CLOSING THE DATA GAPS: TOWARDS A COMPREHENSIVE WILDLIFE-VEHICLE COLLISIONS MITIGATION STRATEGY FOR ONTARIO

By

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STATEMENT OF ETHICS APPROVAL

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Abstract

Wildlife-Vehicle Collisions (WVCs) increased by almost 40 per cent in Ontario between 2000 and 2007. WVCs are a threat to the safety of drivers, passengers, animal populations, and cause significant property damage. This capstone uses case study analysis to explore how Canada's largest province might best reduce WVCs. In examining WVC reduction efforts in British Columbia, Saskatchewan and Newfoundland and Labrador, the capstone finds accurate and detailed data collection holds the key to effective WVC reduction planning. After evaluating data collection systems used in the three case provinces, this study suggests Ontario adopt a system similar to British Columbia's Wildlife Accident Reporting System (WARS).

Keywords: wildlife-vehicle collisions; Ontario; transportation; conservation; safety; BC WARS

Executive Summary

Wildlife-Vehicle Collisions (WVCs) are a public safety and conservation problem, causing human and animal fatalities, injuries, and significant property damage to vehicles. The number of WVCs in Ontario increased by almost 40 per cent between 2000 and 2007, and it is predicted that the frequency of these collisions will continue to increase unless mitigation is implemented.

This capstone uses case study analysis to explore how Canada's largest province might best reduce WVCs. The extent of the problem, current mitigation measures and data collection mechanisms in British Columbia, Saskatchewan and Newfoundland and Labrador are examined, with emphasis on data collection as it pertains to mitigation. The findings from the case study analyses suggest that Ontario must focus on collecting accurate and detailed WVC data, as this holds the key to effective mitigation planning. From the case study findings, interviews and literature, four policy options are determined: the Status Quo - Ontario Provincial Police Collisions Reports, Insurance Claims Information, Ministry of Natural Resources Carcass Count Data, and Highway Maintenance Contractors Carcass Count Data

The options are evaluated using five criteria: effectiveness of the data quality, underreporting correction, cost, administrative complexity and stakeholder acceptability. The data quality measure has five additional criteria: spatial accuracy, time specific, species specific, age and/or gender, and completeness. The effectiveness of data quality is evaluated separately, and then added into the full analysis, where all criteria are weighted equally. After evaluating the four policy options, this study suggests Ontario adopt an adjusted British Columbian Wildlife Accident Reporting System (WARS). Secondary recommendations include using GPS to improve

the spatial accuracy of the data, collecting datasets on species at risk, and acquiring species-specific information in the dataset collected by the Ontario Provincial Police.

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Glossary

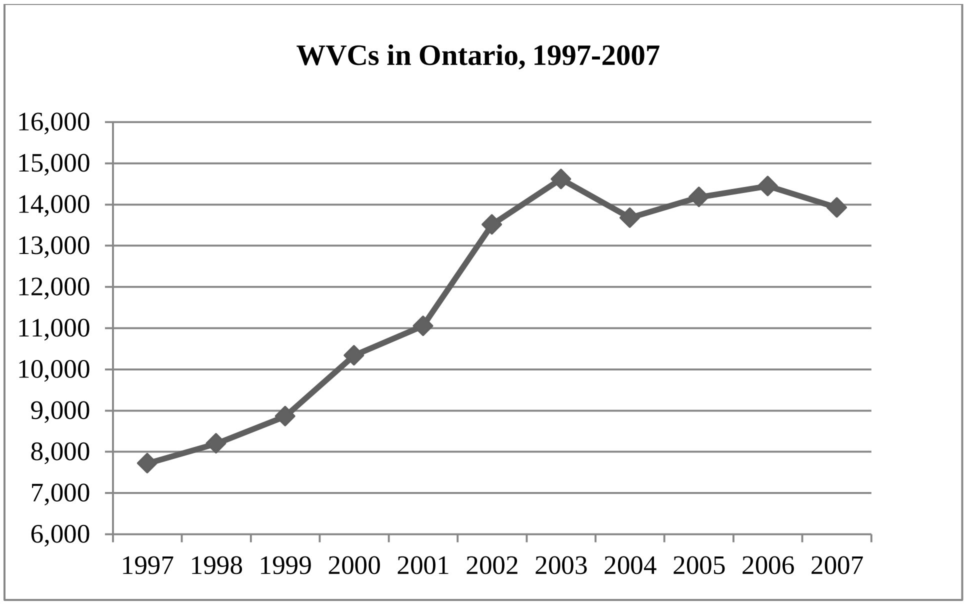
WVC	Wildlife-Vehicle Collision
MVC	Moose-Vehicle Collision
PDO	Property Damage Only
MTO	Ministry of Transportation Ontario
MNR	Ministry of Natural Resources
MOT	Ministry of Transportation
OPP	Ontario Provincial Police
ORSAR	Ontario Road Safety Annual Report
TAIS	Traffic Accident Information Systems
CC	Carcass Count
CCMTA	Canadian Council of Motor Transport Administrators
ADS	Accident Data System
NCD	National Collisions Database
LHRS	Linear Highway Referencing System
SGI	Saskatchewan Government Insurance
WARS	Wildlife Accident Reporting System
SA	Spatially Accurate

1: Introduction and Policy Problem

Ontario has the largest road network, the most vehicles, and highest biodiversity in Canada (Gunson et al 2009b). The province has more than 16,500 kilometres of provincial highways, approximately 11 million registered vehicles and 9.1 million drivers (MTO Website). The best available data suggests there are approximately 14,000 Wildlife Vehicle Collisions (WVCs) in Ontario every year (Garbutt 2009). WVC's threaten the safety of drivers, passengers, animal populations, and cause significant property damage (L-P Tardif & Associates Inc. 2003; Litvaitis and Tash 2008; Lee et al 2006; Huijser et al 2007a). Growing human and animal populations, increasing traffic volumes, and road and highway expansion plans threaten to intensify this problem (Gunson et al 2009b).

The number of police reported WVCs in Ontario has grown significantly over the last decade, with almost twice as many collisions in 2007 as in 1997 (ORSAR 2004-2009; L-P Tardif & Associates Inc. 2006). One in every 21 collisions in the province is a WVC (Elzohairy et al 2004; Gunson and Ireland 2009). Between 1993 and 2003, the number of people injured in WVCs increased by approximately 50 per cent, while the number of people injured in all Ontario collisions decreased over the same period (Jackson 2006). Thus in relative terms, "the seriousness of the wild animal problem has increased" (Jackson 2006, 19).

Figure 1.1 **Large Animal WVCs in Ontario: 1997-2007**



Source: Elzohairy et al 2004, 7; L-P Tardif & Associates Inc. 2006, 30-31; ORSAR, 2004-2007

Table 1.1 illustrates the total number of police reported vehicle collisions with large animals in Ontario between 1997 and 2007. The Ontario Provincial Police (OPP) is the only body that collects collisions information; for a collision to be reportable, it must cause fatality, injury, or more than $1,000 property damage. While this information illustrates the severity of the WVC problem in Ontario, there is strong evidence to suggest this data captures only half of the actual number of WVCs in Ontario (L-P Tardif & Associates Inc. 2006). Determining which organization is responsible for data collection and the how much data they collect is a major part of this study, and discussed throughout.

Table 1.1 **Ontario WVCs: 2002-2007**

Year	Fatalities	Injuries	Property Damage Only	Total
2002	8	610	12,894	13,512
2003	4	596	14,018	14,618
2004	8	556	13,112	13,678
2005	2	554	13,622	14,178
2006	7	550	13,887	14,444
2007	5	523	13,398	13,926

Source: L-P Tardif & Associates Inc. 2006, 30-31; ORSAR 2004-2007

In a wildlife-vehicle collision, the average property damage and value of the killed animal costs approximately $4,500 (L-P Tardif & Associates Inc. 2003). There are additional costs associated with WVCs that are harder to account for. The accumulated costs of lost productivity caused by road delays, foregone hunting licenses and wildlife viewing opportunities, and costs to remove the animal carcasses from the roadside can be very expensive (Huijser et al 2007b). The cost of human lives lost and health care expenditures resulting from these collisions are very significant (Huijser et al 2007a; Leblond 2007). Table 1.1 displays WVCs by severity between 2002 and 2007. MTO data beyond 2007 is currently unavailable. The table illustrates the damages caused by WVCs; they result in human mortality and injury, and significant property damage. An estimated 95 per cent of WVCs cause property damage only (PDO) of approximately $3000 per collision (L-P Tardif & Associates Inc. 2006; Huijser et al 2007b). These property and human costs are extremely expensive for Ontarians.

This study uses a case study approach to investigate WVCs in a set of Canadian provinces to suggest how best to reduce these types of collisions in Ontario. The study has seven sections. Following this brief introduction, Section 2 provides general background, discusses the social and environmental costs of WVCs, and provides information about the status quo in Ontario. Section 3 provides information on the methodology, and rationale for case selection. Section 4 is the case study analysis, examining the WVC strategies in Saskatchewan, Newfoundland & Labrador and British Columbia, including case details and comparative lessons. Section 5 outlines criteria by which to evaluate policy options, including effectiveness, underreporting correction, cost, administrative complexity, and stakeholder acceptability. Section 6 explains and analyses proposed policy options according to these criteria, with conclusions, recommendations and final thoughts included in Section 7.

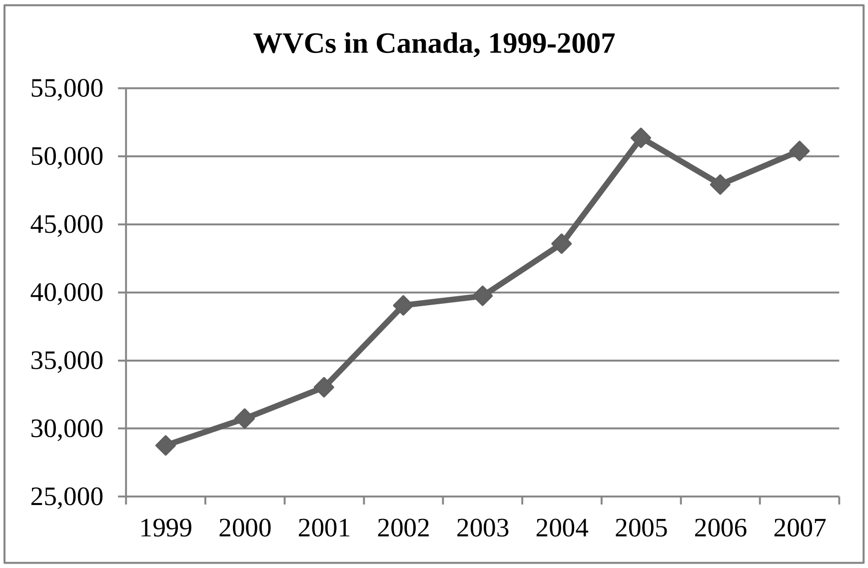
2: Background

This section defines key terms and provides general information about WVCs in Canada and Ontario. The first subsection discusses the public safety problem WVCs pose across Canada. The second subsection introduces associated conservation problems, including effects on animal populations and connectivity. The next section further explains the WVC problem in Ontario, discussing jurisdictional responsibility, the current approach to mitigation, underreporting, and data collection methods in the province. The final subsection identifies and summarizes the key aspects of the current Ontario WVC strategy.

2.1 WVCs in Canada

WVCs are a major problem in Ontario, Canada, and internationally (Seiler 2005; Elzohairy et al 2004; Gunson et al 2009b). A significant portion of the Canadian road network runs alongside or through designated parklands, wilderness, and animal habitats, increasing the incidence of WVCs (L-P Tardif & Associates Inc. 2003). The property damage caused by these accidents costs Canadians approximately $200 million annually (Lee et al 2006). This amount is the property damage associated with the presumed actual number of collisions, and the number of reported collisions has been adjusted to reflect this (L-P Tardif & Associates Inc. 2003). Unless mitigative actions are taken, it is predicted that the frequency of WVCs will continue to increase across the country (Harper 2004; L-P Tardif & Associates Inc. 2003; Huijser et al 2007a).

Figure 2.1 **Total WVCs in Canada**



Source: Transport Canada National Collisions Database 2004-2008[1]*; 1999-2003 L-P Tardif & Associates Inc. 2006, 16-17.*

Figure 2.1 displays the number of reported WVCs in Canada from 1999 to 2007. The information is from the National Collisions Database, which is the best available data, but underreporting hides the true extent of the problem (L-P Tardif & Associates Inc. 2006). Underreporting occurs for a number of reasons. Depending on the circumstance, “animal remains may be obscured by subsequent vehicles; large animals, primarily deer or Moose, may be removed by passing motorists; animals that are hit but move away from the road surface to die are not observed; animal remains are removed by animal predators and scavengers” (Hesse 2006, 5). There can be errors in data collection or processing, including officials incorrectly guessing the species involved or location of the crash (Sielecki 2001). Reporting thresholds can exclude many collisions, drivers do not always report WVCs that cause property damage only (PDO), and

[1] NCD data indicates that the number of WVCs decreases to 38,477 in 2008; there is no explanation for this anomaly. This was not included, as it will be interesting to see the 2009 numbers before assuming the 2008 information is correct. Available provincial numbers do not reflect a significant downward trend, although "fluctuation between years can be considerable" (Sielecki 2004, 6-2).

some jurisdictions lack the mechanisms necessary to collect thorough data (Creative Resource Strategies 2008).

2.2 WVCs and Public Safety

WVCs are a common occurrence in Canada, with approximately four to eight large animals hit every hour (L-P Tardif & Associates Inc. 2003). Collisions with ungulates – deer, moose, bighorn sheep and elk - account for 70 to 80 per cent of all reported Canadian WVCs (Preston et al 2008; Sielecki 2003b). This study concentrates on large animal collisions as these accidents present the greatest safety hazard. Small animal vehicle collisions also cause public safety and conservation concerns, as small animals on the road can lead to erratic driving, property damage, and possible collisions. However, collisions with small animals are unlikely to cause significant injury or property damage, and are therefore seldom reported to authorities (Litvaitis and Tash 2008; Preston et al 2006; Huijser et al 2009). Small animals are more likely to be hit repeatedly, often rendering them unrecognizable, where this is rarely a problem when identifying large animal road mortality (Huijser et al 2007a). The literature often addresses those problems separately, and this study focuses only on the problems associated with large animal vehicle collisions (Hesse 2006).

