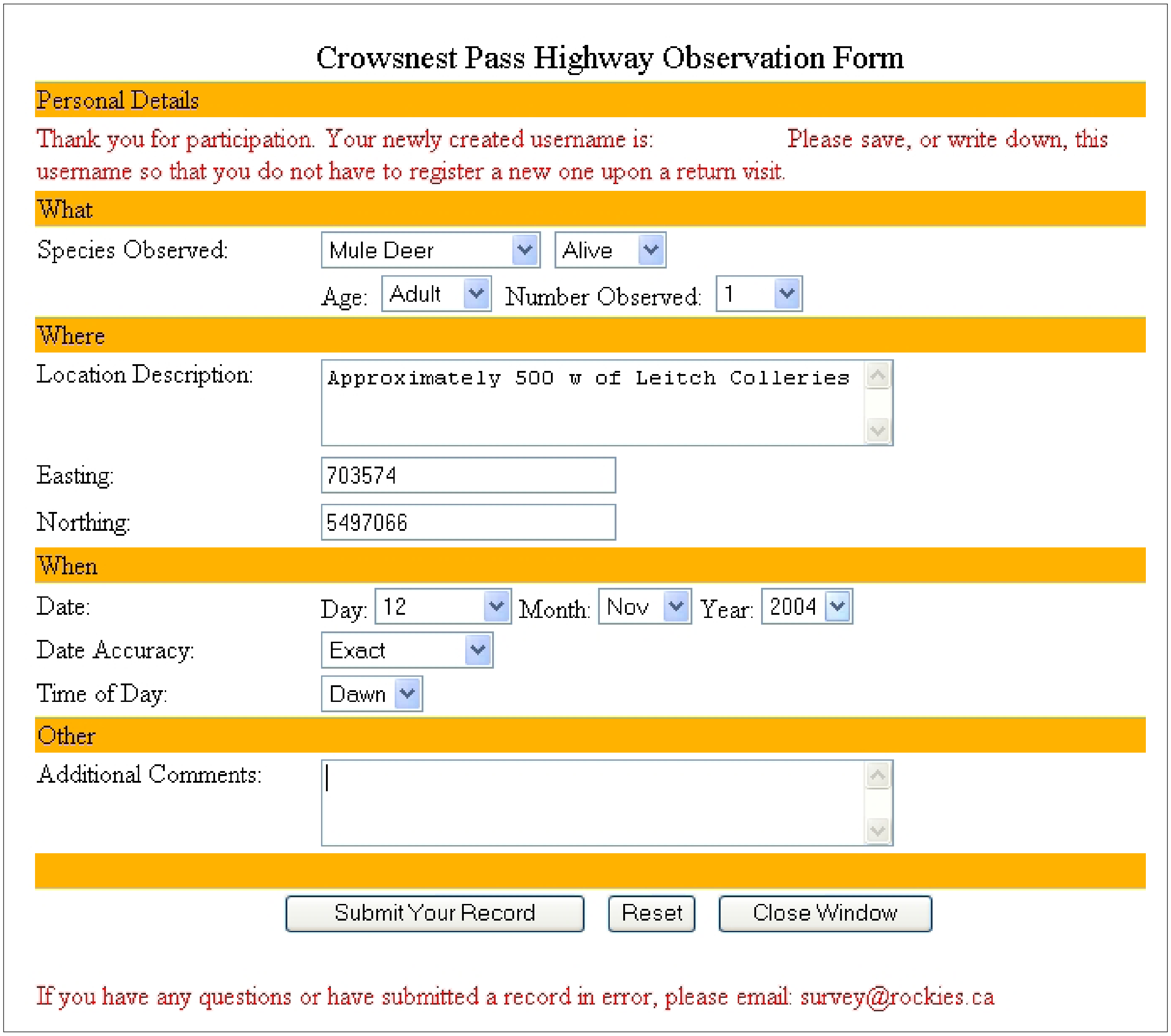
Total Distance Driven (km) 96.5

Add Record Some fields are required. This will prevent saving incomplete records**

	Odometer	Species*	Sex/Age	How many	Location Marker	Mortality
X	000011.6	Glaucous-winged Gull	Adult Sex Unknown	1	2 km south of Goldstream	Dead on Roadsi
X	000036.5	Northwestern Crow	Adult Sex Unknown	1	Mill Bay	Dead on Roadsi
X	000044.0	Eastern Gray Squirrel	Unknown	1	Cowichan Bay Road	Dead in Centre
X	000090.5	Brewer's Blackbird	Adult Female	1	Nanaimo airport	Dead on Roadsi

*Please use complete species names when possible
** To avoid a "Required Field" message when submitting or saving forms, be sure to delete blank records using the X in that record.

