Wildlife & Roadways: Incorporating Wildlife-Management Strategies Into Road Infrastructure in Southern Ontario

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Wildlife-road conflict has a profound negative impact on both wildlife populations and society. Ecological effects, human safety concerns, and economic consequences all contribute to the need to mitigate against wildlife-road conflict. As such, this study examines the incorporation of wildlife management strategies (WMS) into road infrastructure. Such projects include wildlife fencing, wildlife crossing structures, road closure schedules, etc. The purpose of the study was to develop an understanding of the decision-making process that leads to successful incorporation of WMSs by applying the concept of Critical Success Factors. Projects at the provincial and municipal level that involve WMSs were identified. Qualitative semi-structured interviews with decision-makers and key stakeholders involved with these projects were conducted to determine the experience of each project with regards to the development and implementation of the WMSs. The information collected from the interviews was then analyzed using a mixed Grounded Theory and Qualitative Content Analysis approach to identify the critical factors involved in incorporating wildlife management strategies. Finally, a decision support tool was developed based on this analysis as a way of operationalizing the findings of this research for application in the field.

Acknowledgements

There are so many people I would like to thank, starting with my advisor, Dr. Michael Drescher, for his guidance and perseverance through a continually evolving project. Thank-you for helping me pursue a topic I am passionate about. I would also like to thank Dr. Keith Warriner for his continued guidance as my committee member, even into his retirement, and Dr. Peirre Filion for acting as my reader.

This research could not have been completed without the input from the road ecology community and the many people who volunteered their time to share their experiences. I would like to thank them for welcoming me into the field and for all the amazing work they are doing.

I would also like to thank my classmates for an amazing few years; each of you have amazing things to offer the world and I cannot wait to see what you achieve in the future. The many long days and nights in the grad room have finally paid off! And perhaps a few late nights at the Grad House too…

Most importantly though, I would like to thank my amazing friends, family, and boyfriend for their undying support and constant belief that I would finish, despite not believing it myself at times. In particular, Alyssa and Jazzy: I can't begin to describe what you girls mean to me. Your love, optimism, and infallible ability to cheer me up in times of stress were integral to the completion of this thesis. Mom and Dad: thank-you for helping me get to where I am today. Your love and support (and superb editing abilities!) mean the world to me. Finally, Andrew: you somehow managed to keep me sane through this entire process and for that I will be forever grateful. Your intellect and ambition are qualities I strive to mimic on a daily basis. Thank-you for setting this example, and for your daily love and support. I am truly lucky to have you in my life.

Dedication

I would like to dedicate this thesis to my Nana, Gladys Greenfield, who passed away just prior to being able to see its completion. An incredibly intelligent, strong, and loving woman, she is my role model and I hope that this thesis has made her proud.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

CEAA = Canadian Environmental Assessment Agency

CBA = Cost-Benefit Analysis

CA = Conservation Authority

CSF = Critical Success Factors

EA = Environmental Assessment

GTM = Grounded Theory Methods

GIS = Geographic Information System

MNR = Ministry of Natural Resources

MTO = Ministry of Transportation

NCHRP = National Cooperative Highway Research Program

OREG = Ontario Road Ecology Group

QCA = Qualitative Content Analysis

SAR = Species At Risk

WCS = Wildlife-Crossing Structures

WMS = Wildlife-Management Strategy

WRC = Wildlife-Road Conflict

WVC = Wildlife-Vehicle Collision

Chapter 1 Introduction

Roads are essential to every-day life: moving people, transporting goods, and facilitating the development of area that would otherwise be inaccessible. Nowhere is there a better example of this than southern Ontario. As its population has grown over the past century, the extent of southern Ontario's road network has quintupled, increasing from only 7,133km in 1935 to 35,637km in 1995 (Fenech, Taylor, Hansell & Whitelaw, 2000). As a result, the landscape has become increasingly fragmented, creating smaller and smaller parcels of land between roads (Figure 1.1). The Ontario Road Ecology Group (2010) reports that there is now not a single location in southern Ontario that is more than 1.5km away from a road.

Although beneficial for society, our ever-expanding road infrastructure is having a profound negative impact on wildlife. Species displacement, habitat destruction and fragmentation, and animal deaths from wildlife-vehicle collisions are all contributing to the declining health of local wildlife populations (Spellerberg & Morrison, 1998; Coffin, 2007; Bissonette & Cramer, 2008). The study of this impact is the primary focus of road ecology, a relatively new field of study formally described for the first time by Forman and Sperling et al. (2003) in their book *Road Ecology: Science and Solutions*. It is defined as the "study of the interactions between road networks and the natural environment …[that]…examines and addresses the effects of roads on wildlife populations and investigates how roads influence ecological processes," (OREG, 2010, pg. 2).

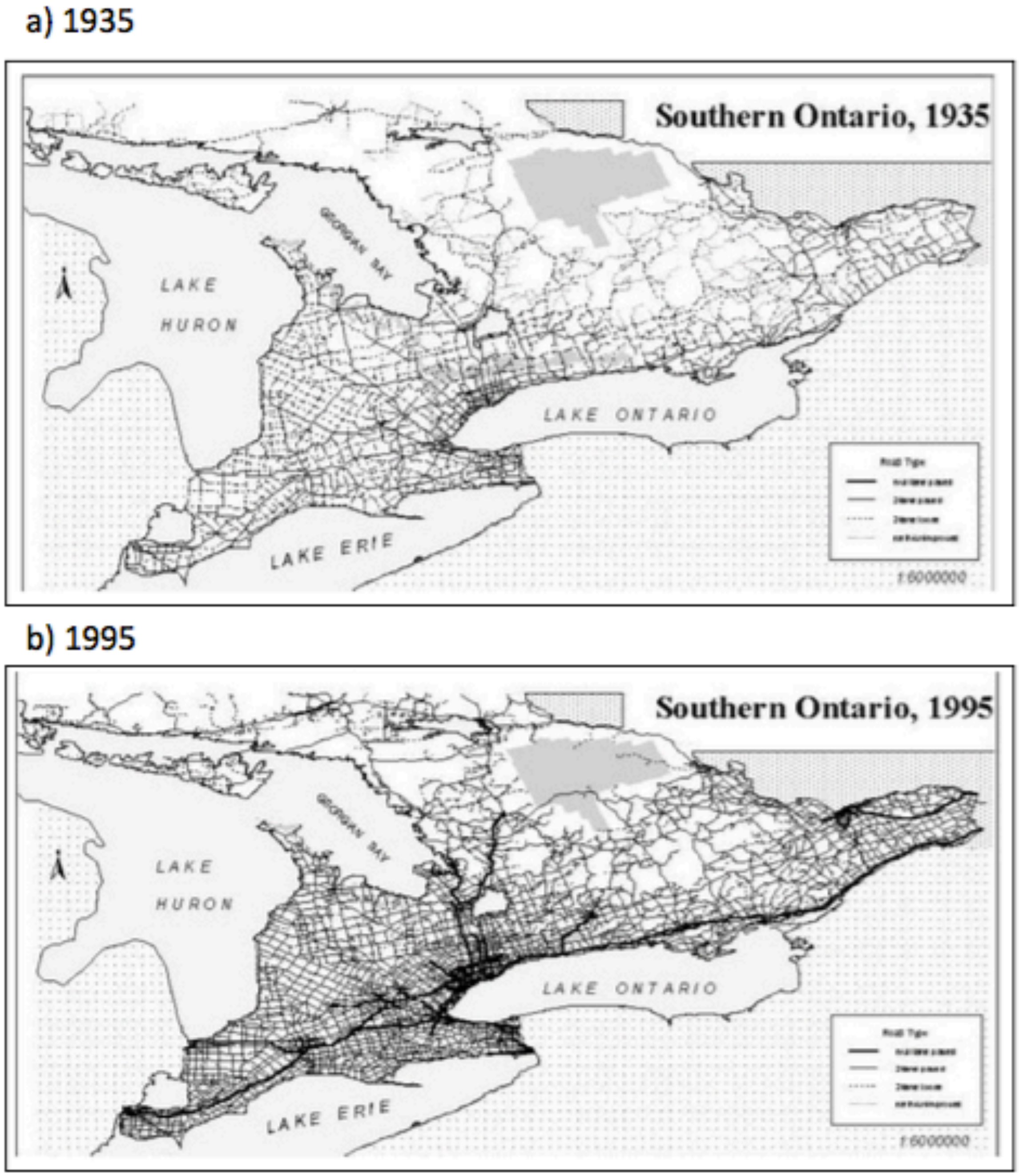


Figure 1.1: Changes in Southern Ontario's road network between 1) 1935 and b) 1995 (Adapted from Fenech et al., 2000)

The majority of the research concerning road ecology has focused on the ecological and technical components of the problem: what the impacts are and the best strategies to mitigate them. These strategies include the likes of road signage, wildlife detection systems, exclusion fencing, and wildlife crossing structures (Glista, DeVault & DeWoody, 2009). Within Canada, larger scale strategies such as fencing and wildlife crossing structures have become very prominent in the Rocky Mountain region and ample research has been conducted that has contributed significantly to the advancement of the field of road ecology (Alexander & Waters, 2000; Gloyne & Clevenger, 2001; Clevenger, Wierzchowski, Chruszcz & Gunson, 2002; Gunson, Chruszcz, & Clevenger, 2004; Clevenger & Waltho, 2005). However, road ecology has remained relatively non-existent in other parts of the country. This is changing though, as an understanding of the need for road ecology considerations spreads. An excellent example of this is in the Province of Ontario, where an increasing number of road infrastructure projects are incorporating wildlife management strategies (WMSs). This provides an excellent oortunity to investigate a key component of road ecology that has yet to be explored: that is, the decision-making process that leads to the incorporation of wildlife management strategies.

Various methods and tools have been developed to help practitioners decide when and where to use WMSs. However, as with the general research on road ecology, the majority of these methods focus on the ecological and technical components, such as which species to target, the best strategies to utilize, and the optimal placement of these strategies. Although undoubtedly necessary components, they do not address an issue of importance which requires additional consideration. The problem is this: roads are publically owned and therefore any decision-making concerning them takes place within the public domain. Governments and their various divisions are tasked with balancing a myriad of competing factors in addition to the technical elements of a problem. These factors include the likes of financial constraints, public opinion, political motivations, etc. Barkenbus (1998) describes this challenge:

> Unfortunately, some researchers assume that environmental decision makers work in what political scientists term a “rational man” context. This is a context in which the decision maker dispassionately—and with unlimited time, resources, and access to information—weighs alternative policies to find the technical solution that best maximizes public welfare. It is now well-established, however, that this context seldom exists in reality (Barkenbus, 1998, pg.2)

He emphasizes the need to recognize the “political realities” under which decisions are made and to understand the various socio-economic and political factors that influence them if effective decision-making is to be achieved. Taking this into consideration, it can be argued that the ‘scientific’ decision-making tools discussed previously can be considered moot if an understanding of the socio-economic and political influences is not developed and considered along-side them. In order for road ecology strategies to be successful, they must first be given the ‘go ahead’ by the respective decision-making parties.