Colliding with any large animal is very dangerous, but some animals are more likely to cause significant damage (Preston et al 2006). Moose-vehicle collisions (MVCs) are particularly hazardous, and the most likely of any WVC to cause injury or death of the people in the vehicle (Transport Canada 2003; Gunson and Mountrakis 2009; AMEC Earth & Environmental 2004). Standing up to nine feet tall and weighing 1000 pounds, moose often cause extreme damage to the vehicle, as the animal is thrown onto the windshield, roof, and often into the front passenger seat after impact (Transport Canada 2003; Gunson and Mountrakis 2009; Christie and Nason 2003). The moose usually has its legs broken upon impact (Transport Canada 2003; Gunson and Mountrakis 2009). In Newfoundland, where the majority of WVCs involve moose, the animal dies in 89 per cent of collisions (L-P Tardif & Associates Inc. 2006). In comparison, the average deer weighs about 110 pounds, and often only damages the front of the vehicle (Jackson 2006; Transport Canada 2003). Between 2002 and 2005, a Vermont study shows 33 per cent of collisions with moose caused the injury or death of drivers or passengers, whereas only seven per cent of collisions with deer caused the same damage (Gunson and Mountrakis 2009). Human fatality occurs in much less than one per cent of all WVCs involving deer, with non-fatal human injuries occurring in 20 per cent of these collisions (L-P Tardif & Associates Inc. 2003).

2.3 WVCs and Conservation

The human safety dangers of WVCs are often easier to understand than the long-term effects of wildlife mortality on animal populations. Fewer human injuries and fatalities result from WVCs than other types of motor vehicle accidents (Huijser et al 2007b). However, WVCs almost always result in the death or serious injury of the involved animals (Gunson et al 2003; Seiler 2004; Huijser et al 2009; Huijser et al 2007b). These collisions “probably overtook hunting as the leading direct human cause of vertebrate mortality on land” over the past few decades (Gunson et al 2003, 355).

Road mortalities can have effects on animal populations beyond the deaths of the involved animals (Huijser et al 2009). Species-specific data collection reveals the erosive effect of wildlife road mortalities, which can lead to local population extinction in some cases (Preston 2006; Litvaitis and Tash 2008). Many species at high risk of population decline from road mortalities share important characteristics. These include slow species, animals drawn to the habitat of the roadside or avoid contact with open areas, with low population density, require large ranges, and those with low reproduction rates (Creative Resource Strategies 2008; Clevenger and Wierzchowski 2006). Some Canadian provinces collect the age and sex of the animal which can help conservation planners understand population level implications of road mortalities. For example, when the female population is at higher risk of being involved in a collision, it can "substantially skew a population and reduce long-term viability even though the species remains present at the site" (Litvaitis and Tash 2008, 690). These trends can significantly reduce animal populations over the long term (Litvaitis and Tash 2008).

In some cases, the barriers created by road networks become too large for species to negotiate, limiting their normal movement and isolating species subpopulations (Creative Resource Strategies 2008; Clevenger and Wierzchowski 2006). Physical, landscape and environmental characteristics such as the traffic volume, speed, road width and roadside habitat or cover, influence the barrier effect of a road (Appendix A). Over time, this can "result in higher mortality, lower reproduction, and ultimately smaller populations and lower population viability" (Clevenger and Wierzchowski 2006, 505). Many WVC mitigation techniques can actually increase the barrier effect, further hindering the ability of wildlife populations to move about the landscape (Appendix B). Facilitating the movement of at risk or endangered species can play a crucial role in ensuring the long-term viability of the animal populations (Creative Resource Strategies 2008). In addition, connectivity is essential for maintaining genetic flows within a number of small sub-populations of a species and important for long-term survival and biodiversity (Creative Resource Strategies 2008; Lee et al 2006).

2.4 WVCs and Data Collection

Transport Canada requires all Canadian provinces to collect WVC data. The police collect this data during normal collisions reporting, as they are required to collect data on all collisions causing injury, death or property damage of more than $1,000 ($2,000 since January 2011) (Anonymous Interview MTO, 2011). A body within each province aggregates this data, and sends their collisions information to Transport Canada's Road Safety Directorate for inclusion in the National Collisions Database (NCD) (Gunson et al 2003).

Much evidence suggests that the NCD data greatly underestimates the actual number of WVCs. First, there are the myriad reasons underreporting occurs that have been identified. Second, the NCD does not include WVCs causing less than $1,000 property damage ($2,000 as of January 2011). Third, police in all provinces are required to report collisions with wild animals, but when police are not at the scene, they must rely on the public to report WVCs, especially in remote areas (Huijser et al 2007a). Self-reported accidents often distort or omit details, meaning location and circumstance details are unreliable or inaccurate (Huijser et al 2007a; Jackson 2006). As such, many collisions remain unreported or erroneously reported (Jackson 2006). Some provinces have higher levels of reporting in their police collected collisions datasets, making interprovincial comparison difficult.

Table 2.1 **WVC underreporting in the National Collisions Database**

	2001		**2002**		**2003**	
Province	**NCD Data**	**Provincial**	**NCD Data**	**Provincial**	**NCD Data**	**Provincial**
BC	1,742	-	2,059	**9,300**	2,346	**9,100**
Saskatchewan	3,727	**11,775**	5,923	**11,514**	9,728	**13,966**
Manitoba	3,413	**9,389**	3,379	**9,262**	4,185	**10,804**
Newfoundland & Labrador	372	**718**	436	**805**	376	**706**

Source: Adapted from L-P Tardif & Associates Inc. 2006, 30

Table 2.1 shows the discrepancy between data included in the NCD and additional data collected within the province. The table suggests considerable under-reporting of WVCs in Canada at the national level, and for provinces without additional data collection (L-P Tardif & Associates Inc. 2003). The provinces included in this table are those that collect additional data at the provincial level. This helps to illustrate the amount of underreporting in the NCD; there are provinces that do not collect additional data provincially, and so cannot determine the actual magnitude of the problem. To reiterate, while underreporting exists in all jurisdictions for a number of reasons, the problem is larger in provinces that do not collect data above that required by Transport Canada and included in the NCD (Huijser et al 2007a).

Studies suggest the data in the NCD represents only half of the actual WVCs in Canada (L-P Tardif & Associates Inc. 2006). Some studies suggest underreporting is high even in provinces collecting additional data, with estimates ranging from 20 to 50 per cent underreporting for easily recognized species (Hesse 2006; L-P Tardif & Associates Inc. 2003; Huijser et al 2007a). Some researchers "allow for a correction factor" to make a more realistic approximation when estimating the total number of WVCs (Huijser et al 2007a, 6).

2.5 Introduction to WVC Mitigation

There is no easy or obvious solution to WVCs and mitigation measures cannot completely eradicate the problem. There are more than 30 WVC mitigation techniques, each with specific attributes (Huijser et al 2009). Mitigation can be permanent, implemented for a short time, over long or short stretches of road, can allow for relocation or be static, and facilitate animals' natural movements to different extents (Huijser et al 2009). Normally, mitigation techniques are meant to change the behaviour of either animals or drivers (Glista et al 2009; Huijser et al 2007a; Appendix B). Many studies report roadside wildlife exclusion fencing combined with ecologically sound overpasses and underpasses as the most effective mitigation strategy (Cramer and Bissonette 2007; Malo et al 2004; Harper 2004). However, the effectiveness and associated costs of most mitigation measures are poorly evaluated (Huijser et al 2009; Clevenger et al 2006a; L-P Tardif & Associates Inc. 2003; Glista et al 2009).[2]

[2] Since the 1970s, the kilometres of road with underpasses and overpasses and exclusion fencing, meant to facilitate wildlife movement, have grown substantially (Cramer and Bissonette 2007; Clevenger and Wierzchowski 2006). More transportation agencies are accepting the importance of mitigation in solving the human safety and conservation problems associated with WVCs (Cramer and Bissonette 2007; Malo et al 2004; Harper 2004).

2.6 WVCs in Ontario

WVC mitigation planning is the responsibility of the Ministry of Transportation in Ontario (MTO). The MTO has five regional offices - Central, Eastern, Northeastern, Northwestern, and Southwestern. Each office is responsible for the "….planning, design, construction, maintenance, operational and management of the provincial highway network" (MTO Website). It is the responsibility of the Regional MTO offices to create WVC mitigation within their Region with respect to the overarching strategies developed by the Ontario Ministry of Natural Resources (MNR)(Anonymous Interview MTO, 2011).To date, the approach to WVCs in Ontario centres more on providing general guidelines and goals than implementing a comprehensive WVC reduction strategy.

Two Ministry of Natural Resources strategies guide the current provincial approach to WVC mitigation (Anonymous Interview MTO, 2011). The Ontario Ministry of Natural Resources (MNR) *Strategy for Preventing and Managing Human-Wildlife Conflicts in Ontario* recognizes WVCs as a problem in need of mitigation, but provides few ideas as to how best to approach this issue – let alone provide for a province-wide strategy (Ontario MNR 2008). Likewise, the *Strategy for Preventing and Managing Human-Deer Conflicts in Southern Ontario* prioritizes collecting additional WVC data to better understand and guide mitigation planning, but suggests few other actions (Ontario MRN-S 2008).

To date, Ontario has implemented relatively inexpensive and small-scale mitigation measures with unknown or limited effectiveness (Huijser et al 2007c; Appendix A). Some areas of Ontario employ "education and awareness, fencing, lighting, repellents, signage and some areas with special speed limits" to reduce the frequency of WVCs on their roadways (L-P Tardif & Associates Inc. 2006, 27). For the first time, the MTO published a wildlife brochure, and there "was significant interest by media outlets in southern and eastern Ontario to host on-air interviews to discuss this issue" (L-P Tardif & Associates Inc. 2006, 28). The Ontario Road

Ecology Group, established in 2007 out of the Toronto Zoo, continues to “raise awareness about the threat of roads to biodiversity in Ontario, and to research and apply solutions to these threats” (Gunson et al 2009b, 2). Plans to expand the provincial highway network have increased activity on this problem in the province. There are some municipal planners working to incorporate mitigation into the planning process in order to build more environmentally acceptable roads (Gunson et al 2009b). Ontario does not have a comprehensive plan that targets the worst collision sites for mitigation, which would allow them to choose the most effective technique to mitigate the number of collisions, and act cost effectively (Sielecki 2004).

Transportation and conservation agencies have scarce resources and a great many responsibilities; accurate, comprehensive, and methodically collected WVC data can be an important step towards comprehensive mitigation planning (Gunson and Mountrakis 2009). In terms of data collection, the Ontario Provincial Police (OPP) database is the only province wide WVC information source in Ontario. The MTO compiles police collision reports in a central database (Elzohairy et al 2004). The regional MTO offices acquire the data through Ontario’s Accident Data System (ADS), and Transport Canada receives this information from the MTO for inclusion in the National Collisions Database (NCD) (Anonymous Interview MTO, 2011). With the exception of the Northeastern Region discussed later, the OPP collects all of the WVC information available to the MTO’s provincial and regional offices (Anonymous Interview MTO, 2011). The MTO has access to information on collisions that occur within cities and municipalities, but the information is limited, and they cannot access location information (Anonymous Interview MTO, 2011).

The OPP collect data on all reportable collisions within the data collection threshold. A reportable collision causes injury, fatality or more than $1,000 property damage (Jackson 2006). The threshold is likely to increase to $2,000 due to a recommendation by the Canadian Council of

Motor Transport Administrators in January 2011 (Anonymous Interview MTO, 2011). [3] Individuals involved in collisions may self-report PDO accidents if the OPP are not at the scene of the collision (Jackson 2006). Collision centres make self-reporting easy, but inevitably mean a large number of PDO collisions go unreported (Jackson 2006; MTO Website). Unreported collisions resulting in fatality or injury happen much less frequently than collisions causing PDO (L-P Tardif & Associates Inc. 2006).

The OPP's primary goal for collecting collisions information is to increase public safety on the road network, which is evident in the variables they collect at the collision site (Huijser et al 2007b). There are three different kinds of information collected through OPP Collisions Reports in Ontario. 'Basic collision information' includes 66 variables about the accident: these include the weather, kind of road, conditions, time and date, and location (Elzohairy et al 2004, 4). The OPP records this basic information for each reported collision. The 'sequence of events variable' has 38 options (Elzohairy et al 2004, 4). When an accident is coded 09, it means that the vehicle hit a wild animal (Elzohairy et al 2004). While the officer may choose to describe the animal in the accident report, they cannot code the species for inclusion in the database (Anonymous Interview MTO, 2011). The final section, 'driver/vehicle information,' consists of 50 parts, and records information such as the speed at time of collision, the driver's demographic information, and model of the car (Elzohairy et al 2004, 4). The OPP fills this out for every vehicle and individual involved in a collision, so there can be multiple reports for each collision (Elzohairy et al 2004). Last, there is 'involved person information,' filled out if the collision causes injury or fatalities to the driver or passengers of the vehicles involved (Elzohairy et al 2004, 4). This last section consists of 14 variables (Elzohairy et al 2004).

The spatial accuracy (SA) of the data is the closeness of the reported collision to the actual collision, determined in distance or spatial error. In OPP reported collisions data, this is

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[3] This new $2,000 threshold has already been implemented in Quebec and Alberta (Anonymous Interview MTO, 2011)

done through a linear highway referencing system (LHRS), based on kilometre reference numbers, which means that the spatial error in each case is partially dependent on the diligence of the officer making the report (Anonymous Interview MTO, 2011). The LHRS can hypothetically predict spatial accuracy to within 3 meters, but some reports can be several hundred meters from the actual crash site, making the data inconsistent (Anonymous Interview MTO, 2011). OPP officers are more careful to record accurate location data when the collision resulted in fatality or injury (Anonymous Interview MTO, 2011). The high spatial error in this dataset limits the kinds of spatial analysis that can be done to determine the worst collision sites.

In Ontario, the “lack of comprehensive data is a serious problem,” stalling efforts to move towards a more effective mitigation strategy (Sielecki 2005a, 19). Although there are inherent issues with police reported WVC data – including the quality of self-reported data and reporting thresholds - “these reports are more effective for analyzing data nationally, because there is more consistency in their collection” than the many different data collection methods found in the provinces (Huijser et al 2007b, 4). Overreliance on Police collected WVC data restricts the progress Ontario can make towards a comprehensive mitigation plan. Limited data collection is “a major challenge that must be addressed before WVCs can be systematically reduced” (Huijser et al 2007b, iii). In order to add significant value, high quality WVC information must be able to “optimize decisions and investments” in mitigation planning; target the worst hotspots, choose the best site-specific mitigation technique, and monitor and evaluate effectiveness (Sielecki 2005a, 19).