Road Watch Alberta Observation Table



Crowsnest Pass Highway Observation Form

Personal Details

Thank you for participation. Your newly created username is: Please save, or write down, this username so that you do not have to register a new one upon a return visit.

What

Species Observed: Mule Deer | Alive

Age: Adult | Number Observed: 1

Where

Location Description: Approximately 500 w of Leitch Collieries

Easting: 703574

Northing: 5497066

When

Date: Day: 12 Month: Nov Year: 2004

Date Accuracy: Exact

Time of Day: Dawn

Other

Additional Comments:

Submit Your Record | Reset | Close Window

If you have any questions or have submitted a record in error, please email: survey@rockies.ca

Ontario Road Ecology Group

WANTED: Wildlife sightings (dead or alive) along roads

Help us find out more about animal-road interactions in Ontario. If you see an animal on or near a road while driving, record the location, the animal species, and the status (i.e. dead or alive) of the animal. Take a picture if you can! We will use these data to get a better understanding of the interactions between animals and roads, and to help identify 'hotspots' where animals frequently get hit by cars. This information can then be used by scientists and policy makers to identify areas where mitigation methods are needed, such as ecopassages and wildlife crossing signs.

Report a Sighting

Please fill out this form to the best of your abilities. Fields with an asterisk (*) are required.

Date of observation (dd/mm/yyyy): Time of observation:

*Road name

*Location description: Please provide details about the location on the road (nearest intersection, town, waterbody, etc.)

Roadside habitat: (e.g. wetland, forest, field, urban, etc)

Geographic location:

X-coordinate : (e.g. lat/long, UTM)

Y co-ordinate : (e.g. lat/long, UTM)

Datum : (e.g. WGS 84, NAD 83, NAD 27)

Data Source:

*Wildlife species: (e.g. turtle, mammal or deer, frog)

*Status: Weather:

Direction heading:

Comments and additional information:

Personal Details

The personal information will not be used by anyone, for anything other than its intended purpose. The coordinator may wish to contact you if you submit a wildlife sighting of particular scientific interest.

Name (First, Last) *

Address *

City *

Province / State *

Postal Code / ZIP *

Country *

Email Address

Phone Number *

If you have a PICTURE, please email it to: oreg@torontozoo.ca
Please include this number : 20120906181738 so that we can relate it to this submission..

APPENDIX 3

COMPILATION OF WILDLIFE-VEHICLE COLLISION (WVC) SUMMARIES FOR EACH PROVINCE AND TERRITORY IN CANADA

*Temporal is the years used for the summary, and not the years when data is collected.