Without this permission, the ecological and technological information and tools are wasted; we simply will not have the opportunity to use them. Therefore, developing an understanding of how to get WMSs projects successfully through the decision-making process is essential to ensuring road ecology is successful across Ontario.

The need for this multi-disciplinary understanding is echoed in the research surrounding *critical success factors* (CSFs) in project management. CSFs are the "few key areas where "things must go right"," for a project, business, or initiative to be successful (Rockhart, 1979, pg. 11). These factors vary depending on the project but they can be organized into general categories: *project-related factors*, such as type and size; *human-related factors*, such as the skills of the project manager and team members; factors related to the *organization and procedures of a project*, such communication and planning; and last but not least, factors related to the *external environment*, such as the economy and society (Belassi & Tukel, 1996; Chan, Scott, & Chan, 2004). Leidecker & Bruno (1984) underline the importance of identifying CSFs by maintaining that they provide "a means by which an organization can assess the threats and opportunities in its environment," (pg. 23). This information can be used to assess the likelihood of a project's success and subsequently 1) avoid projects that are likely to be unsuccessful, 2) identify projects worth pursuing, and 3) identify problems surrounding current projects and take action to correct them (Sanvido, Grobler, Parfitt, Guvenis, & Coyle, 1992). In doing so, effort and resources can be used in the most efficient manner: an important goal when said resources are already limited.

CSFs are inherently associated with the field of strategy development and evaluation (Leidecker & Bruno, 1984; De Vasconcellos E Sá & Hambrick, 1989; Grunert & Ellegaard, 1992). The concept of comparing a strategic alternative (ie. project option) to the CSFs identified is referred to as "CSF Fit" (Leidecker & Bruno, 1984). Alternatives with a better fit will outperform the other options (De Vasconcellos E Sá & Hambrick, 1989). The same process can be applied to alternatives being evaluated individually for their own merit: an alternative with a good fit is likely to be successful, while an alternative with a bad fit is likely to perform poorly (De Vasconcellos E Sá & Hambrick, 1989). However, in order to be able to evaluate an alternative, the CSFs must first be identified in order to have anything to compare it to (Figure 1.2).

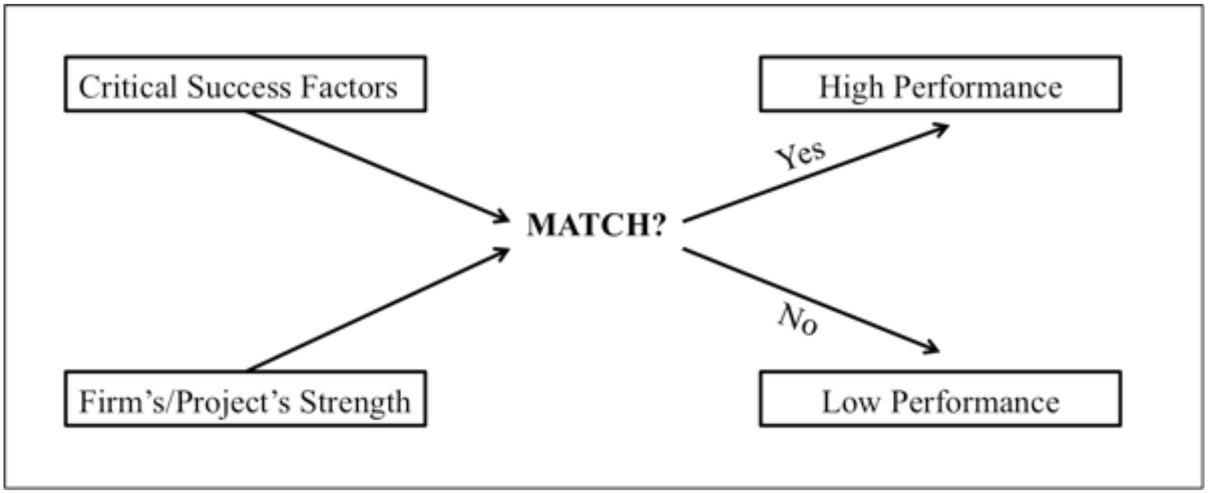


Figure 1.2: Concept of CSF 'Fit' adapted from De Vasconcellos E Sá & Hambrick, 1989.

It is this view that will guide the following research. Optimizing the use of resources to incorporate wildlife management strategies into road infrastructure in Ontario means pursuing projects that are likely to succeed. In order to determine this likelihood of success, practitioners need to be able to assess a project's CSF fit. The only way to do so is to first identify the CSFs concerning WMS projects. As previously stated, much of the technical and ecological knowledge regarding WMS projects is already available and could potentially be used to identify a list of CSFs. However, this list would only be partial; because an understanding of the socio-economic, political, and various other human factors surrounding WMS projects is absent, any such list would miss the critical human-related and external-environment factors. This research will seek to address this gap by exploring various WMS projects in the province, paying particular attention to the socio-economic and political factors surrounding them, in order to develop a comprehensive list of CSFs. In essence, this research develops a typology of road ecology projects in Ontario, which can then be used to enhance widespread WMS incorporation into road infrastructure across the province.

1.1 Purpose Statement

The purpose of this study is to examine the incorporation of wildlife management strategies into Ontario's road infrastructure projects in order to develop a comprehensive understanding of the critical success factors associated with these types of projects. Such projects included wildlife fencing, wildlife crossing structures, road closure schedules, road re-alignment, etc. Projects at the provincial and municipal level that involve such strategies were identified and used as case studies. Qualitative semi-structured interviews with decision-makers and key stakeholders involved with these projects were conducted to determine experiences regarding the process of incorporating a wildlife management strategy(s) in to their respective projects; 'experience' in this sense included the social, financial, political, legal, technological, ecological, and geographic considerations that arose throughout the process. The information collected from the interviews was then analyzed using qualitative content analysis. Finally, a decision-making tool was developed based on the information gained from this research to demonstrate how the knowledge of critical success factors can be applied to aid practitioners with future road ecology endeavours.

1.2 Research Questions

Which factors are critically affecting the incorporation of wildlife management strategies into road infrastructure in south-central Ontario?

a) What factors affected the incorporation of WMSs in previous cases?

b) Were these factors barriers or facilitators for the WMS incorporation?

c) How do these factors interact with each other to affect WMS incorporation?

1.3 Thesis Outline

The following describes the outline and content of the subsequent chapters of this thesis. Chapter 2 presents a review of the relevant literature on the topic of wildlife and roadways. It provides further context on the issues associated with wildlife and roadways, an overview of the options for and use of mitigation strategies, the legal and policy context surrounding the issue, a discussion of the current decision-making and implementation tools available to aid road ecology practitioners, and overview of the research on critical success factors. Chapter 3 details the methods and materials involved in this research, including justification for their use. Chapter 4 presents the results and analysis of the data, outlining which factors critically affect the incorporation of WMSs and in what ways. Chapter 5 discusses the ways this research can be applied in the field and presents a decision-support tool for practitioners to assess projects' likelihood of success. Finally, Chapter 6 offers a discussion of the analysis, including implications for the field of road ecology as a whole, and concludes by summarizing the research and providing recommendations for future work.

Chapter 2 Literature Review

This literature review will be used to detail the past and present information available on the issue of wildlife-roadway conflict (WRC). An extensive review of research, in the form of peer-reviewed journal articles, and grey literature, such as laws and government policies that pertain to WRC, was conducted. The various sections are written in a way as to frame the research questions being asked, and, as such, the predominate research gap in the current state of wildlife and roadway work will be identified and discussed.

2.1 Problems of Wildlife-Roadway Conflict

The problems associated with WRC are multi-faceted. Impacts to wildlife themselves, road safety, and society as a whole are all widely acknowledged (L-P Tardif and Associates Inc., 2006; Huijser et al. 2008; Vanlarr, Gunson, Brown & Robertson, 2012). This review will discuss each of these effects, however, given that the focus of this research is on the human factors that influence decision-making, more detail will be provided on the road safety and societal effects.

2.1.1 Ecological Effects on Wildlife

The ways in which roads negatively impact species are extensive, and the literature is plentiful. Various databases have been established to catalogue such research, including the *ROAD-RIP Roads Bibliographic Database* and *Transportation Research Board Publications U.S.A* (Spellerberg, 1998). General consensus within the literature exists for the negative effects including habitat loss and reduced quality, barrier effects both physical and psychological, behavioral changes in wildlife, invasive species dispersal, habitat fragmentation, and most directly, wildlife mortality (Spellerberg, 1998; van der Ree et al., 2007; Bissonette & Cramer, 2008; OREG, 2010). For a detailed list, see Table 2.1 compiled by Spellerberg and Morrison (1998) in a New Zealand Department of Conservation commissioned literature review and presented in Spellerberg (1998). Jaeger et al. (2005) group these effects into four main categories: effects that 1) decrease habitat and habitat quality, 2) increase mortality via wildlife-vehicle collisions, 3) limit access to resources, and 4) fragment populations into smaller vulnerable subpopulations.

Table 2.1: Ecological Effects of Roads (adapted from Spellerberg, 1998)

Ecological Effects of Roads		
During Construction	**Short Term Effects**	**Long Term Effects**
• Direct loss of habitat & biota • Effects resulting from supporting infrastructure & construction activities • May extend beyond immediate vicinity of road i.e. changes in hydrology	• Linear surface creates new microclimate • Creates new edge habitat for invasive species • Plant mortality along edge & associated effects on animals • Animals relocate due to disturbances • Animals killed by traffic	• Continued animal mortality from traffic • Road kill/carrion are attractants for other animals • Habitat fragmentation • Population isolation • Edge effect supports invasive/ pest species • Associated structures provide some habitat (ie. bridges and barn swallows) • Run-off affects aquatic communities • Pollution; emissions, litter accumulation • Noise disturbance

2.1.2 Road Safety & Societal Costs

Human safety is a prominent theme in the wildlife and roadway literature. Wildlife-vehicle collisions (WVCs) usually result in the death of the animal involved, but can also lead to human injury or fatalities depending on the severity of the collision and if the animal involved is a large mammal (Pynn & Pynn, 2004). Of these collisions, ungulates (deer, moose, etc.) are considered to be the most common threat to human safety (Beckman et al. 2010; Pynn & Pynn, 2004). This is due in part to their increasing abundance and their attraction to roads that provide road salts to lick, preferred shoulder vegetation, and safety provided from predators which are more wary of traffic. Compounded by their increasing abundance, the major threat from ungulates is a result of their body structure and its propensity for inflicting damage when hit; their long limbs, high centre of gravity, and large body mass create the 'perfect-storm' of conditions to cause damage resulting in human injury or death (Pynn & Pynn, 2004). The majority of human injuries that occur include cervical spine and maxillofacial (head, neck, and face) injuries, but long-term psychological effects such as post-traumatic stress disorder have also been observed (2004).