2.7 Ontario Summary

There are a large number of WVCs in Ontario every year, causing significant property damage, injury and human fatalities. These accidents are very expensive for Ontarians. The amount of underreporting in the province makes identifying the actual magnitude of the problem very difficult. Police data is inherently limited by reporting thresholds and self-reporting and there is no easy way to decrease the underreporting in the OPP collisions database. In addition, the data has a high spatial error, is not species specific, and no additional parameters are collected. The WVC problem is not predicted to resolve itself without mitigative measures. While Ontario's MNR has identified the need for mitigation and additional WVC data, they fail to identify next steps. Ontario's current mitigation strategy appears limited, primarily based on small-scale, relatively inexpensive mitigation with limited effectiveness. Despite this, there seems to be some interest in mitigating new highways in the province.

3: Methodology

This study compares WVC mitigation experience in BC, Newfoundland & Labrador and Saskatchewan to explore how Ontario might reduce WVCs. The case study approach makes it possible to understand contextual conditions and practical implications when considering the chosen WVC strategies (Yin 2009). Each case contains subsections regarding the *extent of the problem* within the province and *current mitigation measures.* In each case, special emphasis is on *data collection* as it pertains to mitigation, which is the primary concern of the Ontario MTO. The case studies provide information as to what might be necessary or sufficient to in order to move towards a comprehensive WVC mitigation strategy for Ontario. Interviews with provincial officials from Ontario and the case study jurisdictions provide case study content, augmented with information from government reports and other studies. The remainder of this section outlines the case selection rationale and information collected for each case.

3.1 Rationale for Case Selection

This section briefly outlines the case selection process, with Table 3.1 offering a broad comparison of key mitigation components in each province.[4] Table 3.1 compares provinces according to whether the province: 1) follows a comprehensive mitigation plan; 2) has large-scale mitigation projects; 3) undertakes pilot projects; and, 4) has an additional WVC data collection technique. As explained below, Ontario meets none of these criteria, while all selected case provinces have made progress in at least one of these areas.

[4] PEI is excluded as the Department of Transportation and Public Works reports no WVC problem on the Island (L-P Tardif & Associates Inc. 2006)

Table 3.1 **Canadian Provinces: Towards Comprehensive WVC Mitigation Strategies**

Province	Provincial Plan	Large Scale Mitigation	Pilot Projects	Additional Provincial WVC Data Source
British Columbia	YES	YES	YES	YES
Quebec	NO	YES	YES	YES
Saskatchewan	NO	NO	YES	YES
Alberta	NO	YES	YES	NO
Newfoundland & Labrador	NO	NO	NO	YES
New Brunswick	NO	YES	NO	NO
Manitoba	NO	NO	NO	YES
Ontario	NO	NO[5]	NO	NO
Nova Scotia	NO	NO	NO	NO[6]

Table 3.1 displays the relative advancement of province's WVC policies. This study uses three case studies to examine different WVC strategies: British Columbia, Saskatchewan and Newfoundland & Labrador. British Columbia is included as the province has a provincial WVC mitigation plan, large-scale mitigation, pilot projects, and collects WVC data in addition to that provided by police. Saskatchewan is included as a case due to pilot project experiments and an additional provincial WVC data collection method (L-P Tardif & Associates Inc. 2003). Newfoundland and Labrador round out the cases as this province has an additional WVC data collection source, collected through multiple-ministry cooperation (Anonymous Interview NFLD DNR, 2011).

While ahead of many other provinces, Quebec is not included as the province recently changed data collection methods, and implementation of additional data collection is variable across the provinces 14 regions (Anonymous Interview Quebec MNR, 2011). This study also excludes Alberta. The province has pilot projects and large-scale mitigation, but it does not

[5] There is large scale mitigation and plans for several pilot projects in the Northeastern Region; this is the only MTO Region with additional data collection and more comprehensive mitigation planning

[6] The Nova Scotia DNR might collect CC information; the literature has been unclear (Huijser et al 2007a,; L-P Tardif & Associates Inc. 2006). I was unable to contact anyone in the provincial government to confirm whether they did or not

collect more than the minimum amount of data required for Transport Canada. In addition, most mitigation measures exist along highways administered by Parks Canada within Banff and Jasper National Parks (L-P Tardif & Associates Inc. 2006). While New Brunswick has a number of large-scale mitigation projects, the province is not included due to a piecemeal approach to mitigation through which "various mitigation measures have been attempted, but often without knowledge of accident patterns" (Christie and Nason 2003, 11).

3.1.1 Multi-Case Analysis

This study compares WVC mitigation details and data collection methods in Saskatchewan, Newfoundland & Labrador and British Columbia. Each case study introduces the extent of the WVC problem, and then provides insight into what mechanisms can begin to reduce WVCs as well as general lessons about WVC reduction strategies. Investigated elements include an examination of current provincial mitigation measures, including small and large-scale mitigation, pilot projects, and monitoring efforts followed with an examination of the provincial WVC data collection methods, including all bodies collecting data in the province, with emphasis on any limitations to analyses presented by the data. A review section at the end of each case summarizes its best qualities and recognizes its limitations.

4: Case Studies

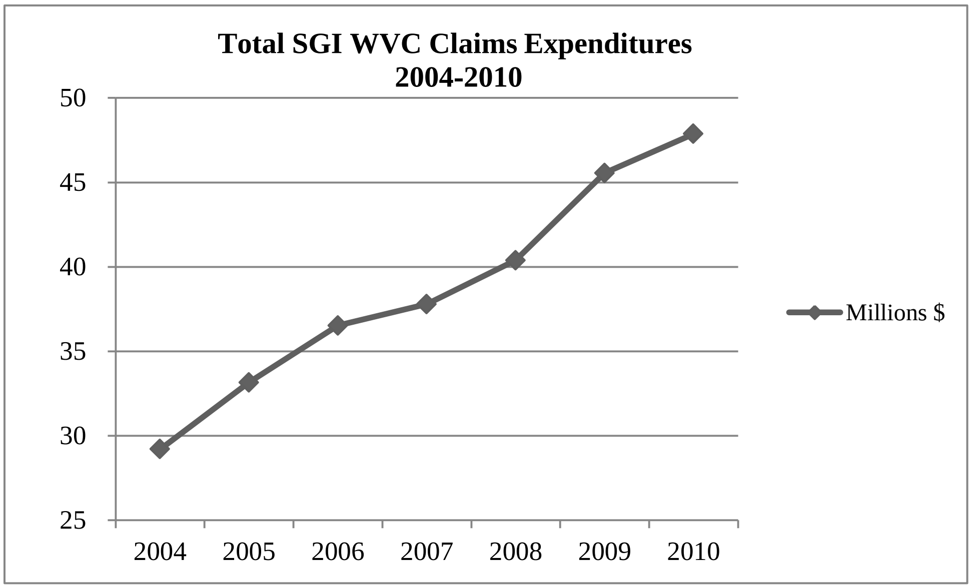
WVCs are an international issue, but as the “severity of the damage problem depends on the number of large animals and the volume of traffic on the roads that animals roam onto,” almost all Canadian provinces face a significant WVC problem (Jackson 2006, 14). Systemic underreporting of these accidents hides the costs, which might be necessary to “justify the expense of mitigation measures” (Huijser et al 2007a, 6). Saskatchewan, Newfoundland and British Columbia’s current mitigation and data collection methods are examined in this section as they have been able to attain greater success in their WVC strategies, and are closer to finding solutions to this problem.

4.1 Saskatchewan

In 2006, the government of Saskatchewan reported almost 16,000 WVC related claims, causing more than $29 million in damage (SGI Website). Animals were involved in approximately 18 per cent of all collisions in 2009, with 66 per cent of all WVCs occurring on provincial highways, 26 per cent on rural roads and only 13 per cent in urban areas (SGI TAIS 2009). These numbers are bound to climb due to increasing numbers of vehicles and animals (SGI TAIS 2008; SGI News Release 2010). Saskatchewan has had deer-vehicle collision problems for decades, but there have been more accidents with larger ungulates, such as elk and moose, in recent years (SGI Website). The Saskatchewan Government Insurance website warns drivers to be extra cautious in the early morning and evening, in the spring, late in the fall, and into the winter because of seasonal movements of animals (SGI Website). The summer months can be high risk because of the increased number of people travelling (SGI Website). Figure 4.1

shows the financial costs of claims associated with WVCs in the province. The total number of claims has increased, as well as the total costs to SGI and taxpayers.

Figure 4.1 **Total SGI WVC Claims Expenditures: 2004-2010**



Source: Saskatchewan Government Insurance

4.1.1 Mitigation

WVC mitigation planning and the safety of the road network is the responsibility of the Saskatchewan Ministry of Highways and Infrastructure. The Ministry has their provincial headquarters in Regina, and operates out of three Regions - Southern, Central and Northern – that have full jurisdiction over the infrastructure on their section of the road network (Anonymous Interview Saskatchewan Highways and Infrastructure, 2011). Saskatchewan has "electronic warning systems, fish culverts, reflectors and zones with special speed limits" intended to reduce the frequency of WVCs on parts of the roadway (L-P Tardif & Associates Inc. 2006, 27). Saskatchewan's mitigation efforts to date have primarily included small-scale, relatively inexpensive mitigation, including signs and public education. The Ministry of Highways and Infrastructure implements these measures after identifying a problem area, and commencing an on-site-inspection. They often clear the area by the roadside in order to increase drivers' visibility of animals (Saskatchewan Highways and Infrastructure Website).

Saskatchewan's long-standing public awareness campaign, *Slow Down & Save A Buck*, is a partnership of the *Saskatchewan Wildlife Federation* (SWF), SGI and the *Saskatchewan Transportation Company* (STC) (STC 2009). The main message of the initiative is to remind the travelling public to be wary and slowdown in high risk areas of the province (STC 2009). This message is distributed on "highway billboards, radio and television PSAs, and informational dinner placemats" throughout Saskatchewan (SGI News Release 2010). Shown below, STC places logos on part of their transportation fleet in order to spread the message (STC 2009; SGI News Release 2010).

Figure 4.2 ***Slow Down & Save A Buck* Campaign Logo**

Source: STC 2009, 17

Many mitigation strategies are still in the experimental stage; implementing and monitoring pilot projects is an expensive process[7] (Glista et al 2009). The "results from most studies are based on anecdotal information," as meaningful conclusions require extensive evaluation before and after construction, which is rarely done (Clevenger and Wierzchowski 2006, 509). In 2002, a two-year Wildlife Warning System pilot project was implemented in Saskatchewan on a five-kilometre WVC hotspot on Highway 7 (Government of Saskatchewan News Release 2002). The project's implementation was a collaborative effort between

[7] Often, a project will put most of its resources into proven mitigation techniques initially, those that are sure to be effective, in order to get more funding; after this, some money is more likely to be put aside for experimental and pilot projects (Huijser 2010).

Saskatchewan Highways and Transportation, SGI and International Road Dynamics, a Saskatoon based company (Government of Saskatchewan News Release 2002). Saskatchewan Highways and Transportation and SGI both contributed $25,000 (Government of Saskatchewan News Release 2002). A Wildlife Warning System senses a car, and then uses sounds or lights to scare the animal away from the road (Government of Saskatchewan News Release 2002). This system would not increase the barrier effect of the road. After the two year period, the pilot was evaluated by the "IRD, SGI, Saskatchewan Highways and Transportation, Saskatchewan Environment, Saskatchewan Wildlife Federation, RCMP, Canadian Automobile Association, Saskatoon and Area Safety Council and the West Central Municipal Government" (Government of Saskatchewan News Release 2002).

4.1.2 Data Collection Methods

In Saskatchewan, the police collect WVC information through collision reporting, and Saskatchewan Government Insurance (SGI) collects additional information through claims. The *Traffic Safety Act*, Section 253 makes the RCMP responsible for completing a Motor Vehicle Accident (MVA) form for every reportable collision in the province (SGI TAIS 2009). The RCMP data codes a WVC as an accident involving a wild animal, but do not collect additional species-specific information (Anonymous Interview Saskatchewan Highways and Infrastructure, 2011). While police reporting thresholds are the same as in other provinces, even if PDO accidents are unreported to the police, SGI claims information captures many of them (SGI Website). When property damage is below the police-reporting threshold, which is still $1,000 in the province, "the damage is less severe, you may continue driving and follow regular SGI claims reporting procedures" (SGI Website).

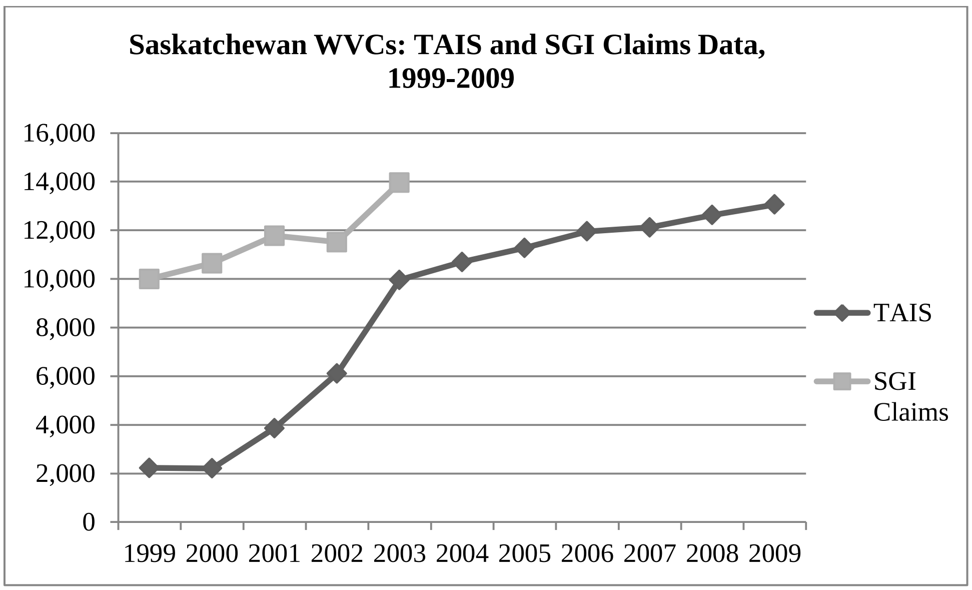
SGI is a public no-fault automobile insurance provider responsible for the vast majority of cars in the province with the same extended coverage, including collisions with wildlife (L-P Tardif & Associates Inc. 2003). SGI publishes an annual report outlining the province's collisions statistics. The Traffic Accident Information System (TAIS) combines police reported information with claims information in order to best represent the true number of collisions (SGI TAIS 2009). TAIS receives police accident reports for all collisions "involving bodily injury or death, a hit and run, and out-of-province vehicle, and unregistered vehicle, an impaired operator and collisions where vehicles have to be towed" (SGI TAIS 2009, i). PDO collisions reported in TAIS include all the claims information that fits into the police-reporting threshold.