Raw Data Source Agency	Publication (Date)	Who Completed	Injury/ Fatality	Cost	Species (gender and age)	Website Host	Format	Spatial	Temporal	Limitations/ Comments
Newfoundland and Labrador (NL)										
Health Agencies, Eastern, Central & Western	Class Action Lawsuit Affidavit (2011)	Ches Crosbie	Yes	No	Moose	Ches Crosbie website	Tabular Tally	Provincial (prov)	1995-2010	Moose specific Lawyer Firm
Office of the Chief Medical Examiner	Class Action Lawsuit Affidavit (2011)	Ches Crosbie	Yes	No	Moose	Ches Crosbie website	Tabular Tally	Prov (2000-2009)	2000-2009	Moose specific
Royal Canadian Mounted Police (RCMP)	Class Action Lawsuit Affidavit (2011)	Ches Crosbie,	No	Yes	Moose, Animal	Ches Crosbie website	Bar chart	Prov	1995-2008	Moose specific 1997 Annual amount estimated for Property damage
Dept. of Environ. Conservation	Strategy Report (2005)1; Poster/ Brochure	Ches Crosbie	Yes	No	Moose	Ches Crosbie website	Tabular Tally	Prov, comparison of TCH and rural routes	1988-2001	Moose specific
Royal NL Constabulary	Class Action Lawsuit Affidavit	Ches Crosbie	No	No	Moose	Ches Crosbie website	Tabular Tally	Prov	2008-2011	Moose specific
Dept. of Works, Services, Transportation, Wildlife Division	Alces publication (1991)	Dept. of Environment and Lands, Wildlife Division	Yes	No	Moose	Alces website	Tabular, bar chart	Prov	1983-1990	Same mitigation measures as using today, hunting, signage brochures, awareness
NL & Labrador Wildlife Division Conservation Officers (CO) & RCMP	Wildlife Society Bulletin (WSB) (2001)	Department of Tourism, Culture and Recreation	Yes	No	Moose (gender, age)	WSB website	Tabular	Prov	Time of day, seasonal, 1988-1994	Reported if \$1,000 and or human injury RCMP and CO overlap

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Raw Data Source Agency	Publication (Date)	Who Completed	Injury/ Fatality	Cost	Species (gender and age)	Website Host	Format	Spatial	Temporal	Limitations/ Comments
N/A	Journal of Bone and Joint Surgery	Dept. of Orthopaedic Surgery, Memorial Uni. Medical School,	Yes	Yes	Moose	Journal access	n/a	n/a	1987-1988	Can't access paper
Dept. of Environ. Conservation	Transport Canada (TC) website (2006) & Report (2003)	Transport Canada/L.P. Tardif & Associates	Yes	No	Animal, Moose	TC/WA website	Tabular Tally	Prov	1999-2003	RCMP & Conservation Officer overlap
TC Road Safety Directorate	TC website (2006) & Report (2003)	TC/L.P. Tardif & Associates	Yes	No	Animal	TC/WA website	Tabular Tally	Prov	1996-2003	
Nova Scotia										
Dept. of Natural Resources	Published peer reviewed paper (2007)	Dept. of Biol., Dalhousie University	No	No	White-tailed Deer, Moose, and Black Bear, gender and age	Journal website	Graph	Prov	1999-2003, seasonal	Voluntary, 60-90% bear and deer reported, and 100% moose Small animal study Temporal patterns, by gender and road-type White-tailed deer most common
Dept. of Transportation and Public Works	TC website (2006) & Report (2003)	Transport Canada/L.P. Tardif & Associates	Yes	No	Deer	TC/WA website	Tabular Tally	Prov	2001-2003	Deer specific Reports Hourly information in 2003 report
TC, Road Safety Directorate	TC website (2006) & Report (2003)	Transport Canada/L.P. Tardif & Associates	Yes	No	Animal	TC/WA website	Tabular Tally	Prov	1996-2003	Large animal, short temporal period, limited information, no provincial summary
New Brunswick (NB)										