Estimates regarding the number of wildlife-vehicle collisions (WVCs) are varied and it is widely acknowledged that they are likely underestimates, given data collection inconsistencies and the reality that people only tend to report collisions with large wildlife that cause personal injury or vehicular damage (L-D Tardif & Assoc., 2006; Vanlarr et al*.* 2012; Wildlife Collision Prevention Program, 2015a.). The Ontario Ministry of Transportation (2011) estimates that 1 out of every 17 vehicle collisions in Ontario involve wildlife, while Transport Canada estimates this number to be 1 out of 21 (L-D Tardif & Assoc. 2006), or 5.9% and 4.8% respectively.

Despite deficiencies in the data, national and provincial statistics are available. Table 2.2 A-C presents the statistics for collisions resulting in fatalities, non-fatal injuries, and property damage for the years 1999 to 2003. Highlighted in yellow are the statistics for Ontario, indicating that it has the highest collision totals of any province: 28 fatalities, 2922 non-fatal injuries, and 57,689 property damage only collisions (L-D Tardif, 2006). This may be attributed to the fact that Ontario has the highest population of any province or territory, but regardless of the reason, this data highlights the importance of dealing with the issues associated with wildlife-roadway conflict in Ontario.

Table 2.2: A-C National and Provincial statistics for WVC's (Adapted from L-D Tardif, 2006)

A) Fatal Collisions

Province	1999	2000	2001	2002	2003	Totals
Alberta	2	1	2	2	0	7
British Columbia	2	0	1	2	3	8
Manitoba	0	0	1	2	0	3
New Brunswick	4	4	1	4	2	15
Newfoundland	0	3	1	2	2	8
Nova Scotia	1	0	0	3	0	4
N.W.T	0	1	0	0	0	1
Ontario	5	7	4	8	4	28
P.E.I.	0	1	0	0	0	1
Quebec	6	5	2	6	6	25
Saskatchewan	1	2	0	3	0	6
Yukon	0	0	0	0	0	0
TOTAL	21	23	12	32	17	105

B) Collisions with Non-Fatal Injuries

Province	1999	2000	2001	2002	2003	Total
Alberta	150	160	166	185	12	673
British Columbia	185	236	276	316	345	1358
Manitoba	158	160	199	159	214	890
New Brunswick	125	117	104	85	106	537
Newfoundland	78	62	56	70	62	328
Nova Scotia	79	105	82	69	47	382
N.W.T	4	3	3	1	2	13
Ontario	562	585	569	610	596	2922
P.E.I.	12	9	7	5	9	42
Quebec	275	330	383	363	435	1786
Saskatchewan	129	117	123	140	164	673
Yukon	4	3	7	6	6	26
TOTAL	1,761	1,887	1,975	2,009	2,003	9635

Collisions with Property Damage Only

Province	1999	2000	2001	2002	2003	Totals
Alberta	4,430	4,672	4,098	5,487	353	19,040
British Columbia	709	931	1,465	1,741	1,998	6,844
Manitoba	2,755	2,658	3,213	3,218	3,971	15,815
New Brunswick	948	876	893	806	786	4,309
Newfoundland	295	336	315	364	312	1,622
Nova Scotia	798	770	688	573	432	3,261
N.W.T	13	10	12	20	16	71
Ontario	9,026	10,503	11,248	12,894	14,018	57,689
P.E.I.	12	23	16	13	14	78
Quebec	5,978	6,082	5,456	6,075	6,256	29,847
Saskatchewan	1,987	1,936	3,604	5,780	9,564	22,871
Yukon	26	29	41	37	34	167
TOTAL	26,977	28,826	31,049	37,008	37,754	161,614

The number of collisions with wildlife relative to total number of vehicle collisions are known to be increasing across North America: a result of expanding road networks, and thriving ungulate populations due to the eradication of many natural predatory species (Huijser et al. 2008; Beckmann et al., 2010; Vanlarr et al. 2012). In their report for the Traffic Injury Research Foundation, Vanlarr et al. (2012) determined the national average increase in WVCs to be 7.55% for varying time periods between 1994 and 2008. Every province, with the exception of Nova Scotia, has seen annual increases (Figure 2.2)(2012). For example, in Ontario there was an increase from 7388 collisions in 1994 to 11,051 in 2001, with large annual increases occurring after 1997 (Elzohairy, Janusz, & Tosca, 2004). Figure 2.3 illustrates this below.

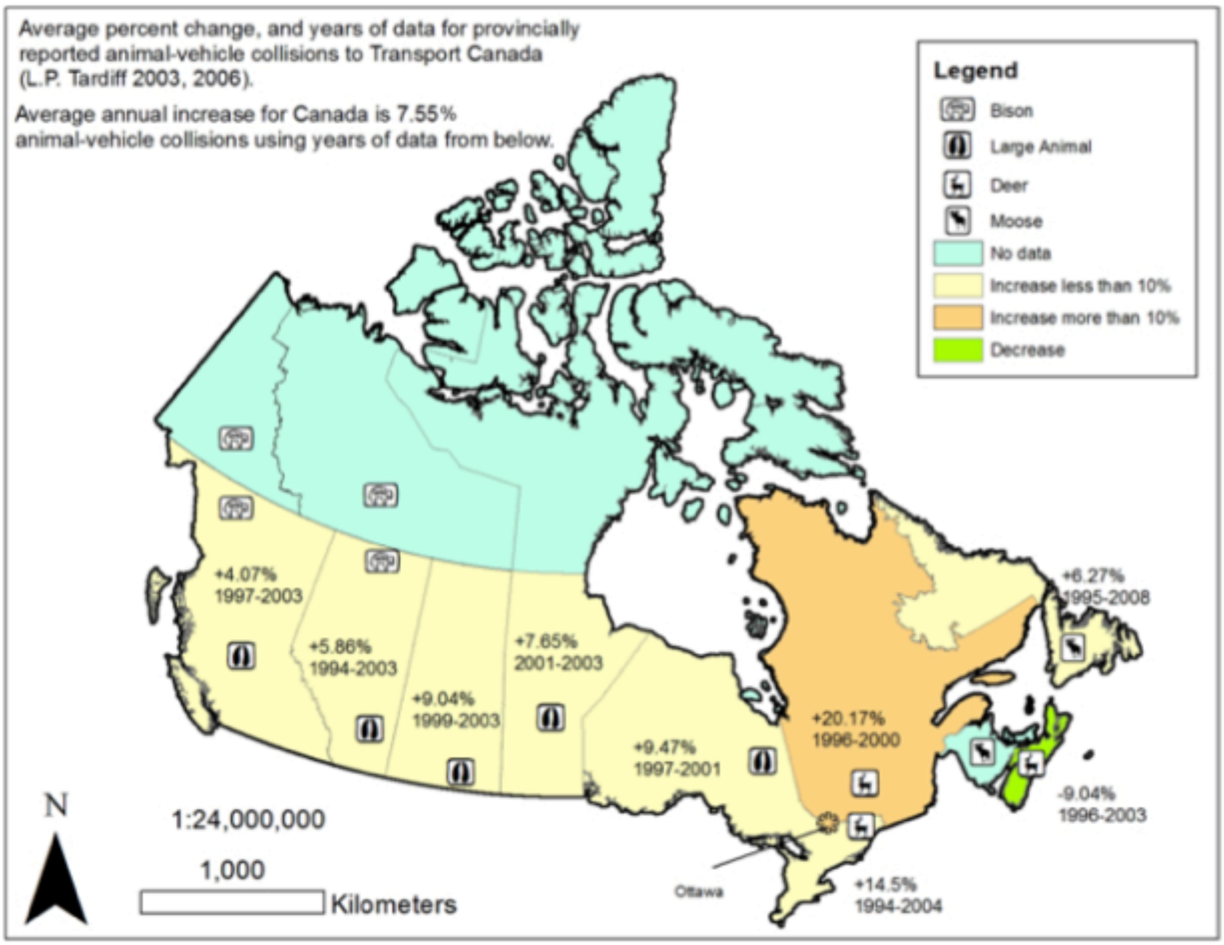


Figure 2.1: Average national and provincial percent changes in the number of wildlife-vehicle collisions (Vanlarr et al., 2012)

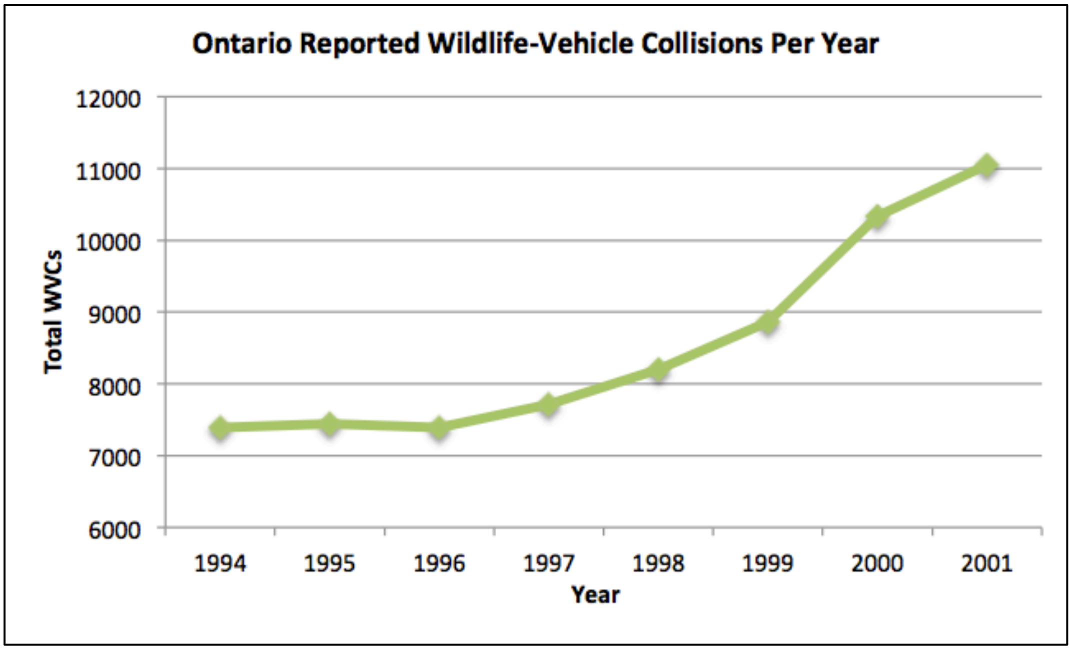


Figure 2.2: Total Reported Wildlife-Vehicle Collisions in Ontario from 1994-2001 (adapted from Elzohairy et al., 2004)