SGI analyses the data, and shares the police and claims information with the Ministry of Highways and Infrastructure. The Ministry determines if the data shows changes that might warrant further inspection and possible safety measures (Anonymous Interview SGI, 2011). If the Ministry decides there is a new high-risk area, they will do an on-site investigation to look at a number of factors, and decide if some small-scale mitigation is necessary at that location (Anonymous Interview Saskatchewan Highways and Infrastructure, 2011). The provincial DNR is not involved in the site inspections, as the practice's intent is to increase the safety of the road network (Anonymous Interview Saskatchewan Highways and Infrastructure, 2011).When making an insurance claim, an individual makes approximations about the location of the collision and the species involved in the accident (Anonymous Interview SGI, 2011). The claims reporting system is not systematic data collection, as there is no reason to believe every person making a claim has enough knowledge to identify different species. Similarly, the claims applicants make approximations to the location of their accident, which ensures an unidentifiably high spatial error within the data. Police reported data and claims information are both collected on all roads in Saskatchewan (Anonymous Interview Saskatchewan Infrastructure and Transportation, 2011).

The high spatial error of the Claims information limits the data's practical uses. While less spatially accurate (SA) datasets can identify rough hotspots at the provincial level, high quality WVC information can be extremely important or crucial for planning and implementing site-specific mitigation (Huijser et al 2007a; Litvaitis and Tash 2008; Clevenger et al 2006b). A

SA dataset is "essential for rigorous analysis and development of sound mitigation recommendations" (Clevenger et al 2006b, 18-20). This information helps planners decide what mitigation strategy is best suited to a site, if mitigation is required, the best location for installation, and allows them to monitor its effectiveness, using before and after information (Huijser et al 2007a; Litvaitis and Tash 2008).

Figure 4.3 **Total WVCs in Saskatchewan: 1999-2009**



Source: SGI TAIS Annual Reports, 2004-2009; L-P Tardif & Associates Inc. 2006, 24

Figure 4.2 shows that the collisions that cause PDO of less than $1,000 "are collected through SGI's claims reporting process," but not included in TAIS reports (SGI TAIS 2009, i). SGI claims represent the most accurate measure of the total number of claims in the province. SGI gives the annual TAIS data to Transport Canada for inclusion in the NCD (L-P Tardif & Associates Inc. 2006). This information is better than many other provinces statistics because it incorporates claims information to make the provincial totals more accurate than provinces with systemic underreporting of PDO collisions through police reporting alone.

4.1.3 Saskatchewan Summary

- Claims information is the best-known way to correct for under-reporting when the insurance company represents most vehicles in a jurisdiction with the same level of coverage (Huijser et al 2007b). Insurance claims information captures a large portion of total accidents that would otherwise be underreported; this includes collisions with PDO that are not reported to police, and collisions with property damage less than the police's collisions reporting threshold (Huijser et al 2007b).
- This system is sometimes criticized for possible over-reporting as members of the public have the incentive to make claims in order to have their damages paid and keep their premiums low, even if the reported collision was not really a WVC (L-P Tardif & Associates Inc. 2003; Huijser et al 2007b).
- The TAIS information sent to Transport Canada for inclusion in the NCD captures many more collisions than only police data, even though it reports within the NCD threshold.
- Public insurance agencies are likely to become involved in mitigation, as it can be a cost-effective means of cutting down the costs of claims, even though they have no obligation to do so
- Claims information rarely includes additional parameters (Huijser et al 2007b). The quality of data is difficult to increase, as additional parameters cannot be collected systematically or reliably when the collection relies on anecdotal claims information. It would be very difficult to acquire spatially accurate or species specific information through the claims process.

4.2 Newfoundland & Labrador

Moose-vehicle collisions (MVCs) are the most significant WVC problem in Newfoundland, representing the vast majority of all WVCs and the greatest threat to human safety and property (Anonymous Interview NFLD DNR, 2011). According to the Newfoundland

RCMP, the average property damage caused by a MVC is $3,000 (L-P Tardif & Associates Inc. 2006). "Cost estimates for vehicle damage alone are more than $1 million annually" in the province, and the total annual cost of this problem is approximately $2,250,000 (NFLD Department of Environment and Conservation Website; Joyce and Mahoney 2001, 285). Almost three quarters of these accidents happen between May and October, with more in the busy summer months (NFLD Department of Environment and Conservation Website). Moose and caribou are the only ungulates in Newfoundland, but the Moose population has continued to grow for the past decades (Anonymous Interview NFLD DNR, 2011).

4.2.1 Mitigation

All mitigation is prioritized at the provincial level by the Department of Transportation and Works and the Department of Environment and Conservation (Anonymous Interview NFLD DNR, 2011). Newfoundland and Labrador primarily use small-scale mitigation to reduce MVCs; they are "focusing mostly on signage and education/awareness campaigns especially during the peak seasons" (L-P Tardif & Associates Inc. 2006, 26). The Department of Transportation and Works is responsible for putting up signs in MVC hotspots, some which indicate the number of collisions occurring long a section of road, and clearing vegetation on the roadside to deter moose and increase driver visibility (AMEC Earth & Environmental 2004). The Department of Environment and Conservation run a MVC awareness campaign (Anonymous Interview NFLD DNR, 2011).

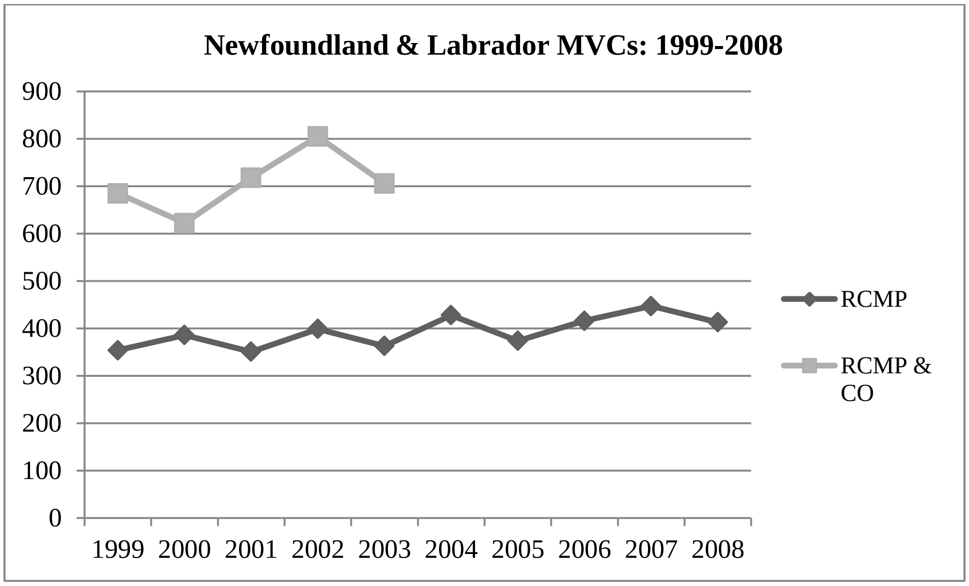
4.2.2 Data Collection Methods

Moose-Vehicle Collisions data is collected by the RCMP collisions reporting, and the Newfoundland and Labrador Department of Natural Resources Forestry Division Conservation Officers (COs) Incidence Reports (Joyce and Mahoney 2001). Two police agencies report MVC data in Newfoundland & Labrador: the RCMP report MVCs through *Royal Newfoundland*

Constabulary Motor Vehicle Collision Reports everywhere in the province except St Johns and Corner Brook. The *Royal Newfoundland Constabulary* is the police force that operates in St. Johns and Corner Brook, and is responsible for reporting MVCs within the cities' limits (Anonymous Interview NFLD DNR, 2011). The Department of Transportation and Works acquires this data from the police agencies, and shares the information with Transport Canada for inclusion in the NCD (L-P Tardif & Associates Inc. 2006). The Wildlife Division in the Department of Environment and Conservation acquires the police MVC dataset through a provincial Access Database (Anonymous Interview NFLD DNR, 2011). Any collision causing more than $1,000 PDO, injury or a fatality must be reported to the police, but evidence suggests there is considerable underreporting (Joyce and Mahoney 2001). Underreporting in the RCMP dataset is apparent in Figure 4.4.

The Forestry Division in the provincial DNR maintains the Conservation Officer (CO) collected CC incidence report database (Anonymous Interview NFLD DNR, 2011). Conservation Officers are responsible for clearing animal carcasses off the provincial road network (Anonymous Interview NFLD DRN, 2011). The RCMP calls the Forestry Division and informs them when there is a moose on the highway right of way, and the CO clears the animal away and fills out an incidence report (Anonymous Interview NFLD DRN, 2011). Carcass count (CC) data is based on the dead animals found by the roadside. As the information does not come from collision reports, there is no proof that the wildlife mortality occurred because of a collision, but the assumption is the vast majority of road kill are consequences of unreported collisions with wildlife. The CO records the gender of the moose and chooses "calf, yearling, adult" for age (Joyce and Mahoney 2001, 284). CO's started using GPS in 2010, significantly increasing the SA of the information collected (Anonymous Interview NFLD DRN, 2011).

Figure 4.4 **Total WVCs in Newfoundland, 1999-2008**



Source: Newfoundland & Labrador Department of Natural Resources; L-P Tardif & Associates Inc. 2006, 18

As show in figure 4.4, between 1988 and1994 the RCMP reported 5,422 MVCs, and CO's reported 6,070 (Joyce and Mahoney 2001). Of these incidences, 648 records overlapped (Joyce and Mahoney 2001). The two databases were reconciled until 2003, and maintained separately since (Anonymous Interview NFLD DRN, 2011). The reconciliation was not adding significant value, as its main limitation was huge spatial error that constrains MVC analysis (Anonymous Interview NFLD DRN, 2011). In order to reconcile the datasets, duplicates had to be removed (Joyce and Mahoney 2001). This process took considerable resources - one employee was working on it specifically – which was unsustainable due to a lack of resources and manpower (Anonymous Interview NFLD DNR, 2011). The Department of Transportation and Works and the Wildlife Division in the Department of Environment and Conservation use the police reported MVC database. They choose to use this data because the police record more variables on the crash site and accident characteristics, and the information collection is more systematic (Anonymous Interview NFLD DNR, 2011). The Department of Transportation &

Works is in the process of acquiring GPS for the police collision reports as well, as poor SA has limited their ability to do effective analysis (Anonymous Interview NFLD DNR, 2011).

The huge spatial accuracy associated with the data constrains its possible applications for transportation and conservation planners (Anonymous Interview NFLD DNR, 2011). Hotspots are areas that experience comparatively high WVC rates, and are found where wildlife crossing points are crowded into specific sections of the road and times of day instead of occurring randomly (Gunson and Mountrakis 2010; Clevenger et al 2006a; Malo et al 2004; Leblond et al 2007). Hotspots identification occurs at different scales, roughly over large areas, or on particular road segments at the project level. Identifying hotspots allows transportation planners to prioritize dangerous road segments and choose effective mitigation techniques. In order to do site specific hotspot analysis, it is critical to have SA data. Ideally, the spatial accuracy of the data would be within 3 meters of the actual collision site, but accuracy to within 100 meters can still create a meaningful dataset (Clevenger et al 2006a; Gunson 2009). Hotspots are especially apparent in heterogeneous landscapes, where WVCs are rarely randomly distributed, and more likely be found tightly grouped (Gunson et al 2005; Clevenger et al 2006b). There are a number of statistical modelling techniques used to find hotspots within datasets, including but not limited to, the kernel density estimation, the nearest-neighbour method, cluster analysis, and segmental analysis of densities (Gunson and Mountrakis 2009; Clevenger et al 2006b). The RCMP collisions reporting process collect data with a huge spatial error, making meaningful hotspot analysis virtually impossible at the project level (Anonymous Interview NFLD DNR, 2011). This was the case with both datasets in 2003, as even rough provincial level hotspot identification was difficult with the high spatial error of the data, and so there was little added value combining the datasets (Anonymous Interview NFLD DNR, 2011).

4.2.3 Newfoundland & Labrador Summary

- The different government ministries work together on mitigation within the province, as well as sharing information. This coordination can be important when planning larger strategies (Huijser et al 2007a).
- Spatially accurate data is extremely important. Introducing GPS to conservation officers has made the information much more valuable to transportation and conservation planners by making hotspot analysis possible at a more practical scale. High spatial error makes the information less valuable. The costs of reconciling the data were prohibitively high when there was little added benefit to doing so because of the high spatial error.
- CC information partially corrects for underreporting; this data does not have a PDO threshold, so records collisions that would not be reportable by the RCMP. When the databases are reconciled, the number of collisions is a more meaningful reflection of the actual magnitude of the problem.
- Newfoundland has chosen to look at moose because they cause the most destruction and they are most often involved in animal-vehicle collisions in the province

4.3 British Columbia

BC's road network is approximately 41,000 kilometres long, and more animals are killed through collisions than hunting (Sielecki 2005a). At least 90 percent of all collisions are with ungulates (Sielecki 2003b). Eighty percent of all WVCs are with deer (Sielecki 2003b). While most of BC's population lives in small areas of the province, WVCs occur throughout the province (Hesse 2006). The approximate cost of WVCs in BC in 2002 was $56 million, $26 million of which were wild animal related claims (Sielecki 2003b). Most accidents occur in May and November in all regions of the province (Sielecki 2004). There are many different ecosystems and habitats within the province, and "as a result of the exceptional range of wildlife habitats provided by these bio-geographical zones, British Columbia has one of the most diverse variety of large ungulate and carnivore species in North America" (Sielecki 2005a, 20). The Yellowstone to Yukon initiative is a huge connectivity based project, working to maintain movements for the large variety of species found in the province (Clevenger et al 2010).

Mitigation planning is the responsibility of the British Columbia Ministry of Transportation (MoT). BC MoT strives to "to reduce, and ultimately eliminate" the financial, social, human, and ecological costs of WVCs in the province (Sielecki 2001, 478). The BC MoT has three administrative regions – Southern Interior, South Coast and Northern Regions (Sielecki 2004). The vast majority of WVCs in BC occur in the Southern Interior Region (Sielecki 2004).