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Raw Data Source Agency	Publication (Date)	Who Completed	Injury/ Fatality	Cost	Species (gender and age)	Website Host	Format	Spatial	Temporal	Limitations/ Comments
Dept. of Transportation, Maintenance & Traffic Branch	Institute Transportation Engineers Conference Proceedings (2004)	University of New Brunswick (UNB)	Yes	No	Deer, moose	UNB website	Tabular Accident Rate by route	Prov	1995-2000	Arterial Highways,
										Claims ($1,000)
										Control Section
										Spatial Model
										Rate by route, trends
Dept. of Transportation & Infrastructure	Safety bulletin, posters, radio audio files	Dept. of Transportation & Infrastructure	No	No	Moose	Govt. of NB website	Maps, Text	Prov	2001-2009	Major routes only
TC, Road Safety Directorate	TC website (2006) & Report (2003)	TC/L.P. Tardif & Associates	Yes	No	Animal	TC/WA website	Tabular Tally	Prov	1996-2003	Large animal, short temporal period, limited information, no provincial summary
Prince Edward Island									Transport Canada website	
TC, Road Safety Directorate	TC website (2006) & Report (2003)	TC/L.P. Tardif & Associates	Yes	No	Animal	TC/WA website	Tabular Tally	Prov	1999-2003	Large animal, short temporal period, limited information, no provincial summary
Quebec (QC)										
QC Ministry of Transportation (MTQ)	Brochure (unk)	Quebec Ministry of Transportation (MTQ)	Yes	No	Deer, Moose	MTQ site	Text	Prov	unk	Informative summaries
MTQ	Poster	Quebec Ministry of Transportation (MTQ)	Yes	No	Large Animal, white-tailed deer	MTQ website	Map, Table, Bar Chart, Graph	Estrie	2005-2009	Regional Statistics, Major Routes
										French
MTQ	Peer-Reviewed Publication	University of Quebec, Ministry of Natural Resources, MTQ	No	No	Moose	MTQ website	Graph	Laurentides Wildlife Reserve	1990-2002	1 km road marker
										Spatial and temporal model
										Annual trend, seasonal, day of week

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Raw Data Source Agency	Publication (Date)	Who Completed	Injury/ Fatality	Cost	Species (gender and age)	Website Host	Format	Spatial	Temporal	Limitations/ Comments
MTQ	Transport Canada website (2006) & Report (2003)	Transport Canada/L.P. Tardif & Associates	Yes	No	Deer, Moose, Bear, Caribou	TC/WA website			1996 to 2000	
TC, Road Safety Directorate	TC website (2006) & Report (2003)	Transport Canada/L.P. Tardif & Associates	Yes	No	Large Animal	TC/WA website	Tabular Tally	Prov	1996-2003	Large animal, short temporal period, limited information
Ontario										
Ministry of Transportation (MTO)	Conference Proceedings (2009)	MTO/NE Division	Yes	Yes	Large Animal	Transport Assoc. Canada (TAC) website	Text	NE division	2009	Collisions exceed $2,000 Broad Total Cost Customized database, and RCMP
MTO	Safety Bulletin (unk)	MTO	No	No	Wild animals	MTO website	Bar chart	Prov	Unk	By month
MTO, NE division & Ontario Provincial Police	Report (2010)	Morrison Hershfield	No	No	Animal, Deer, Moose	Not accessible	Graph	NE division	1988-2010	199 Ontario Automobile Insurance companies Traffic Volume, Month, Day, habitat correlates Missing years of data Cannot be merged
MTO, Road Safety Program Office	Transportation Research Board (TRB) Annual Meeting (2004)	MTO, central office	Yes	No	Wild animal	Peaceful Parks website	Bar chart, tabular	Prov	1996-2001	Time of Day and Month, severity by vehicle damage, and road characteristics
MTO, Road Safety Program Office	Transport Canada website (2006)	Transport Canada/L.P. Tardif & Associates	Yes	No	Animal	TC web site	Tabular Tally	Prov	2001	Obtained data from 2004 report, no prov. summary in L.P. 2003 document

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Raw Data Source Agency	Publication (Date)	Who Completed	Injury/ Fatality	Cost	Species (gender and age)	Website Host	Format	Spatial	Temporal	Limitations/ Comments
TC, Road Safety Directorate	TC website (2006) & Report (2003)	TC/L.P. Tardif & Associates	Yes	No	Animal	TC/WA website	Tabular Tally	Prov	1996-2003	Discrepancy between claim amount $2,000 Ontario, $1,000 NTDB
City of Ottawa										
Transportation, Utilities and Public Works Department	Informational Bulletin (2006)	Transportation, Utilities and Public Works Department	No	No	Deer	City of Ottawa website	Text, TV ad	Regional City of Ottawa	2006	Since 2006, deer collisions dropped by 38% Publish annual report (not accessible)
Transportation, Utilities and Public Works Department	Transport Canada website (2006) & Report (2003)	Transport Canada/L.P. Tardif & Associates	Yes	No	Deer	TC/WA website	Tabular, Graph	City of Ottawa	1994-2004	Data by deer population and registered vehicle for each district
Manitoba (MB)										
Manitoba Public Insurance (MPI)	News Release (2010)	MPI	Yes	Yes (claim amount)	Deer	MPI and MB government website	Maps, text	Winnipeg area	2006-2009	Only claims Map for Winnipeg and rural hotspots
MPI	TC website (2006)	Transport Canada/L.P. Tardif & Associates	Yes	No	Animal	TC web site	Tabular Tally	Prov	2001-2003	No prov. summary in L.P. 2003 document Claim data, not all PD covered on insurance
TC, Road Safety Directorate	TC website (2006) & Report (2003)	Transport Canada/L.P. Tardif & Associates	Yes	No	Large Animal	TC/WA website	Tabular Tally	Prov	1996-2003	Exceeds $1,000, wild animal
Saskatchewan (SK)										
SK Govt. Insurance (SGI), Traffic Accident Information System (TAIS)	Safety bulletin (2007?)	SGI,TAIS	Yes	Yes	Animal	SGI web site	Video	Prov	unk	Not updated Seasonal summary