It is acknowledged that the number of collisions with wildlife resulting in the injury or death of the passengers of the car is low, if not rare, relative to the number of WVCs that occur (Pynn & Pynn, 2004; Huijser et al., 2008). Elzohairy et al. (2004) report that in Ontario only 0.1% of WVCs result in human fatalities and only 4.8% in injury; the remaining 95% report only property damage. This being said, there are a whole host of societal costs that result from these collisions; these include traffic delays, emergency services use, insurance premium increases, and, most directly, vehicle damage and medical costs (Huijser et al., 2008; Beckmann et al., 2010; Vanlarr et al., 2012). Huijser et al. (2008) estimate that in the United States WVC's result in a total cost to society of $8.39 billion annually. Specific to WVCs involving deer, Bissonette, Kassar & Cook (2008) determined that, in Utah alone, the average annual cost between 1996 and 2001 was $7,529,242, roughly $3,470 per collision. This estimate was developed by taking into account the costs associated with injuries, damage to vehicles, loss of the animal itself, and human fatalities. Huijser, Duffield, Clevenger, Ament & McGowan (2009) also provide estimated costs for deer, elk, and moose more broadly across the United States and Canada. They estimate deer-vehicle collisions cost the least at $6,617 per collision while moose-vehicle collisions cost the most at $30,760 per collision (Table 2.3); this is to be expected as the amount of damage would increase relative to the size of the animal.

Table 2.3: Huijser et al. (2009) estimation of the costs per collision of deer-, elk-, and moose-vehicle collisions in the United States and Canada.

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

The breakdown of total costs in depicted in Figure 2.4 which indicates that, although rare, human fatality costs make up 53% of the total annual cost of WVC's in Utah (Bissonette, Kassar & Cook, 2008). Specific to Canada, the average cost of vehicle damage alone per accident with deer is $2,800 (L-D Tardif, 2006), which translates to $39.2 million per year, excluding loss of the animal and medical costs (Vanlarr et al*.,* 2012). These costs are not only shouldered by those directly involved in WVCs; Lowy (2001) states that, in some states, 6-8% of every vehicle insurance dollar goes towards paying out claims involving wildlife-vehicle collisions, which could presumably result in insurance premium increases.

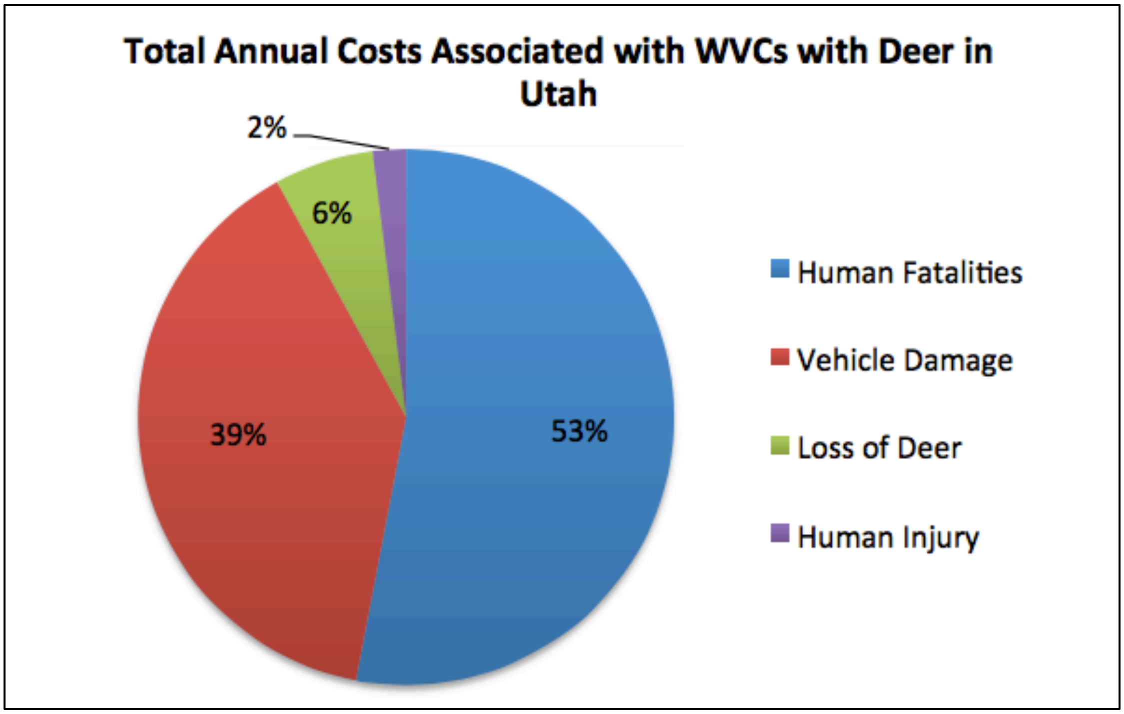


Figure 2.3: Total annual cost breakdown of wildlife-vehicle collisions with deer in Utah (adapted from Bissonette, Kassar & Cook, 2008)

2.2 Designing Mitigation Strategies

The mitigation strategies available for reducing the problems associated with wildlife and roads can be classified two ways. The first is by the objective of the strategy: Beckmann et al. (2010) identifies these as either connecting habitats and wildlife populations or the improvement to motorist and wildlife safety through reductions in WVCs. Improving connectivity requires wildlife crossing structures be installed, while improving safety and reducing WVCs can be achieved using a variety of strategies such as exclusion fencing and wildlife-detection systems (Figure 2.5). The Ontario Road Ecology Group (2010) lists many of the same mitigation options, or 'Applied Road Ecology Solutions' as they refer to them, but they divide them into three different objectives: maintaining habitat connectivity and keeping animals off the road, improving driver awareness and visibility in order to avoid wildlife on the road, and minimizing habitat degradation and disturbances to wildlife.

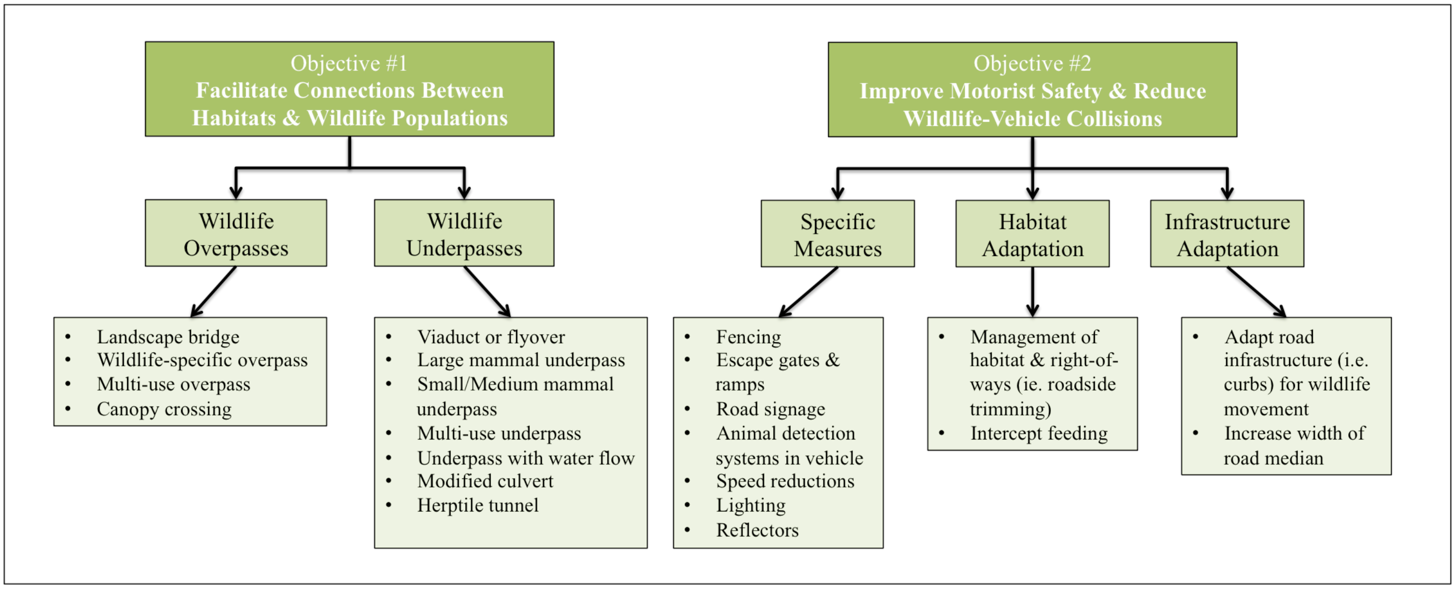


Figure 2.4: Various strategies for reducing wildlife-road conflict given different objectives (adapted from Beckmann et al., 2010)

A second method of classifying WMSs is whether the strategy is meant to influence human behavior, such as driving speed, or wildlife behavior, such as lingering near roadways (Glista, DeVault & DeWoody, 2009; Beckmann et al., 2010). Beckmann et al. (2010) identify the various types of strategies for each (Table 2.4).

Table 2.4: Wildlife-vehicle collision reduction strategies used to influence human and wildlife behaviour (adapted from Beckmann et al., 2010)

Strategies Influencing Human Behaviour	Strategies Influencing Wildlife Behaviour
• Public information & outreach • Standard & enhanced warning signs • Seasonal warning signs • Animal detection systems • Increased visibility (roadside lighting, vegetation clearance, wider road striping, reflective animal collars, snow bank reduction) • Reduced traffic volumes • Temporary road closures • Reduced vehicle speeds • Wildlife crossing assistants	• Deer reflectors & mirrors • Deer whistles • Olfactory repellents • Deer flagging models • Hazing of large ungulates • Escape paths from road corridor • De-icing alternatives • Intercept feeding • Minimizing appeal of roadside vegetation • Carcass removal • Increased median width • Population size reductions (culling, relocation, antifertility treatments, habitat alteration) • Wildlife fencing • Wildlife crossing structures • Boulders • Long bridge & tunnels

Of these mitigation strategies, wildlife crossing structures (WCSs) will be the most prominent focus of this research. Beckmann et al. (2010) present five ecological functions that WCSs should provide:

1. *Reduce mortality and increase genetic movement within population*
2. *Facilitate meeting biological requirements for food, shelter, and reproduction*
3. *Facilitate dispersal from maternal/natal ranges and recolonization*
4. *Redistribute populations during natural disturbances and periods of stress*
5. *Provide long-term maintenance of metapopulations, stability, and ecosystem processes*

Another key consideration when using WCSs is the type of species that is being targeted, as different species vary in their ecological requirements and in how roads affect them (Beckmann et al., 2010). For example, large mammal and amphibian populations are both highly susceptible to road mortality, but the focus for large mammals is likely to be on connecting large ranges of general habitat whereas the amphibian focus would likely be on placing WCSs in areas with highly specific habitat across small distances (2010). Table 2.5 lists the eight species groups identified with detail regarding how roads affect them.