4.3.1 Mitigation

British Columbia is very active on mitigation, has implemented a variety of small and large-scale measures, and tested pilot projects. The province has "overpasses, underpasses, fish culverts, badger culverts, fencing, signage, animal detection systems, right-of-way habitat modifications, reflectors and public awareness campaigns" (L-P Tardif & Associates Inc. 2006, 29). The Wildlife Collision Prevention Program (WCPP) ran by the BC Conservation Foundation collaborated with ICBC to implement a Wildlife Protection System (WPS) pilot project on Highway 93S through Kootenay National Park in 2002 (Hesse 2006). In this system, infrared cameras detect wildlife on the road and warn approaching vehicles; this project was monitored for effectiveness (Sielecki 2005a). The WCPP is also committed to raising driver awareness by increasing the incidence and effectiveness of roadside signs, and "conducts print advertising, places brochures in Visitor Information Centres and other businesses, places signs at highway rest stops" (Hesse 2006, 4).

Planners are advised to most effectively focus their energies on species that cause significant public safety problems and those that at high risk of population decline[8] (Litvaitis and Tash 2008; Huijser et al 2009). Indicators of success are often tied to the decrease in total number of WVCs; measuring conservation success is much harder to do, and it can be the mitigation measure's "potential reduction in wildlife-vehicle collisions rather than conservation objectives for threatened, endangered, or relatively rare species" that labels the project a success (Huijser 2010, 10). An effective mitigation strategy should reduce the WVC rate and also maintain or facilitate the movements of animal populations; evaluations of the effectiveness of mitigation techniques must take both of these variables into consideration in order to acknowledge the range of issues associated with WVCs (Clevenger et al 2006a; Huijser et al 2007a).

British Columbia has implemented wildlife exclusion fencing with ecologically adapted overpasses and/or underpasses on the Okanagan Connector, Coquihalla Highway, and the Vancouver Island Highway; the province also has detailed implementation plan for similar structures for the Crowsnest Highway and Highway 93S through Kootenay National Park (Hesse 2006; Sielecki 2005b; Clevenger 2010) . The Coquihalla "is an example of a retro-fit installation on an existing highway" while the mitigation was built into the installation process on the Connector project (Sielecki 2005b, 83). It is more cost effective to work WVC mitigation into new construction projects than on existing roads (Gunson and Mountrakis 2010; Malo et al 2004). However, while the construction of new roads typically seeks to avoid animal habitats and migration routes, this is often not possible (Cramer and Bissonette 2007; Anonymous Interview NE MTO, 2011).

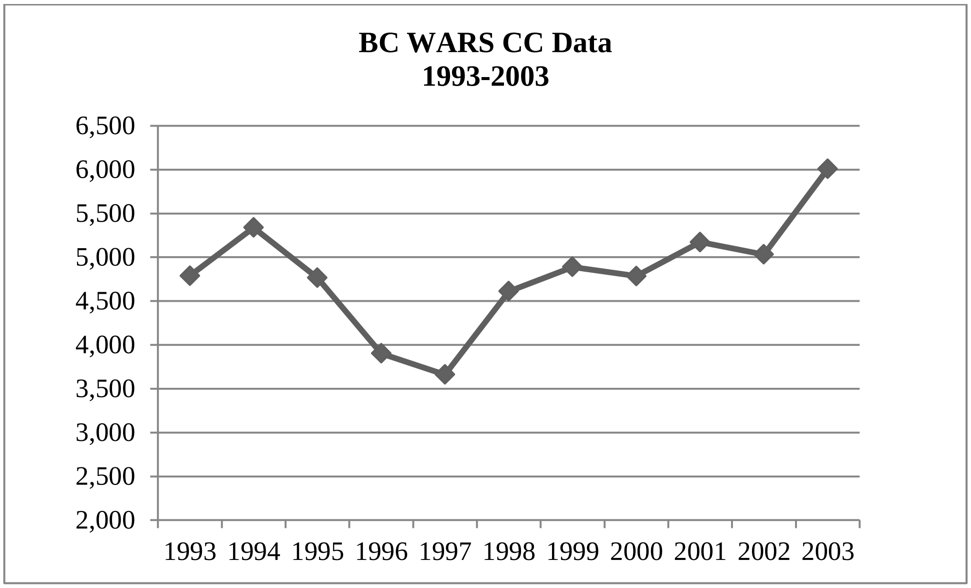
[8] It is easier to determine hotspots for ungulates, as they are involved in most WVCs and therefore have substantial datasets, than species with a smaller number of WVCs, even if they have more significant conservation significance (Litvaitis and Tash 2008).

4.3.2 Data Collection Methods

Three organizations in British Columbia collect WVC and CC information. The RCMP, the Insurance Corporation of British Columbia (ICBC), and the Wildlife-Accident Reporting System (WARS), which is administered by the Ministry of Transportation. The WARS database is "designed to be a decision-supporting tool for developing proactive and reactive wildlife accident mitigation solutions" (Sielecki 2005a, 22). An RCMP officer fills out a Traffic Accident Police Investigation Report, MV6020, for every collision that causes injury, fatality, or more than $1,000 PDO (Jackson 2006; BC Traffic Collision Statistics 2009). Individuals who are involved in a collision that meets this description must self-report to the police within one day if the police did not attend accident (Jackson 2006). Police attend fewer accidents now than they used to before 1996, and there is more underreporting of PDO accidents (BC Traffic Collision Statistics 2009). As is the case with most police reported data, there is probably considerable underreporting of accidents that caused PDO, and accidents that result in injury (Jackson 2006). The Traffic Services Management Information Tool (TSMIT) is the police's collision database, in which all collisions distinguish whether the accident involved a wild animal, but do not contain any species-specific information (Hesse 2006). ICBC compiles and analyses the information on all collisions that result in a fatality or injury, and publishes this in an annual *Traffic Collision Statistics* report (ICBC 2007).

The Insurance Corporation of British Columbia (ICBC) is a public Crown Corporation that provides no fault insurance to the vast majority of vehicles in the province and offers extended coverage on WVCs (Jackson 2006). The claims information contains accurate collision time information, but the species-specific and location information are approximations (Hesse 2006; Jackson 2006). ICBC estimates that three-quarters of all WVCs are included in the claims information (Hesse 2006). Collisions are not eligible for a claim when they cause less than $100 PDO or involve visitors to the province that are insured elsewhere (Hesse 2006). ICBC claims information is the best for compiling the total property damage costs and the total number of WVCs in the province (L-P Tardif & Associates Inc. 2003).

Figure 4.5 **BC WARS CC Information, 1992-2002**



Source: Sielecki 2005a, 29

The Wildlife Accident Reporting System (WARS) is a carcass count (CC) incidence database dating back to 1978; private highways maintenance contractors collect the data on numbered provincial highways (L-P Tardif & Associates Inc. 2003; Sielecki 2001). Figure 4.5 displays WARS collected data from 1993 until 2003. Contractor personnel fill out a WARS H0107 incident form for every animal found by the roadside (Sielecki 2003b; Appendix C). The contractors give the incidence reports to a district level MoT office, where they examine the information before sending it so the provincial MoT can add it to the database (Sielecki 2003b). This data is analysed and periodically published by the BC MoT (L-P Tardif 2003; Hesse 2006). According to Sielecki 2004, WARS information is used by the MOT to:

"1) Identify accident-prone locations and accident trends;

2) direct cost-effective mitigation efforts;

3) evaluate the effectiveness of mitigation techniques;

4) provide data for highway planning purposes;
5) model and forecast accidents;
6) analyze traffic and climatic relationships for species-specific accident trends;
7) develop species-specific accident risk profiles for highway corridors; and
8) establish policies and strategies for accident issues and mitigation initiatives" (Sielecki 2004, i)

The information is systematically collected on a daily basis, and reported monthly; the data includes the "date, estimated time of kill, location, presence/absence of wildlife warning signs and/or reflectors, number of animals killed in the incident, species, and sex" of the animal (Hesse 2006, 4; Appendix C). The depth and accuracy of the WARS data allows transportation and conservation planners to undertake site-specific as well as provincial level analysis (Sielecki 2001). The quality of the information and additional parameters allow planners to make smart decisions concerning public safety and conservation.

Predictive modelling identifies factors that make WVC hotspots more susceptible to high WVC rates (Appendix A). Studies generally test a large number of variables to determine "what characteristics about a hotspot make it more prone to accidents" (Huijser et al 2007a, 7). Researchers determine which characteristics are statistically significant in the creation of collision hotspots (Litvaitis and Tash 2008). Significant factors can include "animal distributions, abundances, dispersal habits, and road-related factors including local topography, vegetation, vehicle speed, and fence location or type" (Clevenger 2006b, 2). Each study is specific to certain habitats, times of year, regions, species populations, and so conclusions will not apply universally. Comparing characteristics at WVC hotspots and cold spots allow planners to export this knowledge to design new roads or plan mitigation that compensate for these factors on existing roads (Litvaitis and Tash 2008; Malo et al 2004).

Spatially accurate (SA) WVC data can identify more statistically significant factors in predicting high WVC locations than data with high spatial error (Clevenger et al 2006a). A study done by Clevenger et al in 2006a found that one-half of the factors they proposed in the study were statistically significant when tested using a data set accurate to three meters, whereas only one tenth were significant when tested with an inaccurate data set. They found that spatially accurate collision data had a “high predictive power,” much more than the spatially inaccurate dataset (Clevenger et al 2006a, 19). Predictive modelling research using data with a high spatial error will “inevitably lead to spurious results at best and thus not produce properly directed or applied mitigation of traffic-related accidents with wildlife” (Clevenger et al 2006a, 20). Many WVC studies fail to explain the quality of their data, “limiting the analyses, conclusions, and recommendations that can be drawn from them” (Huijser et al 2007a, 5). Agencies that collect and analyse WVC data should be aware of the limited applications of datasets with high spatial error (Clevenger et al 2006a). Typical transportation agencies have a high spatial error in their datasets, with WVC location information accurate to about 500 to 800 meters of the actual collisions sites (Clevenger et al 2006a).

The WARS system relies on the diligence of the maintenance personnel to accurately record information, including important parameters such as location and the species of the animal (Sielecki 2003b). The “process is based on goodwill and trust,” there has never been an audit of the system (Sielecki 2005a, 26). The BC MoT has updated their incident report form to make the data collection easier for maintenance operators, which has significantly increased the quality of the data collection (Sielecki 2003b).

4.3.3 British Columbia Summary

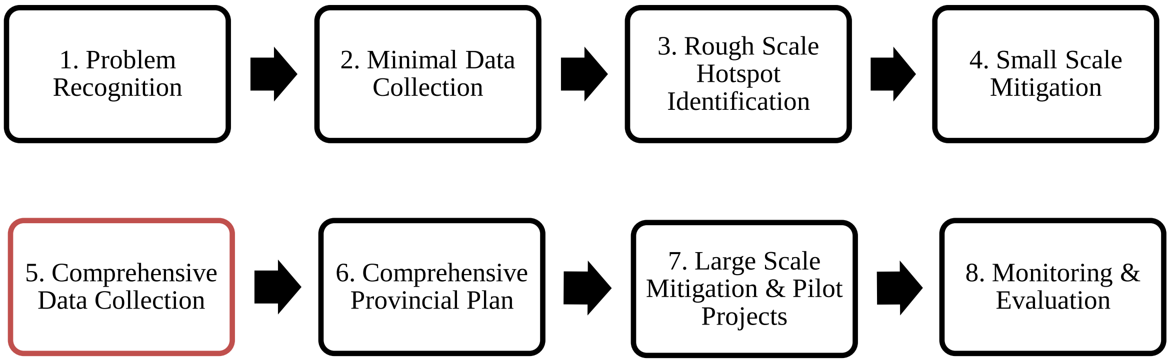
- WARS information is systematically collected carcass count data on numbered provincial highways.

- There is no monetary threshold for inclusion, and so CC methods often record many more incidences of WVCs than police collected data (Huijer et al 2007b). This limits the underreporting animal road mortalities, but only on the numbered provincial highways
- CC data is considered "the most comprehensive data available" on WVCs, as the information tends to be more inclusive and with more parameters than other methods, although this varies by jurisdiction and collection techniques (Huijser et al 2007b, 4). Data is not limited in its potential to mitigate for public safety or conservation objectives, including hotspot analysis and predictive modeling.
- GPS units could improve the SA of the data, and their use would "ensure more consistent and accurate reporting of the accident locations" (Sielecki 2003a, 5). This would make the data easier to move into and analyse in a GIS program (Sielecki 2003a).
- The WARS database does not include "detailed information about rare or endangered species" in the province, which could be used to choose mitigation measures and monitor populations; this would require additional species identification training for maintenance personnel (Sielecki 2003a, 5).
- Reliant on the diligence of maintenance personnel, there has never been an audit of the system (Sielecki 2005a)

4.4 Comparative Lessons

The case study selection process and details from the Saskatchewan, Newfoundland and BC case studies provide a number of lessons as how best to mitigate Ontario's WVCs. As shown in figure 4.6, lessons from these provinces suggest effective WVC mitigation requires following a series of steps, starting with recognizing the extent to the problem, moving through data collection, pilot projects and comprehensive planning, and finishing with targeted mitigation efforts.

Figure 4.6 **8 Steps to Effective Mitigation**



As explained in the first part of this section, all Canadian provinces currently undertake steps one to four, with few moving further. In terms of step 1, there is widespread recognition across North America that WVCs pose a significant problem that is getting worse, and will continue unless mitigation can reduce the problem (Huijser et al 2007b; L-P Tardif & Associates Inc. 2006). PEI is the only Canadian exception as the province "is not facing much of an issue regarding animal-vehicle collisions" (L-P Tardif & Associates Inc. 2006, 27). For step 2, Transport Canada's requirements define minimal WVC data collection in Canada, which enables provinces to conduct rough hotspot analysis (step 3) by identifying areas with frequent WVCs. The rough analysis has led to small-scale mitigation (step 4), including public education, highway signs, or clearing on the roadside (L-P Tardif & Associates Inc. 2006). These findings suggest many provinces have yet to undertake steps 5 to 8 to reduce WVCs.

Most importantly, moving forward requires provinces to adopt new data collection methods currently undertaken in only a few provinces. WVC data collection is a prerequisite for comprehensive WVC mitigation. As shown in the case studies, comprehensive, high quality data allows for hotspot analysis at different scales, more effective predictive modelling and mitigation program evaluation. As such, the policy options proposed are limited to address data collection issues.