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Raw Data Source Agency	Publication (Date)	Who Completed	Injury/ Fatality	Cost	Species (gender and age)	Website Host	Format	Spatial	Temporal	Limitations/ Comments
SK Ministry of Highways and Infrastructure (HIS)	Press Release (2007), Campaign	SK Highways and Transportation	No	Yes property amage, PD)	Deer	SK government website	Text	Prov	2000, 2006, 2007	Save a Buck Campaign Increasing over 15 years Cost in claims Describe hotspots
SK HSI	Press Release (2002)	SK Highways and Transportation	Yes	Yes (PD)	Wild Animal	SK government website	Text	Prov	2011, 1998, 1999	IRD Wildlife Warning System Wildlife hotspots
SK HSI	CARPS Conference Proceedings (2009)	University of Regina/SK HSI	No	No	Wild Animal	Abstract on carsp website	Graphs	Prov	1988-2006	Provincial Highways
SGI	TC website (2006)	Transport Canada/L.P. Tardif & Associates	Yes	No	Wild Animal	TC web site	Tabular Tally	Prov	1996-2003	No. by Injury, Fatality, Property Damage
TC, Road Safety Directorate	TC website (2006) & Report (2003)	Transport Canada/L.P. Tardif & Associates	Yes	No	Animal	TC/WA website	Tabular Tally	Prov	1996-2003	Exceed $1,000
Alberta (AB)										
AB Infrastructure and Transportation (AIT), Road Animal Fatality Information Application	Report (2005)	EBA Engineering	Yes	No	Wild Animal	Centre for Transportation Engineering Planning website	Tabular	Prov	2004	Obtained from annual report Urban vs. Rural
AIT	Hunting for Tomorrow What's New summary (2010)	Hunting For Tomorrow Foundation	Yes	Yes (2008 total societal cost)	Wild Animal	Hunting for Tomorrow website	Bar chart	Prov	1991-2008,	AIT annual report Collisions Involving Animals (1991-2008, 2008) (not accessible? By internet) Annual Trend
AIT	Wildlife collision prevention bulletin (2007)	AIT	Yes	No	Large Animal	AIT website	Text	Prov	2001-2005	Time of Day

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Raw Data Source Agency	Publication (Date)	Who Completed	Injury/ Fatality	Cost	Species (gender and age)	Website Host	Format	Spatial	Temporal	Limitations/ Comments
Edmonton Animal Control Services	Wildlife Society Bulletin (WSB) (2011)	Dept. of Biological Sciences, University of AB	No	No	Deer	WSB website	Bar chart	Edmonton	2002-2007,	Monthly Effectiveness of wildlife signage Hotspot locations
AB Transportation, Parks Canada	International Conference of Ecology & Transportation Proceedings (2003)	Parks Canada/ Western Transportation Institute/ Independent Researchers	Yes	No	Wild and Domestic Animal	Road Ecology Center eScholarship Repository (internet)	Bar chart	Prov	1991-2000	Time Day, Day of Week Closest control section Vehicle Type Derived from vehicle report forms from RCMP ($1,000 or more). Overlap with Parks Service (wardens) and Alberta Sustainable Resource Development (Canmore office, maintenance contractors), and provincial park (CO) data collection RCMP more reliable for time of occurrence
Parks Canada & Alberta Resource Agencies	Environmental Management (2009)	Parks Canada/ Western Transportation Institute/ Independent Researchers	No	No	Ungulates (deer, elk, moose, sheep)	Eco-Kare and Journal website	Model Statistics	Central Can. Rocky Mtn.	2003-2005	Geographic Positioning System accuracy Hotspots Data from various sources