Table 2.5: Eight species groups, their descriptions, and the ways roads affect them (adapted from Beckmann et al. 2010)

Animal Category	Examples	Description	Type of Conflict
Large Mammals	Deer, elk, moose, pronghorn, bears, wolves, cougars	Species with large area requirements, some migratory behaviour	• Large enough to safety concern for motorists • Road-related mortality threat to local populations • Susceptible to habitat fragmentation
High Mobility Medium-sized Mammals	Bobcat, fisher, coyote, fox	Species range widely	• Habitat fragmentation impacts to local populations
Low Mobility Medium-Sized Mammals	Raccoon, skunk, hare, groundhog	Species with smaller area requirements, relatively abundant populations	• Common road-related mortality
Semiarboreal Mammals	Marten, red squirrel, flying squirrel	Species dependent on forested habitats	• Common road-related mortality
Semi Aquatic Mammals	Beaver, river otter, mink, muskrat	Species depend on riparian habitats	• Common road-related mortality
Small Mammals	Ground squirrels, voles, mice	Relatively abundant populations	• Common road-related mortality
Amphibians	Frogs, toads, salamanders	Species with special habitat requirement including habitat complementation, relatively abundant populations at local scale	• Highly susceptible to road mortality (migratory and slow moving) • Local populations threatened by road-related mortality
Reptiles	Snakes, lizards, turtles	Species require special habitats, relatively abundant populations at local scale	• Road environment attracts individuals • Highly susceptible to road mortality (slow moving)

2.3 Research Groups & Initiatives

Although road ecology is a relatively new and small field, there are various research groups in North America that specialize in this work. The Western Transportation Institute at Montana State University is home to the Road Ecology Program where researchers "strive to develop and implement solutions through research, education, outreach and communications," (Western Transportation Institute, 2008). Another research group, The Road Ecology Centre based out of the University of California, Davis, has the goal of bringing together researchers and policy makers from ecology and transportation to develop a program "dedicated to the design of transportation systems that are environmentally and socially friendly," (Road Ecology Center, n.d.). At a broader scale, the Transportation Research Board (TRB) facilitates and encourages research regarding road ecology through the National Cooperative Highway Research Program, a research panel under the TRB. It has devoted resources to addressing the problems associated with WRC, publishing "Synthesis 305: Interaction Between Roadways and Wildlife Ecology, A Synthesis of Highway Practice" in 2002 and "Report 615: Evaluation of the Use and Effectiveness of Wildlife Crossings" in 2008. As well, the TRB maintains a Standing Committee on Ecology and Transportation whose mission is:

> *To stimulate research in transportation ecology and communicate the results of recent and ongoing research to and throughout the transportation community. It engages in research, planning, evaluation, education and outreach associated with sound ecological principles and designs, and strives to integrate ecologically sound principles into transportation planning, decision-making, maintenance and design. (Transportation Research Board, 2014)*

Another example of an organization is the Wildlife Collision Prevention Program, formed in 2001 as a partnership between the British Columbia Conservation Program and the Insurance Corporation of British Columbia to "save human lives and prevent injuries, protect wildlife species from unnecessary death and injury, and reduce the economic losses to society caused by wildlife vehicle collisions," (Wildlife Collision Prevention Program, 2015b). The organization works to achieve this through issue awareness, driver education, and research and implementation of mitigation techniques (2015b). A similar organization, the Ontario Road Ecology Group (OREG), is a not-for-profit conservation program that brings together transportation planners, scientists, educators, and government organizations to reduce the threats of roads to wildlife through data collection, public awareness, and engagement in the policy-making process (Kerr, 2014). The group places particular emphasis on the Species at Risk identified by the Province of Ontario. Most recently OREG hosted a national road ecology conference in Ottawa, Ontario, as a discussion-based forum for exploring the development of a national agenda for the future of road ecology in Canada.

Finally, the TransWild Alliance is an international coalition of conservation advocacy organizations that aims to promote wildlife-friendly transportation policy and action through facilitating communication, coordination, partnerships, and information-sharing (TransWild Alliance, n.d.).

2.4 Legal & Policy Context

To determine the policy framework around road ecology, an academic search for peer-reviewed journal articles was conducted using Google Scholar and the University of Waterloo's Primo database. Keywords included various combinations of "road ecology" or "wildlife crossings" and "government", "legal", "politics", "political", and "law". No resources were found, emphasizing an indication of the lack of research being conducted in this area. Instead, a grey literature review was conducted of Government of Ontario Acts that could potentially apply to road ecology, as well as any policies that deal directly with the issue. Policies were examined at the provincial, regional, and municipal levels. Finally, a supplementary Google search on the topic of wildlife, roadways and law was used to find further information in media reports dealing with the topic.

2.4.1 Legal Requirements

Various Acts of law and policies in Ontario pertain to road ecology. This section provides a brief overview of theses acts and policies; it describes the particular components within each that can be applied to require the mitigation of the negative effects associated with wildlife and roadways.

2.4.1.1 Planning Acts and Policies

With regards to planning and development, various Acts and policies can apply when looking to resolve road ecology issues. Most generally, the Oak Ridges Moraine Conservation Act, 2001, although not making direct mention of roads, was put in place to regulate the development and various uses along the moraine in order to protect its ecological and hydrological integrity and maintain a continuous natural landform and environment (Oak Ridges Moraine Conservation Act, 2001). The Niagara Escarpment Planning and Development Act shares similar goals as the Oak Ridges Moraine Conservation Act, 2001, but actually makes specific reference to the inclusion of policies regarding the location and development of transportation systems in section 9 (a)(v) (Niagara Escarpment Planning and Development Act, 1990). The Greenbelt Act, 2005, addresses the issue even further and lists environmentally sensitive transportation development as an objective of the act in section 5 (j) (Greenbelt Act, 2005). Relating to a larger portion of Southern Ontario is the Places to Grow Act, 2005, and associated Growth Plan for the Greater Golden Horseshoe, 2006: these documents provide guidance for dealing with the projected population increases over the next 25 years, with the vision of "building stronger, prosperous communities by better managing growth in [the] region," (Ontario Ministry of Infrastructure, 2013, pg. 6). Although heavily focused on developing economic prosperity and high quality of human life within the region, the Growth Plan also emphasizes the need for a clean and healthy environment through the protection of natural heritage and resources (2013). Although not making specific mention of wildlife conservation, the Places To Grow Act, 2005, states in section 14. (4)(5) that in the event of a conflict between the Places To Grow Act and another Act, the one offering more protection to the natural environment prevails (Places To Grow Act, 2005).

2.4.1.2 Provincial Policy Statement, 2014

The Provincial Policy Statement, 2014, also applies to road ecology in Ontario. Although not a legal act itself, the policy holds legislative authority under section 3 of the Planning Act (Planning Act, 1990). The policy is meant to guide land-use planning within the province in order to "meet the full range of current and future needs, while achieving efficient development patterns and avoiding significant or sensitive resources and areas which may pose a risk to public health and safety," (Ministry of Municipal Affairs & Housing, 2014, pg. 4). It lists the wise use and management of resources as a key priority and recognizes the role of efficient planning in minimizing the undesirable effects of development on natural resources (2014). It also alludes to the preference for proactive measures when stating "[t]aking action to conserve land and resources avoids the need for costly remedial measures to correct problems and support economic and environmental principles," (2014, pg. 5).

Specific to natural heritage, section 2.1 emphasizes the importance of protecting the connectivity and ecological function of natural heritage systems (Ministry of Municipal Affairs & Housing, 2014). With regards to wildlife, section 2.1.5. d) prohibits the development or site alteration of significant wildlife habitat unless it can be demonstrated that no negative impacts will result from it (2014). Along similar lines, sections 2.1.6-7 prohibit development or site alternation of any fish habitat or endangered or threatened species' habitat unless in accordance with provincial and federal law (2014). The policy also includes the protection of adjacent land to these habitats, which is recommended to be 120m (Ontario Ministry of Natural Resources, 2010; Ministry of Municipal Affairs & Housing, 2014).

This policy also goes beyond any other planning legislation with regards to road ecology by making direct mention of the impacts of roads on the environment; section 1.6.8.5 states that consideration must be given to the natural heritage resources outlined in section 2.1 when planning transportation corridors (Ministry of Municipal Affairs & Housing, 2014). Directly related to the policy, its associated Natural Heritage Reference Manual advocates for the use of various wildlife mitigation measures when addressing the specific impacts of roads; these include, but are not limited to, wildlife fencing, aquatic and dry culverts, wildlife crossing structures, and ecological design considerations (Ontario Ministry of Natural Resources, 2010).

2.4.1.3 Endangered Species Act, 2007

A more directly relevant Act for road ecology is the Endangered Species Act, 2007. The purpose of the Act is to identify species at risk in Ontario, protect both these species and their habitats, and promote the recovery of the species through stewardship activities (Endangered Species Act, 2007). Under section 9 (1)(a) no person shall kill or harm a species listed as extirpated, endangered, or threatened, and section 10 (1) prohibits any damage or destruction of their habitat (2007). These sections apply not only to people but also to any development, including road projects. In particular, section 10(1) is highly relevant to road projects, given that it is usually the habitat being affected and not the animal directly. In theory, these sections would prohibit any project from being approved that is proven to be within a Species at Risk habitat. In fact, section 11 (3) even states that the precautionary principle be employed in the event there is a lack of full scientific certainty (Endangered Species Act, 2007). However, ambiguity exists in this legislation in section 17 (1), which states that the Minister of Natural Resources may issue a permit to engage in an activity that would otherwise be prohibited by sections 9 or 10 (2007). There are requirements within section 17 (1) but the development and improvement of roads usually meets these. The limitations with potential to merit granting a road project permission despite impacts to Species at Risk are listed in Table 2.6.