Table 4.1 **Canadian Provinces with Additional WVC Data Sources**

Province	Insurance Companies Claims	Private Highway Contractors CC	DNR Conservation Officers CC
British Columbia	**YES**	**YES**	**NO**
Saskatchewan	**YES**	**NO**	**NO**
Manitoba	**YES**	**NO**	**NO**
Newfoundland & Labrador	**NO**	**NO**	**YES**[9]
Ontario	**NO**	**NO**	**NO**
Quebec	**YES**	**NO**	**NO**

Table 4.1 displays provinces with additional data collection sources. The table shows police collision reports, insurance company's claims information, and carcass counts (CC) as they are the three main WVC information sources in North America (Huijser et al 2007b). The impetus for the three methods of data collection can be very different (Huijser et al 2007a). Police reported data collection intends to increase human safety, where CC information is often collected to aid conservation planners, and this can result "in different methodologies for data collection and separate databases and analyses" (Huijser et al 2007a, 2).

Across North America, "consistency, accuracy and completeness" were the main changes that transportation and conservation planners suggested could improve their datasets (Huijser et al 2007a, 19). The quality of a WVC dataset dictates its practical applications (Huijser et al 2007a). Collecting accurate data and additional parameters adds quality that can be indispensable in successfully mitigating the human safety and conservation problems associated with WVCs (Huijser et al 2007a). In order to evaluate the comprehensiveness of the different datasets, it is important to identify "priority and non-priority variables," and weigh them appropriately (Huijser et al 2007a, 32). Literature review and case study analysis suggests collected data needs to be: 1)

[9] To reiterate: the Nova Scotia DNR might also collect CC information, but the literature has been unclear, and I was unable to get a hold of someone to confirm whether they did or not (Huijser et al 2007a; L-P Tardif & Associates Inc. 2006)

spatially accurate 2) time specific 3) species specific 4) gender and/or age specific and 5) complete.

4.4.1 Spatial Accuracy

Spatially accurate data can identify more statistically significant factors in predicting WVC hotspots and can determine where to best install mitigation efforts at the project level (Clevenger et al 2006a). Datasets with high spatial error are limited in their possible uses (Clevenger et al 2006a). Ideally, transportation agencies would have datasets with spatial error of less than 3 meters, which typically involves using a GPS unit (Clevenger et al 2006 a; Gunson 2009a). Datasets can be meaningful when they are SA within 100 meters of the collision site (Gunson and Mountrakis 2009). Data with high error is easier to obtain and common in transportation agency datasets (Clevenger et al 2006a; Gunson 2009a).

4.4.2 Time Specific

Time specific WVCs information makes it possible for decision makers and researchers to detect trends, and plan mitigation in an appropriate time oriented manner in response. Acknowledging temporal patterns in WVCs can guide mitigation planning, as more collisions occur at specific times of the day and year for most species (Huijser et al 2007b). At a minimum, the data should be accurate to the month and the year of the collisions occurrence (Gunson and Mountrakis 2009). For collisions information, the time of the accident is very clear, but it can be less so for CC information (Huijser et al 2007a). For carcass count information, the data collector might speculate the actual collision time, or record the time the carcass was found (Huijser et al 2007a).

4.4.3 Species Specific

Knowing what species are involved in collisions "is essential to make the AVC data more useful" (Huijser et al 2007a, 31). There can be diminishing marginal returns to collecting species-specific information on all species, and jurisdictions often choose a number of reportable species. If this is the case, literature suggests that jurisdictions should prioritize species that present human safety problems, cause significant property damage, or are of conservation concern (Huijser et al 2007a). The agency or body responsible for data collection must ensure that their collection employees are able to identify the chosen species in order to make the data reliable (Creative Resource Strategies 2008).

4.4.4 Gender and Age

The age and gender of animals killed in WVCs can have important repercussions for the population dynamics of the species. This data can identify population index for select species, such as white tailed deer (Huijser et al 2007a). It can also determine when a population might be at risk of population decline resulting from road mortality (Litvaitis and Tash 2008). This information is important information, but “can be considered to have a lower priority” than other parameters (Huijser et al 2007a, 31).

4.4.5 Completeness

Completeness is the portion of the road network systematically monitored for data. Some jurisdictions justify collecting more information on certain roads, typically those with higher traffic volumes. This is not the same as underreporting; while the police collect data on the entire provincial road network, their data threshold suggests there is considerable underreporting.

5: Criteria for Policy Option Evaluation

This section introduces the criteria used to evaluate the policy options. The first subsection describes how effectiveness is determined, and the other criteria are discussed in the following subsection. The evaluation is comprised of five criteria. There is a separate evaluation process for the effectiveness measure, which ascertains the quality of data collected in each of the policy options, but it is added back into the general evaluation once the effectiveness of the options have been identified . This section shows the weighting and scoring process of these variables that will guide the evaluation.

5.1 Effectiveness of the Data Quality

The five variables identified in the previous section – spatial accuracy, time, species-specific, age and/or gender and completeness - combine to create the effectiveness of data quality measure used to evaluate the policy options. The section below explains how these variables are measured and weighed in the analysis.

Table 5.1 **Evaluating Effectiveness of Data Quality**

	Significance	Measure
Spatial Accuracy	Very important consequences for conservation and human safety	**Ideal (1.5)** – Systematically within 3 meters of the collision site **Meaningful (1.0)** – Systematically within 100 meters of the collision site **High Spatial Error (0.5)** – More than 100 meters of the collision site
Time Specific	Some conservation and human safety significance	**Ideal (0.5)** – Systematically collected day, month and year **Meaningful (0.3)** – Systematically collected month and year **Poor (0)** – Data is not systematically collected in a meaningful way to find temporal patterns
Species Specific	High conservation significance	**Ideal (1.0)** – Information on all species **Meaningful (0.5)** – Information on a number of reportable species, justified by the data collection agency **Poor (0)** – No species specific information is collected, but it has been determined a WVC
Age and/or Gender	Some conservation significance	**Ideal (0.5)** – systematically collects both the gender and age of the animal **Meaningful (0.3)** – Systematically collects either age or gender of the animal **Neither (0)** – Does not systematically collect either the age or gender of the animal
Completeness	Some conservation and human safety significance	**Ideal (0.5)** – Data systematically collected on all roads **Meaningful (0.3)** – Data systematically collected on high-risk roads **Poor (0)** – Data not collected systematically on any roads

Table 5.2 **Effectiveness of Data Quality Criterion**

Policy Option	SA	Time Specific	Species Specific	Gender and/or Age	Completeness	Total
Ideal	1.5	0.5	1.0	0.5	0.5	**4.0**

5.2 Criteria to Evaluate the Policy Options

The policy options are evaluated using a number of criteria to judge their usefulness and applicability to Ontario. There are five criteria through which the policy options are evaluated: 1) Effectiveness 2) Underreporting Correction 3) Cost 4) Administrative Complexity and 5) Stakeholder Acceptability. While the effectiveness criterion has been described, the section below defines the other criteria and explains how they are measured in more detail.

1. ***Underreporting Correction*** – The extent to which the data collection mechanism limits underreporting in order to identify the actual magnitude of the problem. The size of the problem needs to be identified "in order to assess the environmental, economic, and social costs" associated with the problem (Huijser et al 2007a, 6). Compiling additional reports is "a necessary first step toward identifying and addressing the issue" (Huijser et al 2007a, 6).

2. ***Cost* -** New systems can be costly ventures, and it is important to make cost effective choices. In these times of tight budgets, a very expensive recommendation would likely be unpopular and put aside as infeasible

3. ***Administrative Complexity*** – This criterion identifies the extent to which the data collection mechanism fits into Ontario's current structures and processes. A new system cannot be overly complex to implement and run before it becomes too much of a burden despite the value it might add to WVC decision making.

4. ***Stakeholder acceptability*** – This criterion takes the acceptance of the bodies involved in the options into consideration, especially those organizations that would have to shoulder the additional data collection responsibilities.

Table 5.3 **Criteria to Evaluate the Policy Options**

Criteria	Definition	Measure
Effectiveness	The extent to which data assists planning	High (3-4)(4) Medium (2-3)(2) Low (0-2) (0)
Underreporting Correction	The extent to which the system is able to record the true magnitude of the problem	High (More than 70%)(4) Medium (50-70%) (2) Low (Less than 50%)(0)
Cost	The costs of implementing an option, and expected on-going costs of running the system	High (0) Medium (2) Low (4)
Administrative Complexity	The number and magnitude of changes needed to implement the option	High (4) Medium (2) Low (0)
Stakeholder Acceptability	The extent to which involved players will support the changes	High (4) Medium (2) Low (0)

6: Policy Options and Analysis

This section introduces the policy options and describes them in some detail. In states and provinces across North America, some important barriers to adopting or refining data analysis and collection practices are “lack of demonstrated need, underreporting, and poor data quality [consistency, accuracy (especially spatial accuracy), and/or completeness], and delays in data entry” (Huijser et al 2007a, 2). The policy options attempt to overcome some of these barriers to find a functional system that is less constraining for transportation and conservation planners. After describing the policy options, they are analysed through the criteria determined in the previous section. The analysis addresses the primary benefits and drawbacks inherent in the different data collection techniques, as determined through the case studies.

6.1 Policy Options

The policy options typify the three most common WVC data collection methods, which also represents the range of approaches taken by Canadian provinces to acquire additional WVC data (Huijser et al 2007b). The chosen policy options are the status quo, Insurance Claims Data, Ministry of Natural Resources Carcass Count (MNR CC) Data, and Highway Maintenance Contractor Carcass Count (CC) Data. The literature identifies CC data as the method with the highest potential to be comprehensive (Huijser et al 2007b). For this reason, the CC collection method is the basis for two of the policy options, which also incorporates the two most common organizations responsible for this data’s collection (Huijser et al 2007a).

1. ***The Status Quo in Ontario*** – In this option, OPP collisions reporting would continue to be the only WVC data collection source in the province. The police dataset systematically collects the “occurrence or severity of property damage, human injuries or human

fatalities" caused by WVCs (Huijser et al 2007a, 5). The quantity of data collected is constrained by the reporting threshold, and while the dataset collects information on a large number of variables, it is "focused on safety" (Huijser et al 2007b, 4). The factors reported on in collisions reflect this goal, not the eradication of WVCs. Collisions reports do not record species-specific information, and the collisions continue to be coded in the collisions reports to distinguish them as accidents with wildlife.

2. ***Insurance Claims Information* -** In this option, motor vehicle insurance providers in Ontario would compile their claims information, and share this data with the MTO. While claims information has the potential to be the most proficient at showing the true number of collisions in a jurisdiction, this is primarily true when the vast majority of cars have extended coverage that includes WVCs (Huijser et al 2007b). There is no public insurance scheme in Ontario that covers the majority of cars with extended coverage, so a number of companies would be responsible for this data collection (Anonymous Interview MTO, 2011). The insurance companies would compile and submit this information to the MTO for further analysis.

3. ***MNR CC Data* -** In this option, the Ontario Ministry of Natural Resources (MNR) would be responsible for collecting CC information on all of the roads in the province. The literature shows that Departments of Natural Resources are more likely to use the information for conservation purposes than a Ministry of Transportation (Huijser et al 2007a). This is important because collisions reporting and CC data "helps natural resource managers estimate the minimum road mortality for certain species in an area and whether this may affect their population size or population survival probability" (Huijser et al 2007a, 6). The Ontario MNR would compile and share this information with the MTO. The literature also identifies MNR's as more likely not to share information they collect, but it would be crucial that this information is shared within the government

ministries, especially as the MTO is responsible for planning and implementing mitigation (Huijser et al 2007a).

4. ***Highway Maintenance Contractor CC Data*** – In this option, the private maintenance contractors would be responsible for collecting CC information on all of the roads they are responsible for maintaining. This would be a responsibility in addition to their current maintenance activities. These responsibilities would be included in the contracts of the highway maintenance companies, and there would be a single reporting form used in all Regions in order to collect comparable information. The highway maintenance contractors would report their data to the regional MTO offices for compiling, which in turn would send the data to the provincial MTO headquarters to add to a central database.

6.2 Analysis of the Policy Options

The policy options evaluation is a two-part process, whereby five criteria ultimately evaluate the options. First, a number of additional criteria – spatial accuracy, time, species specific, gender and/or age, completeness - evaluate the effectiveness of the data compiled through each policy option. There is a brief discussion following the evaluation of the data quality. Once the effectiveness scores are determined, they are incorporated into the other criteria. Each criterion weighs equally in this analysis, and the policy options are analysed separately based on the same criteria and scoring process.

6.2.1 Analysis of Data Quality

The effectiveness measure evaluates the mechanism's potential capacity to collect the identified parameters, and is not based on practical application in a particular jurisdiction. This is so the analysis does not overlook its capacity to collect higher quality data if a jurisdiction has applied the mechanism in an ineffective manner.

Table 6.1 **Effectiveness of Data Quality**

Policy Option	SA	Time Specific	Species Specific	Gender and/or Age	Completeness	Total
Status Quo in Ontario	0.5	0.5	0	0	0.5	**1.5**
Insurance Claims Data	0.5	0.5	0.5	0	0.5	**2.0**
MNR CC Data	1.5	0.3	1.0	0.5	0.5	**3.8**
Highway Maintenance Contractor CC Data	1.5	0.3	1.0	0.5	0.3	**3.6**

Ideally, WVC information would be spatially accurate, time and species specific, include gender and age information, and be collected systematically on all roads in a province. In reality, there are some trade-offs made, as additional information can be costly, and the data collection officials have scarce resources. The OPP currently collects time specific information with high coverage, but limited spatial accuracy and no species-specific information or additional parameters. The insurance claims data would add little value, as the nature of claims information makes the data collection inherently inaccurate. It is, however, time specific, has the ability to collect some species information, and is collected equally across the province's entire road network.

Both options that count CC incidences have potential to collect high quality datasets. This type of information can be spatially accurate, species-specific, and include additional parameters. CC data cannot definitively record the time of the accident with the same confidence as collisions information, as the animals are not necessarily found at the time they are hit (Huijser et al 2007a).

For the highway maintenance CC data option, these contractors employed to collect the CC data on particular roads, while MNR officers can collect information on the entire road network.