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AIT	TC website (2006) & Report (2003)	Transport Canada/L.P. Tardif & Associates	Yes	No	Animal (wild & domestic)	TC/WA website	Tabular Tally	Prov	1996-2003	Annual No. by Injury, Fatality, Property Damage
										Includes domestic and wild animal
										Reports derived by RCMP
TC, Road Safety Directorate	TC website (2006) & Report (2003)	Transport Canada/L.P Tardif & Associates	Yes	No	Animal	TC/WA website	Tabular Tally	Prov	1996-2003	Exceed $1,000
British Columbia (BC)										
BC MOT, Wildlife Accident Reporting System (WARS; 1993 - present)	Wildlife Afield	Wildlife Collision Prevention Program	No	No	Species Specific	WA website	Tabular	Prov	1983-2002,	Wildlife Accident Reporting System
										Numbered Highways
										Maintenance contractors
										Animals that are a hazard
										Annual Trend
BC MOT, WARS	Annual Report (2004)	BC MOT, Environmental Management Section, Engineering Branch	Unk	Unk	Unk	Not accessible	Unk	Prov	1998-2007	Derived from WARS and RCMP data
										Nearest mile post
										Annual Trend
International Corporation of BC (ICBC)	Wildlife Afield	Wildlife Collision Prevention Program	Yes, injury	Yes (claim)	Wild or domestic Wild or domestic	WA website	Text	Prov	2001-2005	Time of Day accurate, but not species specific or accurate location
										75% of collisions

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Raw Data Source Agency	Publication (Date)	Who Completed	Injury/ Fatality	Cost	Species (gender and age)	Website Host	Format	Spatial	Temporal	Limitations/ Comments
RCMP, RCMP's Traffic Services Management Information Tool (TSMIT).	Wildlife Afield	Wildlife Collision Prevention Program	Yes	No	Wild or domestic	WA website	Text	Prov	2000-2004	Privacy issues Fatality Only, no injury
BC WARS	Alces (1991)	Ministry of Environment	No	No	Moose	Alces website	Bar chart, graph	Prov	1987-1990,	Regional estimates Annual trend, monthly
ICBC	TC website (2006) & Report (2003)	Transport Canada/L.P Tardif & Associates	Yes	Yes (claim amount)	Animal	TC /WA web site	Tabular Tally	Prov	1997-2003	Annual No. by Injury, Property Damage, Total Claim cost Includes domestic and wild animal Reports derived by RCMP
TC, Road Safety Directorate	TC website (2006) & Report (2003)	Transport Canada/L.P Tardif & Associates	Yes	No	Animal	TC/WA website	Tabular Tally	Prov	1996-2003	Exceed $1,000
City of Prince George										
Conservation Officer Service and City of Prince George	Report (2004)	Northern University of British Columbia/ICBC	No	Yes	Moose	WA website	Graph, map, and text	Prince George	2001-2004	Requires city worker or CO officer at scene for report Moose collision locations
Yukon Territory										
TC, Road Safety Directorate	TC website (2006) & Report (2003)	Transport Canada/L.P Tardif & Associates	Yes	No	Animal	TC/WA website	Tabular Tally	Prov	1996-2003	Exceed $1,000 Bison issue on wildlife accidents website
Northwest Territory										
TC, Road Safety Directorate	TC website (2006) & Report (2003)	Transport Canada/L.P Tardif & Associates	Yes	No	Animal	TC/WA website	Tabular Tally	Prov	1996-2003	Exceed $1,000 Bison issue on wildlife accidents website

*** Annual span of data summary accessible, not the span of the actual data**