Table 2.6: Limitations within the Endangered Species Act, 2007, that could allow for permit issuance despite impacts to Species At Risk (adapted from Endangered Species Act, 2007)

Section	Limitation
17. (2)(a)	The Minister is of the opinion that the activity authorized by the permit is necessary for the protection of human health or safety
17. (2)(b)	The Minister is of the opinion that the main purpose of the activity authorized by the permit is to assist, and that the activity will assist, in the protection or recovery of the species specified in the permit;
17. (2)(c)(i)	The Minister is of the opinion that an overall benefit to the species will be achieved within a reasonable time through requirements imposed by conditions of the permit
17. (2)(c)(ii)	The Minister is of the opinion that reasonable alternatives have been considered, including alternatives that would not adversely affect the species, and the best alternative has been adopted
17. (2)(c)(iii)	The Minister is of the opinion that reasonable steps to minimize adverse effects on individual members of the species are required by conditions of the permit
17. (2)(d)(i)	The Minister is of the opinion that the activity will result in a significant social or economic benefit to Ontario
17. (2)(d)(ii)	The Minister has consulted with a person who is considered by the Minister to be an expert on the possible effects of the activity on the species and to be independent of the person who would be authorized by the permit to engage in the activity
17. (2)(d)(vi)	The Minister is of the opinion that reasonable steps to minimize adverse effects on individual members of the species are required by conditions of the permit

In order to obtain these permits, it is likely that conditions will be placed on the permit. Possible conditions are listed in section 17 (5) and include limiting the timeframe of the permit, requiring the permit holder to take additional steps before starting or during the project (eg. mitigation), requiring the permit holder to monitor effects of the activity to ensure compliance, and requiring the permit holder to rehabilitate any damaged or destroyed habitat (Endangered Species Act, 2007).

Ample research has identified the effects of roads on various Species at Risk in Ontario (Fahrig, Pedlar, Pope, Taylor, & Wegner, 1995; Hels & Buchwald, 2001; Jaeger et al. 2005; MacKinnon, Moore & Brooks, 2005). The Ontario Road Ecology Group (2010) has used this information to compile a list of Species At Risk that are affected by roads which includes the jefferson salamander (*Ambystoma jeffersonianum)*, eastern foxsnake (*Plestiodon fasciatus*), milksnake (*Lamropeltis triangulum*), blanding's turtle (*Emydoidea blandingii*), snapping turtle (*Chelydra sperpentina*), and american badger (*Taxidea taxus jacksoni*) (OREG, 2010). Table 2.7 provides a more complete listing, including 'Species At Risk in Ontario' status and location specifics (OREG, 2010). This table suggests that reptiles listed as SARs are the most susceptible to WRC.

Table 2.7: Species At Risk in Ontario affected by roads (adapted from OREG, 2010)

Common Name	Population Specifics	Status
Amphibians		
Allegheny Mountain Dusky Salamander		Endangered
Fowler's Toad		Threatened
Jefferson Salamander		Threatened
Reptiles		
Blanding's Turtle		Threatened
Butler's Gartersnake		Threatened
Common Five-lined Skink	Southern Shield/Carolinian	Special Concern/Endangered
Eastern Foxsnake	Georgian Bay/Carolinian	Endangered/Endangered
Eastern Hog-nosed Snake		Threatened
Eastern Ribbonsnake		Special Concern
Gray Ratsnake	Frontenac Axis/Carolinian	Threatened/Endangered
Massasauga Rattlesnake		Threatened
Milksnake		Special Concern
Northern Map Turtle		Special Concern
Queen Snake		Threatened
Snapping Turtle		Special Concern
Spiny Softshell Turtle		Threatened
Stinkpot Turtle		Threatened
Wood Turtle		Endangered
Birds		
Acadian Flycatcher		Endangered
Cerulean Warbler		Special Concern
Hooded Warbler		Special Concern
King Rail		Endangered
Least Bittern		Threatened
Loggerhead Shrike		Endangered
Louisiana Waterthrush		Special Concern
Prothonotary Warbler		Endangered
Red-headed Woodpecker		Special Concern
Short-eared Owl		Special Concern
Mammals		
American Badger		Endangered
Woodland Vole		Special Concern
Insects		
Monarch Butterfly		Special Concern

2.4.1.4 Environmental Assessments

Environmental assessments (EAs) are another regulatory mechanism that can lead to incorporating wildlife mitigation into road infrastructure. Environmental assessments are a planning tool used to evaluate and predict the environmental effects of a proposed project before it begins in order to include environmental factors in the decision-making process and avoid or minimize any adverse effects (Canadian Environmental Assessment Agency, 2014). Various process elements are required for an EA; these include potential environmental effects and their significance, development and evaluation of alternatives, consultation with the public and any impacted parties, and establishment of mitigation measures and monitoring requirements (CEAA, 2014; Government of Ontario, 2015). It is during the EA process that the effects of a road project on wildlife can be identified and mitigation planned for.

Two different environmental assessment processes apply to projects conducted in Ontario: federal and provincial. The first is through the Canadian Environmental Assessment Act, 2012, and requires an EA to be completed if a proposed project within federal jurisdiction has the potential to have negative impacts on the environment (CEAA, 2014). However, federal jurisdiction regarding EAs is limited in Ontario, only applying to projects concerning the following: federal land, transboundary impacts, effects on fish, fish habitat, aquatic species and migratory birds, and effects on the environment that impact Aboriginal peoples (Becklumb, 2013). As a result, the federal EA process does not pertain to most road projects in the province of Ontario, however it is beneficial to be aware of. Given it's limited use within the context of this research, this review will focus on the provincial EA process. It should be noted that in the event a project requires both a federal and provincial EA, the Canada-Ontario Agreement on Environmental Assessment Cooperation provides guidance on the roles and responsibilities of implementing a coordinated EA (Ministry of Environment & CEAA, 2007).

At the provincial level, environmental assessments are conducted under the Environmental Assessment Act and are divided into two types: individual EAs and streamlined EAs. Individual EAs are conducted for large, complex projects with potential for significant environmental effects, such as a pipeline expansion or new freeway construction (Government of Ontario, 2015). These EAs are very detailed and follow a stringent process, including extensive public consultation and review by the Ministry of Environment and Climate Change. Approval by the Minister of the Environment and the Ontario Cabinet is required in order for the project to proceed (Government of Ontario, 2015). Streamlined EAs, on the other hand, are a less intense process and are used for what are described as "routed projects that have predictable and manageable environmental effects" (Gov. Ontario, 2015). These EAs are conducted by the project proponent, follow a self-assessment process, and are preapproved or exempt from Minister approval as long as the streamlined process is followed (Gov. Ontario, 2015). There are various types of streamlined EAs, but the ones applying to road projects are Class EAs. Class EAs are approved planning documents that outline the EA process for a particular group of projects that share similar characteristics with regards to type of project and potential impacts to the environment (Ministry of Transportation, 1997). Eleven Class EA categories exist; of these, the two that pertain to road projects are the Class EA for Provincial Transportation Facilities and the Class EA for Municipal Infrastructure Projects (Gov. Ontario, 2015). Within each of these Class EAs, the projects are broken down further into 'Groups' or 'Schedules' respectively based on the anticipated environmental impact and level of consultation required (Ministry of Transportation, 2000; Municipal Engineers Association, 2011).

The majority of projects examined for this research fall under the Class EA category, if an EA is required. This is due to the fact that at any one time, there will always be a large number of small-scale road infrastructure projects taking place in the province with very few new, large-scale projects.

2.4.1.5 Unique Legal Cases

Throughout the research process, two unique legal cases regarding the issue of wildlife and roads were discovered in the media. The first dealt with the creation of 'Wildlife Zones' on Colorado highways. In 2010 the *Wildlife Crossing Zones Traffic Safety Bill* was passed resulting in the legal designation of 100 miles of highway in the state where speed limits would be reduced at night and fines for improper driving would increase in an attempt to reduce wildlife-vehicle collisions by modifying human driving behavior (Colorado Department of Transportation, 2011). Although many places identify wildlife conflict areas and notify drivers with signage, the Colorado endeavor is significant in that it is the first attempt to legally require a change in human-driver behavior rather than simply suggestion. Unfortunately, in December 2014 it was announced that these zones would be removed after the data over the previous four years had proven inconclusive. Although an overall reduction in wildlife-vehicle collisions of 9% was observed, the data varied largely across the various zones and even increased in some areas (2011). Although the notion of slowing down in these problem areas is supported and strongly encouraged by the Colorado Ministry of Transportation, the agency is not legally allowed to leave the signs up if the regulated speed limit is not supported by the data or an official speed study (2011).

The second legal case involved a class-action lawsuit against the Province of Newfoundland regarding moose-vehicle collisions. The lawsuit, being put forth by Ches Crosbie Barristers on behalf of 135 plaintiffs, is suing the Government of Newfoundland and Labrador over moose-vehicle collisions causing serious injury or death on the island of Newfoundland (Ches Crosbie Barristers, 2014). The argument put forth is that moose were purposely introduced to the island in 1904 as a source of meat, but lacking any natural predators and failure to control the population by other means has lead to the animal becoming a public nuisance (Bailey, 2014). Originally filed in January 2011, the trial began in April 2014 and the judge announced a dismissal of the case in September 2014 (Ches Crosbie Barristers, 2014). The province defended its use of roadside warning signs, limited wildlife exclusion fencing, brush cutting, and public awareness campaigns as measures to reduce wildlife-vehicle collisions (Bailey, 2014). Ultimately the dismissal was based on the judges ruling that the presence of moose on highways is not a result of an "activity" of government (Stokes-Sullivan, 2014). The judge also ruled that the government does not owe the traveling public a "duty of care" (Stokes-Sullivan, 2014). Despite this, an appeal was submitted and a hearing set for January 2015, with a decision anticipated to follow within six months (Stokes-Sullivan, 2014). The outcome of this case will provide interesting ramifications given Canada's tort common-law system; in the event that the ruling is overturned, it would set the precedent that governments can be held accountable in future cases and required to pay out large sums of litigation money that could, in theory, be greater than the cost of incorporating WMSs. However, no matter what decision is made, the case will set a precedent on the way WRC mitigation is or is not taken into consideration during roadway planning.

2.5 Decision-Making & Implementation

Ample research is being conducted on the technical aspects of wildlife mitigation projects that have already been put in place. Extensive work on monitoring (Clevenger & Waltho, 2003; Clevenger & Sawaya, 2009; Eco-Kare International, 2009; Ford, Clevenger, & Bennett, 2009) as well as effectiveness is available (Gloyne & Clevenger, 2001; Clevenger & Waltho, 2005; Bissonette & Cramer, 2008; Huijser et al., 2008; Glista et al., 2009; Eco-Kare International, 2012; van der Grift et al., 2013). Although the results from the aforementioned research will have an impact on future projects, the research being undertaken for this study deals directly with the WMS decision-making process itself and therefore this literature review will focus on the work being done to aid decision-makers with the planning and implementation of future projects.