6.2.2 Status Quo in Ontario

The OPP dataset is not of high enough quality to guide decisions for human safety or conservation planning. While the OPP reported WVC data are systematically recorded, complete, and includes the time of the collision, the SA is unreliable and the information is not species specific (Huijser et al 2007a; Anonymous Interview MTO, 2011). The reporting threshold and self-reporting limits the amount and accuracy of the information they collect, which leads to significant underreporting in the province (Jackson 2006; MTO Website).

The OPP collects WVC information within their existing budget, and the system is already in place to continue this collection. There are plans to update the OPP collisions data reporting system, in order to collect more variables at the collision sites (Anonymous Interview MTO, 2011). The modernization of the OPP collisions reporting process would make it less complex and easier for the officers (Anonymous Interview MTO, 2011). There is no explicit intention to include additional parameters for WVC analysis, but it could prove to be an interesting opportunity to lobby for the inclusion of species-specific information (Anonymous Interview MTO, 2011). Additional parameters would add value to the police data, as "allowing for checkboxes for the most commonly hit species and/or a space to write in the species name is essential to make the AVC data more useful" (Huijser et al 2007a, 31). Quebec includes species identification in their police collisions reporting. Unfortunately, this would not increase spatial accuracy or underreporting, and the data would continue to have limited practical applications and underestimate the actual size of the problem. While enhancing the quality of OPP data would not be the entire solution, additional parameters would add value to the data they are already collecting.

More information on WVCs is required for the province to prioritize hotspots, create predictive models, plan comprehensively, and evaluate and monitor mitigation. New Brunswick's Department of Transportation has actively created mitigation, but has been criticized, as "various mitigation measures have been attempted, but often without knowledge of accident patterns," leading to an ad hoc approach (Christie and Nason 2003, 11). The location of mitigation techniques is very important in determining their overall effectiveness, which requires analysis with high quality datasets (Glista et al 2009; Gunson et al 2009a).The high cost of site appraisals and mitigation measures makes thorough and systematic data collection a prudent and cost effective first step towards large-scale mitigation (Appendix B).

Table 6.2 **Evaluation: Status Quo in Ontario**

	Status Quo
Effectiveness	**Low**
Underreporting Correction	**Low**
Cost	**Low** The OPP is already collecting collisions information, and would not change its practices; it does not cost the police more time or training to record collisions involving wild animals
Administrative Complexity	**Low** No changes would be necessary
Stakeholder Acceptability	**High** No changes would be necessary

6.2.3 Insurance Claims Information

The quality of claims information does not meet the goals of this study; it would not allow planners to create comprehensive plans for provincial mitigation without additional data. Claims information is very complete, as its application is uniform across the province.

Unfortunately, the data is of limited quality, restricting its usefulness for transportation and conservation planners. Claims information often collects fewer parameters than other collection methods (Huijser et al 2007b). The collection of additional parameters would be difficult as much of claims information is approximations by the people making the claims, which cannot be systematically accurate. This includes the highest weighted parameters, spatial accuracy and species-specific information.

Claims information can supply a lot of insight into the true number of collisions within a province, and show the actual magnitude and cost of collisions for society. It can also give the insurance company incentive to provide information and funds for research and mitigation initiatives within the province. Unlike Saskatchewan, in Ontario there are a number of private automobile insurance companies. Even if sanctioned by the provincial government to collect and collate claims information on WVCs, the variation in coverage would not produce the same completeness as found in Saskatchewan, where all cars have the same comprehensive coverage and provider. There are some regions in Ontario where there is no coverage for motorists involved in WVCs (Anonymous Interview MTO, 2011).

Table 6.3 **Evaluation: Insurance Claims Data**

	Insurance Claims Data
Effectiveness	**Medium-Low**
Underreporting Correction	**Medium**
Cost	**Medium** There are a number of private insurance companies in Ontario that would have to make sure they were collecting information in the same way, these training costs would be expensive ▪ As is shown in Saskatchewan, the WVC data is treated the same as other collisions data, and therefore there is not an additional on-going cost associated with its collection

Administrative Complexity	**High** Based on application to the private automobile insurance in Ontario ▪ Ontario has a number of private motor-vehicle insurance companies, each covering a limited percent of the cars in the province with different levels of coverage. They would have to work together in order to create a WVC database
Stakeholder Acceptability	**Low** It would take considerable effort to coordinate the efforts of the private insurance companies to create a meaningful dataset ▪ This would be inequitable in that those companies with more extensive coverage of WVC claims that would have to collate and submit data where those companies without the same coverage would not

6.2.4 MNR CC Information

MNR CC information has the potential to be the very comprehensive. This information can be spatially accurate, species specific, and include additional parameters. As was the case in Newfoundland, this collection source could provide incentive for the MTO and MNR to work together to plan mitigation efforts. In Newfoundland, the additional dataset added value to the RCMP collision database. Carcass count information reduces underreporting, especially when the CC data are collected for the entire province, as is the case in Newfoundland. In Newfoundland, Conservation Officers acquired GPS devices just months ago; spatial accuracy adds considerable value to the collected data for transportation and conservation planners.

Based on the experiences in Quebec and Newfoundland, the MNR would be willing to take on this additional responsibility, but it would likely be a prohibitively expensive endeavour. It is expensive to implement and the on-going costs are very high. This option was too expensive in Newfoundland, which is proportionately minute beside Ontario (Anonymous Interview NFLD MNR, 2011). The MNR in Quebec was responsible for collecting CC information in a number of regions, but stopped because the expense was too high for the province (Anonymous Interview Quebec MNR, 2011). Conservation Officers (CO's) in Ontario work in the enforcement branch of the MNR, and are responsible for providing "effective regulatory protection of Ontario's natural resources, environment and public safety" (Ontario MNR Website). The CO's "enforce(s) 27 Acts and Regulations and administer(s) 45," and have many responsibilities in the province (Ontario MNR Website). The MNR does not play a large role in WVC mitigation planning and provision of species information to the MTO, as they do not have the resources to take on additional responsibilities (Anonymous Interview NE MTO, 2011). As was the case in Newfoundland and Quebec, adding WVC data collection as a responsibility would require additional full time employees in the Ontario MNR, which is inherently expensive.

Table 6.4 **Evaluation: MNR CC Data**

	MNR CC Data
Effectiveness	**High**
Underreporting Correction	**Medium**
Cost	**High** Based on experiences in Newfoundland and Quebec ▪ There is a high initial cost of creating the capacity within the organization, and then the on-going cost of having employees spending their time/this was found to be prohibitive in other provinces
Administrative Complexity	**Low** Based on experiences in Newfoundland and Quebec
Stakeholder Acceptability	**High** Based on experiences in Newfoundland and Quebec

6.2.5 Highway Maintenance Contractor CC Data

This data collection mechanism has potential to collect high quality data. British Columbia's systematic collection of WVC information adds value to police collision-reporting datasets. Additional parameters are collected, and the system is able to collect data with meaningful spatial accuracy. This information is not limited in its applications, both for human safety and conservation problems. It allows transportation and conservation planners to prioritize and target hotspots in a cost-effective manner, and to evaluate mitigation choices at the local scale, in order to determine the best solutions.

This database would add value to the OPP dataset currently collected in Ontario, and would provide meaningful correction to the underreporting of WVCs. The CC data does not correct for underreporting in the same way that a public extended coverage insurance provider does, but is still significant (L-P Tardif & Associates Inc. 2006). The costs of implementing and running a highway contractor CC data collection system are low, and the system is not complex to implement (Sielecki 2003b).

A considerable amount has been written about the BC WARS system:

> "Given its fundamental simplicity, ease of implementation and low operational cost, the WARS system can provide a model that is suitable for any transportation agency with a need to document wildlife mortality on roads, highways and railways. The model can be implemented by most transportation agencies within their existing organizational maintenance reporting structures"
> (Sielecki 2003b, 1)

There are a number of imperfections with this data collection mechanism identified in BC's experiences with the WARS. The quality of the data is reliant on the maintenance personnel being diligent in their data collecting duties; it took a number of years for the WARS system to systematically collect high quality information (Sielecki 2005a). BC has identified two goals to improve the system, and each would raise the costs of running the system. First, supplying GPS devices to all of the highway maintenance workers and providing training to ensure their proper use, to improve the SA of the WVC data (Sielecki 2003b). In addition, ensuring that information in Species at Risk, that are difficult to identify, are diligently collected (Sielecki 2003b). This would likely require costly species identification "training by wildlife biologists" for all highway maintenance personnel in order to collect meaningful datasets (Sielecki 2003b, 5).

Table 6.5 **Evaluation: Highway Maintenance Contractor CC Data**

	Highway Maintenance Contractor CC Data
Effectiveness	**High**
Underreporting Correction	**Medium**
Cost	**Low** Based on the BC case study, and the implementation of this in Northeastern Ontario, which is discussed later
Administrative Complexity	**Low** Based on experiences in BC and Northeastern Ontario
Stakeholder Acceptability	**High** Based on experiences in BC and Northeastern Ontario

6.3 Summary and Northeastern Ontario

This section summarizes the analysis of the policy options, bringing them together to allow for a final comparison. The next subsection is an examination of recent practices in Northeastern Ontario, in order to make assumptions about implementing data collection strategies in the rest of the province. This includes mitigation efforts as well as data collection methods used in that region. This section helps inform the final recommendations, and answers some questions about implementing the recommendations in Ontario.

6.3.1 Summary Evaluation

Ontario currently collects poor quality data with limited practical applications. The data is stopping Ontario from moving towards a more comprehensive provincial mitigation strategy.

Table 6.6 **Summary Evaluation of Policy Options**

	MNR CC Data	Highway Maintenance Contractor CC Data	Insurance Claims Data	Status Quo in Ontario
Effectiveness	4	**4**	2	0
Underreporting Correction	2	**2**	2	0
Cost	0	**4**	2	4
Administrative Complexity	4	**4**	0	4
Stakeholder Acceptability	4	**4**	0	4
Total	14	**18**	6	12

Claims information is a poor fit for Ontario. Due to the low effectiveness of the dataset, which would add little value to the existing data, the barriers to implementation appear to be larger than the value added by the claims information. When there is a public insurance scheme with extended coverage, claims information adds value to police collisions data. Unfortunately, these advantages do not apply to Ontario based on their current motor-vehicle insurance policies. The CC information collected by the MNR has the potential to be of high quality, and includes multiple government bodies in the information's analysis. Regrettably, based on experiences in Newfoundland and Quebec, it would be prohibitively expensive to implement and to run. The high quality of the MNR CC data cannot make up for low cost effectiveness, which makes it infeasible at this time. The data collected by the highway maintenance contractors scores the highest in the summary evaluation. The system collects high quality data, at low cost, and the system is comparatively easy to implement and maintain (Sielecki 2003b). This option is likely to be acceptable to the maintenance workers based on experiences in Northeastern Region of Ontario, discussed below (Anonymous Interview NE MTO, 2011).

The Northeastern Region of the MTO is the only Region that collects an additional WVC dataset. This region is the forerunner of mitigation in the province. Approximately 10 percent of all WVCs in Ontario occur in the Northeastern Region each year (Garbutt 2009). WVC mitigation planning and prioritization is the responsibility of the MTO at the regional level, which is committed to solve the human safety and conservation issues resulting from WVCs (Eco-Kare International 2009). Highway maintenance contractors have collected CC data since 2006, allowing the Region to target and implement mitigation. The Northeastern Region has gone from small-mitigation to large-scale mitigation and pilot projects within a number of years after beginning to collect comprehensive WVC information.

6.3.2 Northeastern Ontario Mitigation

Since starting to collect additional information, the Region has been active in prioritizing and implementing mitigation. They have implemented small and large-scale mitigation and well as pilot projects, and are monitoring and evaluating their effectiveness. The MTO is committed to solving the human safety issues without increasing the barrier effect of roads for animals and is working with the MNR to make this possible (Garbutt 2009). Small-scale mitigation measures include driver awareness programs, collaboratively run by the MTO, MNR and OPP in the region, roadside signs, and roadside vegetation and salt removal (Garbutt 2009). They have installed and are currently monitoring reflectors on Highway 540, meant to scare animals from the roadside when oncoming traffic approaches (Garbutt 2009). The Region has installed the first ecologically sound “large scale wildlife crossing east of the Rocky Mountains” on Highway 69, along with “a joint-use culvert, smaller ‘turtle’ culverts, oversized bridges and associated fencing” (Garbutt 2009, 3; Eco-Kare International 2009, 1). In addition, two Wildlife Warning System pilot projects are being tested in the region, which incorporates a system to sense animals on the road, and lights that warn drivers (Garbutt 2009). One of these trials is occurring is an exclusion-fencing gap, which is experimental, and will be carefully monitored to evaluate the effectiveness of the trial (Garbutt 2009).

6.3.3 Northeastern Ontario Data Collection Methods

The Region acquires OPP collected data using Ontario's Accident Data System (ADS) (Anonymous Interview NE MTO, 2011). In 2006, transportation planners were frustrated with the limitations of this dataset, and asked private maintenance contractors if they would collect CC information on the provincial highways (Anonymous Interview NE MTO, 2011). The MTO particularly wanted to be able to identify hotspot locations and predictive modelling factors (Anonymous Interview NE MTO, 2011). Since that time, this task has been added into the highway maintenance organizations' contracts as they come up for renewal (Anonymous Interview NE MTO, 2011). This additional data has a meaningful underreporting correction, as it includes previously unreported collisions, and has no reporting threshold. The Northeastern MTO adds this CC information to the dataset collected by the OPP (Garbutt 2009). The process of removing duplicates within the datasets has not been expensive; the Northeastern MTO employs a summer student to input a years' worth of data at the beginning of their work term (Anonymous Interview NE MTO, 2011).

The private maintenance contractors collect high quality data within the Region. The regional CC information in the region includes both spatially accurate and species-specific information. The maintenance workers also collect the age and gender of the animals (Garbutt 2009). Most of the regional maintenance contractors are equipped with GPS devices and the CC incidence report form requests coordinates, so that the location data has a low spatial error (Anonymous Interview NE MTO, 2011).

7: Recommendations

There are too many WVCs in Ontario. The province does not have a WVC mitigation strategy or systems in place to stop the annual number of accidents from increasing.