2.5.1 Factors Contributing to Wildlife-Roadway Conflict

A variety of research has been conducted on the most effective ways of incorporating wildlife mitigation measures into road infrastructure. Although there are many effects of roads on wildlife, the research in this area seems to focus on wildlife-vehicle collisions (WVCs), presumably because they are more tangible to measure than less definably effects such as habitat fragmentation. With this in mind, there are many factors that contribute to WVCs, as outlined in Figure 2.7, and the research in this area attempts to understand these factors in order to inform road ecology decision-making.

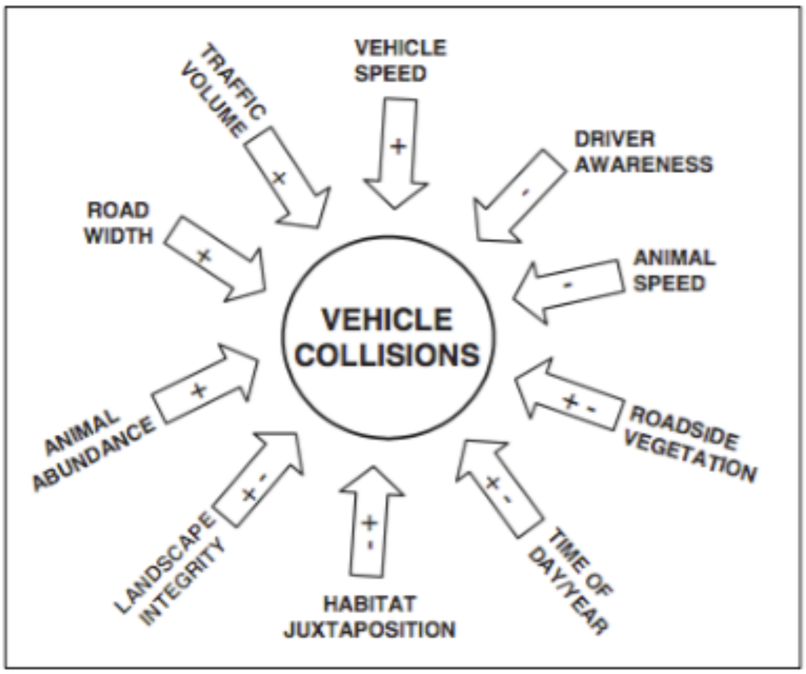


Figure 2.5: Various factors that contribute to wildlife-vehicle collisions (Litvaitis & Tash, 2008)

2.5.1 Identifying Target-Species and Problem Areas

A large portion of the research being conducted is focused on identifying the particular species that require WMSs and the best areas to focus the mitigation. Identifying the target-species and problem areas increases the efficiency of a project because the WMSs can then be tailored to work best with the species and conditions. For example, it would be inefficient to put in a dry culvert if the target-species are turtles, given their preference for moving in water. The dry culvert would surely help other species, and perhaps a few turtles, but it would not be as effective as a wet-culvert.

Hels and Buchwald (2001) developed a mathematical model to determine the probability of various amphibian species being killed during a road crossing by relating animal velocity, diurnal activity patterns, and traffic intensity. From this they were able to determine which species was most at risk individually, as well as for the population as a whole by considering the cumulative impact on population persistence (2001). Knowing which species is most at-risk leads to targeted mitigation measures, therefore providing more effective results. Although Hels and Buchwald's research was focused on amphibian species, the same principles they based their approach on could feasibly be applied to other groups of species, as was done by Polak, Rhodes, Jones & Possingham (2014) with koala velocities to predict risk.

A large portion of the available research deals with the best ways to predict the problem areas and in turn, site the location of the mitigation measures. Much of the literature refers to these areas as 'hot spots'. Numerous methods are available. Spatial wildlife-vehicle collision modeling involves using available geo-referenced WVC locations to determine any patterns in distribution and comparing these to landscape and road related characteristics (Gunson, Mountrakis & Quackenbush, 2011). Expert-based models are another predictive tool being used; these involve using expert opinions or literature to identify weighted criteria based on surrounding features in order to develop a habitat linkages model (Clevenger, Wierzchowski, Chruszcz & Gunson, 2002; Huijser, McGowen, Clevenger & Ament, 2008). This information is then used to infer where the potential for WVCs is high and mitigate accordingly in these areas. One variation of expert-based modeling is the use of local knowledge (Huijser, McGowen, Clevenger & Ament, 2008), most notably as traditional ecological knowledge, which perceives those who have lived and worked in the area of question as the experts. Even if not the sole form of prediction, the use of local knowledge is highly encouraged alongside other primary methods for the benefit of unique perspective (2008). Finally, more unconventional methods have also been used, such as social media: Webb (2012) utilized citizen science and photo-sharing sites to collect pictures of deer and their locations in the San Francisco Bay area in order to successfully predict high-risk sections of freeway.

With the various methods available, the common trend in the literature appears to be the comparison of one method's effectiveness to another. For example, Neumann et al. (2012) compared spatiotemporal methods using WVC data and wildlife movement patterns and determined that using each method individually was not sufficient; rather, they needed to be combined in order to accurately predict problem areas (2012). Clevenger, Wierzchowski, Chruszcz & Gunson (2002) compared the effectiveness of expert opinion-based and expert literature-based GIS models and determined expert-literature to be more successful. Litvaitis and Tash (2008) compared three different methods, road-kill hotspots, road density thresholds, and WVC models, and outlined the characteristics and suitable application of each (Table 2.5).

Table 2.8: Characteristics and applications of three different WVC problem area prediction methods (adapted from Latvaitis & Tash, 2008)

Method	Data Needed	Information Provided	Suitable Applications
Roadkill Hot Spot Assessment	• Locations of WVCs • Inventory of habitat features at these sites with comparable information at sites with no WVCs	• May identify features that attract or direct wildlife to specific road segments	• If features identified, habitat can be modified or mitigation device installed
Road-Density Thresholds	• Detailed information on geographic distribution of species	• Can reveal association of road abundance and presence/absence of target species • But: researcher inters with cause-and-effect relationship	• Most suitable for regional evaluation
Wildlife-Vehicle Collision Models	• Information on traffic volume, estimated kill zone, & animal velocity when crossing road	• Can estimate probability of mortality per crossing and annual mortality rate	• Can be road, are, or population specific depending on resolution of data

Although there are variations in methods for predicting problem areas, one commonality across all seems to be the use of some form of Geographic Information System (GIS) or basic geo-mapping software (Google Maps). This technology appears to be an integral component of the process: providing the visual platform needed for combining and analyzing the data they collect. Figure 2.8 demonstrates this with an example from Southern Ontario. The image combines road maps, wildlife habitat, regional planning information, and WVC hot-spots to provide detailed understanding of how these various aspects interact in the area in question (Ontario Road Ecology Group, 2010). With this information, decision-makers can identify the areas in highest need of wildlife management strategies and allocate their resources accordingly.

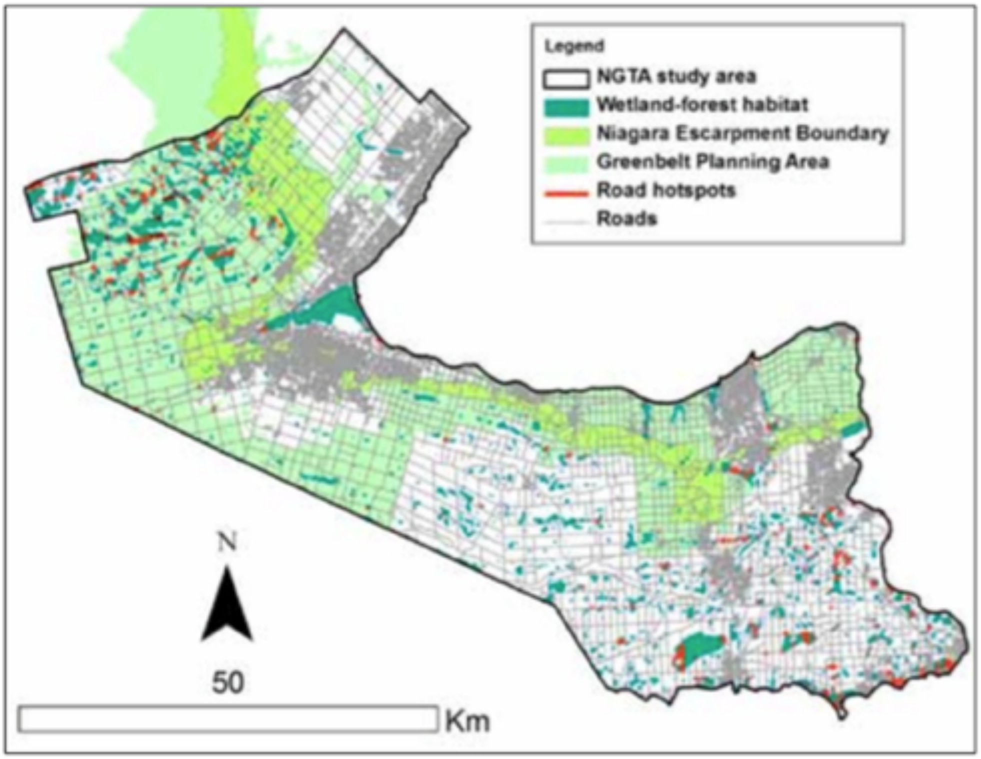


Figure 2.6: Example of GIS use for understanding road ecology characteristics along the west coast of Lake Ontario (Ontario Road Ecology Group, 2010 ©Eco-Kare International)

2.5.2 Decision-Making Tools

Although the benefit of the aforementioned research cannot be denied, ultimately a human decision must be made to incorporate WMSs into road infrastructure. As such, it is also important to have an understanding of the decision-making processes that concern WMS incorporation. As described by Polak, Rhodes, Jones & Possingham (2014), in order to be useful the ecological information that has been collected "needs to be translated into decisions and then actions," (pg. 2). The literature review process revealed that there are two main types of aides available to assist with this translation that are specific to WMS incorporation: guides and concrete tools.

2.5.3.1 Guides

The first is in the form of guides, either indirectly or directly related to road ecology. Guides that relate directly are those that deal with broader environmental issues but whose concepts can be applied more specifically to WMS incorporation. A primary example of this in Ontario is the Ontario Ministry of

Transportation's hierarchy of environmental protection that details the preferred approaches to environmental protection during road infrastructure projects (Ministry of Transportation Ontario, 2006a). The approaches are as follows, in order of decreasing preference:

1. Avoidance/Prevention
2. Control/Mitigation
3. Compensation/Enhancement
4. Environmental Monitoring During Construction

Usually a combination of these approaches is used given the plethora of different environmental impacts it may face and varying capacities to accommodate them (2006). However, for specific issues within a road project, such as a high wildlife-vehicle collision rate in a particular area, the hierarchy is followed as best as possible when designing solutions.