> "As the incidence of WVCs is predicted to continue to increase in Canada, accurate information on the extent of the problem will be very important for creating mitigation strategies, and getting resources. Improving the data collection methods in the provinces that do not collect additional information, and some that do, as well as at the national level would make data comparable, between jurisdictions and through time; this improved data would have accurate information that reflects the safety and conservation issues associated with WVCs and therefore reveal their real costs to society; allow the Ministry responsible for planning mitigation to identify hotspots and prioritize within the province, and measure the effectiveness of the mitigation technique after it has been implemented"
>
> (Huijser et al 2007a, 389)

In order to move towards a comprehensive WVC strategy for the province, the MTO must have access to high quality WVC information that allows for comprehensive planning at the provincial level. From the case studies and the analysis, this study concludes with a number of recommendations; there is one major and three minor recommendations. The conclusions are presented in the section following the recommendations.

1. ***Major Recommendation: Implementation of the WARS system adjusted for Ontario***

Of the three main sources of WVC data collected – insurance claims information, police collision reports, and carcass count incidence – CC data is often the most comprehensive (Huijser et al 2007b). Private maintenance contractors collect cost-effective high quality information in British Columbia and Northeastern Ontario. Both of these jurisdictions are leaders in WVC mitigation in Canada. The BC Wildlife Accident Reporting System (WARS), adjusted for use in

Ontario, would allow transportation and conservation planners' access to the information necessary to create a comprehensive mitigation strategy for the province. This would allow mitigation planning on existing and new roads, at low cost, and with no foreseeable barriers to implementation.

The data is an important first step for the province to realize the extent of the problem, and make significant moves towards mitigation. Northeastern Ontario is very interested to see the other MTO regions adopt similar principles, and have actively promoted their system within the province; so far, no other regions have adopted the system (Anonymous Interview NE MTO, 2011). The region is sharing their experiences within the MTO through a Sharepoint program, and "has also undertaken to maintain a current list of all available wildlife mitigation literature" (Garbutt 2009, 1). Regional coordination could make the data collection uniform across the province, making a provincial database possible. Having a database at the provincial level is especially important for interregional mitigation, which has been a problem for Northeastern Ontario (Anonymous Interview MTO, 2011).

2. ***GPS is important for high quality data collection***

Datasets with high spatial error were identified as a definitive barrier in each case study, and the literature. In Newfoundland, high spatial error was the primary reason to stop reconciling their datasets, as its applications were inherently limited on account of inaccurate data (Anonymous Interview NFLD DNR, 2011). Irreconcilable high error of claims information data makes it much less valuable for decision makers. In BC, the MoT has identified acquiring GPS as a long term goal to improve the system and the quality of the data (Sielecki 2003b). Despite the high costs of implementing GPS, it adds considerable value to the datasets, and should be considered by jurisdictions considering implementing WVC mitigation. The high cost of implementing GPS makes less easily attainable than data with higher spatial error (Gunson et al 2009a).

3. Data on Species at Risk

Collecting data on Species at Risk has been identified as a way to improve the WVC information collected through the WARS system in BC (Sielecki 2003b). This could become more important as human transportation corridors encroach even more into previously pristine habitat. Planners could better identify legacy and erosive effects in populations, and maintain population indexes for some species . This would require additional training of the highway maintenance personnel to identify specific species (Huijser et al 2007a).

4. *Updated OPP Collisions Reporting*

The MTO is considering updating the collisions reporting system to a more modern, electronic system, allowing the OPP to collect more variables at a collision site without too much additional effort (Anonymous Interview MTO, 2011). When this becomes a reality, the Ontario MTO should take the opportunity to collect species specific information in their police datasets; this adds significant value for WVC planning, and the data is more useful when combined with other WVC datasets (Huijser et al 2007a). For example, the Northeastern MTO reconciles the OPP dataset with the CC information collected by the private maintenance contractors (Anonymous Interview NE MTO, 2011). While this is not a priority action, if a policy window arises, the MTO would be advised to take the opportunity to add value to their data set, whether or not they implement the primary recommendation of this study, an additional data collection source.

7.1 Conclusion

This study identified systematically collected high quality WVC data as the next step to for Ontario to move towards a comprehensive mitigation scheme. Ultimately, political will and significant resources will have to be available to make any ambitious mitigation scheme a reality. The scope of this project is limited to WVCs in Ontario, and the creation of a provincial database.

The literature suggests a high quality national WVC database "would not only stimulate transportation departments and other organizations to collect more spatially accurate road-kill data, but it would also allow for a better integration and analyses of the data," and should be a long term goal (Clevenger et al 2006a, 20). This reflects a strategic goal of Canada's *Road Safety Vision 2010*, to "improve national road safety data quality and collection," even though WVC statistics were not an explicit goal in the strategy (BC Traffic Collision Statistics 2007, ix). Ontario's acquisition of better data collection methods could be instrumental in sharing best practices and national comparisons (Clevenger et al 2006a). The next step is to acquire the necessary data to make creating a comprehensive wildlife-vehicle collisions strategy for the province a reality. As this study has shown, Ontario could choose to employ their highway maintenance contractors to do just that. Given the current provincial strategies, Ontario has the opportunity to become a leader in WVC mitigation and planning.

Appendices

Appendix A: Predictive Factors

Many studies identify factors that make a piece of road more likely to be susceptible to be high WVC location or hotspot. Predictive models of hotspot locations and spatiotemporal trends provide important information to guide decisions about mitigation.

Driver and Road Characteristics

- There are more WVCs between dusk and dawn than during the day, primarily because there are more animals moving at this time (Gunson et al 2005); in addition, drivers have impaired vision and less time to react when they see animals on the road (Litvaitis and Tash 2008; Christie and Nason 2004); moose are particularly hard to see at night, as their eyes do not reflect light back at oncoming vehicles, and their fur is very dark (Elzohairy et al 2004; AMEC Earth & Environmental 2004). Even though more WVCs occur at night, some species prefer to move across roads during the day (Elzohairy et al 2004; L-P Tardif & Associates Inc. 2006).
- A disproportionate number of WVCs occur in October and November, with a smaller peak in the May and June; these increases are species specific, and depend on animal's preferences for movement (Elzohairy et al 2004; L-P Tardif & Associates Inc. 2006; Huijser et al 2007b).
- Speed limits have been identified as particularly indicative of the number of WVCs; there is two time greater risk of injury when travelling at highway speeds than on other slower roads (Glista et al 2009). Some jurisdictions have special speed limits to compensate for high WVCs (L-P Tardif & Associates Inc. 2006). A better predictor of the actual speed cars drive than the posted speed limit is the physical construction of the road; how wide the road is, if it is twinned, etc. (Elzohairy et al 2004; Gunson and Mountrakis 2010; Christie and Nason 2004; Huijser 2010).
- Increased traffic on a road is indicative of the number of WVCs, even though high volumes of traffic can also discourage species from crossing at all (Elzohairy et al 2004; Gunson and Mountrakis 2010; Christie and Nason 2004; Clevenger et al 2006a; Huijser et al 2007a).
- WVCs are more likely to occur when there is "clear weather, on dry roads," as drivers are more likely to be driving quickly, and with their guards down (Christie and Nason 2004). Favorable weather conditions could also mean that more species are moving around or that that the frequency of hunting is lower (Elzohairy et al 2004; Huijser et al 2007b).

Animal Preference Characteristics

- WVCs are common in areas where the roadside is forested for protection, and there are large areas of natural habitat or species specific habitat (Clevenger and Wierzchowski 2006; Gunson et al 2005), along typical migration routes, many ungulate routes along valley bottoms (Harper 2004, 11), on flat areas (Gunson and Mountrakis 2010; L-P Tardif & Associates Inc. 2003; Gunson et al 2005), and near water sources (Elzohairy et al 2004; AMEC Earth & Environmental 2004)
- WVCs are less likely to occur in urban areas, when there is agriculture along the roadside, or where there are embankments along the roadside (Malo et al 2004; Gunson and Mountrakis 2010)
- Evidence suggests that in some instances, heterogeneous landscapes might create natural corridors for animal movements, while more homogeneous landscapes encourage a more random WVC distribution (Gunson et al 2005; Malo et al 2004)

While the area around roads are sometimes avoided by wildlife (Laurias et al 2007), some species are attracted to the habitat of the roadside. Open space create different types of vegetation growth, extensive edge environment can appeal to species, some animals go to the roadside to lick salt (Creative Resource Strategies 2008; Litvaitis and Tash 2008; Clevenger and Wierzchowski 2006; Harper 2004). Carnivores are sometimes attracted to the road if their prey spends time in these open spaces, or they are attracted by animal carcasses of WVCs on the roadside, while others use roads to facilitate their own movements (Gunson and Mountrakis 2010; Preston 2006; Clevenger and Wierzchowski 2006). Ungulates use roads as transportation corridors, sometimes spending considerable time by the roadside (Gunson and Mountrakis 2010). Roads that are close to wetlands, which typically host a variety of species populations, are high risk of having many animals lingering by the roadside (Litvaitis and Tash 2008).

Appendix B: Types of Mitigation

Below are a selection of WVC mitigation techniques used in Canada. It is included to give some indication of the effectiveness – WVC rate and road permeability – and cost, of different mitigation measures.

Examples of mitigation techniques meant to change animal behaviour:

Mitigation Technique	Effectiveness	Effectiveness	Cost	Jurisdiction
Exclusion Fencing	Effective (Huijser et al 2007c; Anthony 2006; L-P Tardif & Associates Inc. 2003; Transport Canada 2003)	Detrimental - meant to increase the barrier effect (Huijser et al 2007c)	Approximately $40-80,000 per km; requires maintenance; life of approximately 20 years (Sielecki 2003;Huijser et al 2007c; Jackson 2006, 24; Transport Canada 2003)	BC, Manitoba, Ontario, Quebec, New Brunswick (L-P Tardif & Associates Inc. 2006)
Underpasses	Effective	Positive – Meant to facilitate animal movements *	More than $1 million (large animal); requires maintenance (Jackson 2006;Huijser et al 2007c; Transport Canada 2003)**	BC, Alberta, Saskatchewan, Manitoba, Quebec, Nova Scotia (L-P Tardif & Associates Inc. 2006)
Overpasses	Effective	Positive – meant to facilitate animal movements*	From $33,650- $230,000 per meter; requires maintenance (Huijser et al 2007c;Transport Canada 2003)**	BC, Alberta, Quebec, New Brunswick (L-P Tardif & Associates Inc. 2006)
Roadside Vegetation	Not well tested/ some effectiveness (Huijser et al 2007c)	Detrimental - meant to increase the barrier effect (Huijser et al 2007c)	Estimated $500 per km ($9000 per year) (Huijser et al 2007c)	BC, Alberta, Ontario, Quebec (L-P Tardif & Associates Inc. 2006)
Roadside Reflectors	Limited effectiveness / not well tested (Huijser et al 2007c)	Detrimental – can increase barrier effect (Huijser et al 2007c)	$8,000-12,000 per km; requires maintenance (Transport Canada 2003; Sielecki 2003)	BC, Alberta, Saskatchewan, Ontario, Quebec, New Brunswick (L-P Tardif & Associates Inc. 2006)

*Studies show underpasses and overpasses can facilitate animal movement

**Additional cost for evaluating the effectiveness of the crossing structure by monitoring the usage by species (Eco-Kare International 2009).

Examples of changing drivers' behaviour:

Mitigation Technique	Effectiveness (Reduction of the WVC Rate)	Effectiveness (Facilitates Movement)	Cost	Where Implemented (Canada Provinces)
Driver Education	Unknown	Unknown	Wide range based on scope and reach of campaign	BC, Ontario, Newfoundland, Northwest Territories (L-P Tardif & Associates Inc. 2006)
Static Wildlife Warning Signs	Limited effectiveness /not well tested (Huijser et al 2007c)	No Change	Approximately $100 per sign; requires maintenance (Huijser et al 2007c)	All Provinces but PEI (L-P Tardif & Associates Inc. 2006)
Speed limits	Ineffective/limited effectiveness (Huijser et al 2007c)	No Change	Low upfront speed sign replacement; high compliance costs (Huijser et al 2007c)	Alberta, Saskatchewan, Ontario, Quebec (L-P Tardif & Associates Inc. 2006)
Wildlife Warning Systems	Being tested/somewhat effective (L-P Tardif & Associates Inc. 2006;Huijser et al 2007c)	Meant to facilitate movement	$40,625-96,250 per km; implementation costs; requires maintenance (Huijser et al 2007c)	BC, Saskatchewan, Quebec (L-P Tardif & Associates Inc. 2006)

Appendix C: WARS H0107 Form

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.** ______

Day	Time of Kill 1 = Dawn 2 = Day 3 = Dusk 4 = Dark	Location of Killed Animal RFI = Road Features Inventory (optional) **LKI = Landmark Kilometre Index (must be completed)**						Deer Sign within 100m	Deer Rflctr	# Killed	Animal Type Please Specify Sex (Male / Female / Unknown) Please Use "Y" to indicate if Yearling or Younger **(Other: Sheep, Caribou, Coyote, Porcupine, etc)**													Comments
		Hwy	RFI		LKI		Nearest				Deer			Moose			Elk			Bear			Other	
		No.	Landmark	Offset	Segment	Km	Town	Y/N	Y/N		M	F	U	M	F	U	M	F	U	M	F	U	(please specify)	

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 Sielecki, WARS Manager
Wildlife Accident Reporting System (WARS)
British Columbia Ministry of Transportation
4B - 940 Blanshard Street, PO Box 9850 STN PROV GOVT
Victoria BC V8W 9T5
Phone: (250) 356-2255 / Email: leonard.sielecki@gems9.gov.bc.ca

***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 ____

Source: Sielecki 2005, 5

Appendix D: Other WVC Hotspot Identification Techniques

There are "less precise hotspot identification techniques" agencies use to predict WVC hotspots when high quality WVC information is not available (Huijser et al 2007a, 6). Use of these models is somewhat limited, because without actual road kill information they cannot definitively predict all high collision sites (Gunson and Mountrakis 2009). Nevertheless, it is important to identify all of the major planning tools in order to give a thorough idea of the limitations of poor quality WVC data. Planners use landscape characteristics, population models and expert opinion (Huijser et al 2007a). Landscape and wildlife population models use behavioural patterns and species habitats, as well as local topography, to predict hotspot locations (Huijser et al 2007a; Lee et al 2006). These projections are "helpful when planning new roads, upgrading old roads, or making changes to road attributes such as the speed limit or road alignment" (Huijser et al 2007a, 7). Some models use GIS to incorporate areas beyond the immediate roadside, to analyse local landscape and animal migration routes in order to predict animal behaviour (Clevenger and Wierzchowski 2006). Some use the knowledge of experts who are "familiar with the species and area concerned, including the road sections where animals may cross or are killed most often" to predict plausible hotspot points (Huijser et al 2007a, 6).

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