Another example of a guide that indirectly relates to WMS incorporation into road infrastructure is the Ontario Ministry of Natural Resources' Natural Heritage Guide for the Provincial Policy Statement. This guide provides detailed information on how to adhere to the policies within the PPS and includes 'how-to' process diagrams for identifying significant wildlife and Species At Risk habitat (Figure 2.9) (Ontario Ministry of Natural Resources, 2010). Again, although not specifically about road ecology, this guide and the tools within it can be applied when conducting a road project.

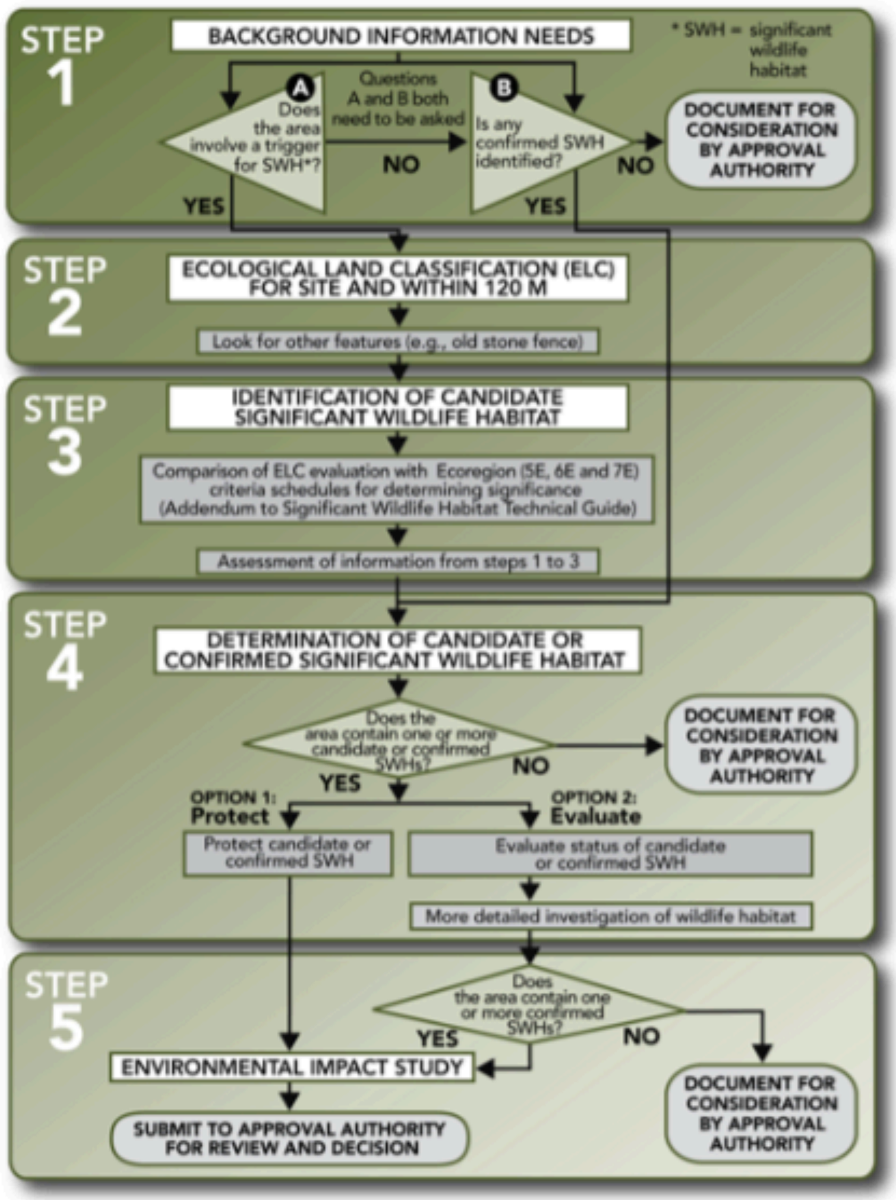


Figure 2.7: Ontario Ministry of Natural Resources process for identifying significant wildlife habitat (Ontario Ministry of Natural Resources, 2010). For Species At Risk process, see Appendix A.

There are also guides that deal particularly with road ecology. For example, the Wildlife-Vehicle Collision Reduction Study: Best Practices Manual provides design and implementation guidelines for mitigation options and details the best practices for planning for their incorporation at various geographic scales (Huijser et al., 2008). These planning practices are depicted in Figure 2.10.

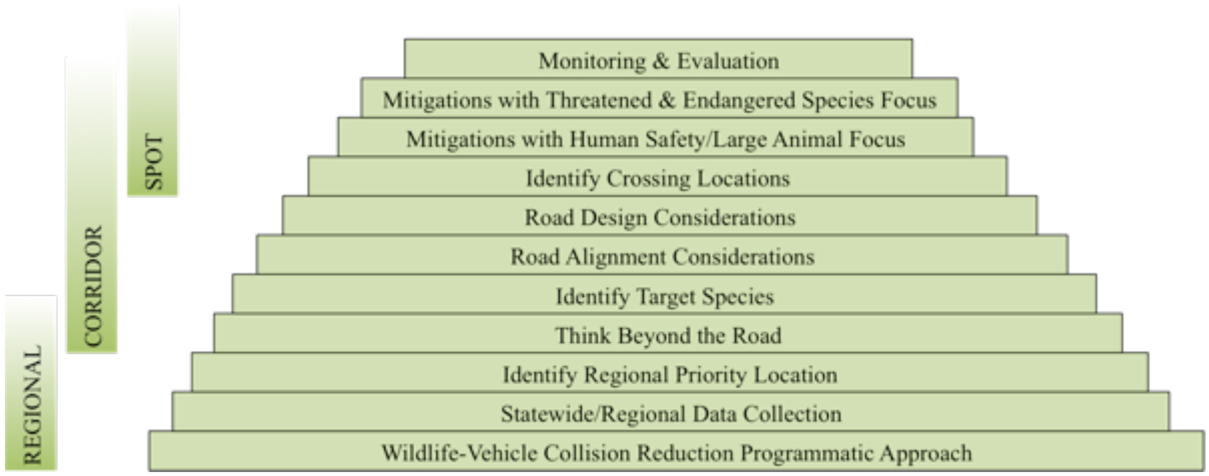


Figure 2.8: Best practices for planning the incorporation of measures to reduce wildlife-vehicle collisions at the regional, corridor, and localized spot scale (adapted from Huijser et al., 2008)

More specific to Ontario, the Ministry of Transportation's Environmental Guide for Wildlife in the Oak Ridges Moraine is intended as a tool-kit to "advise highway proponents on potential wildlife mitigation strategies based on an extensive literature review of the current scientific knowledge supplemented by professional experience," (Ministry of Transportation Ontario, 2006c). The guide provides an overview of the mitigation options for different species and conditions while detailing the general process for reducing wildlife-vehicle conflict (Figure 2.11).

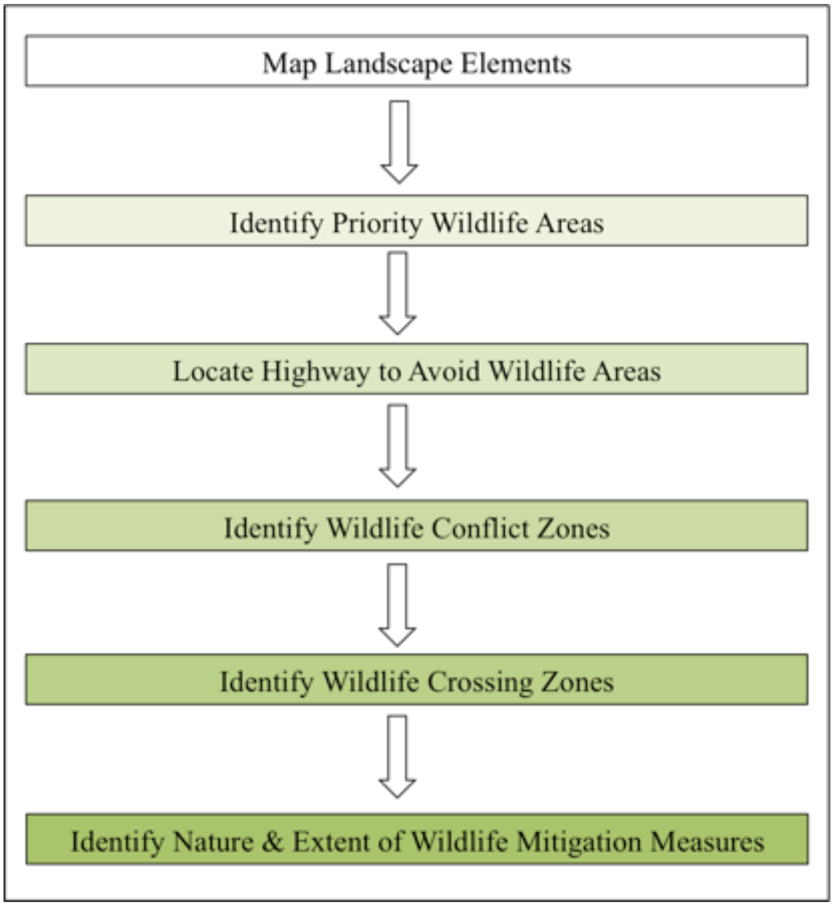


Figure 2.9: Process for reducing wildlife-vehicle conflict (Adapted from Ministry of Transportation, 2006c)

Another of the Ministry of Transportation guides specific to road ecology is Section 5: Wildlife Habitats and Movements within their Environmental Standards and Practices User Guide. This document provides detailed information on the process of incorporating WMSs into road infrastructure. This process includes data collection, analysis, and mitigation design at both the preliminary and detailed design levels, followed by the construction and monitoring phase. The necessary documentation and corresponding steps of the Environmental Assessment process are also detailed along with opportunities for WMS intervention to deal with habitat loss, wildlife mortality, obstruction of wildlife movement, and interference with Species At Risk (Ministry of Transportation Ontario, 2006b). The document also provides a thorough checklist to be used for the environmental review of a project with regards to wildlife habitat and movements, including compliance requirements and the locations of necessary information in various documents (Appendix B).

2.5.2.1 Concrete Tools

In addition to guides, there are also more concrete tools that have been utilized or developed specifically for dealing with wildlife and roadway conflicts. The most frequently used is cost-benefit analysis (CBA). From the literature review process it appears that CBA is the primary choice for wildlife and roadway conflicts, likely for two reasons: because it is easier to assess financial cost than it is to assess the loss of intrinsic value, and because financial arguments tend to be preferred by decision-makers. Various case-studies using CBA exist: Huijser, Duffield, Clevenger, Ament & McGowan (2009) used CBA to examine 13 different mitigation measures aimed at reducing large ungulate collisions. Using this CBA they also determined how many wildlife-vehicle collisions would need to occur per kilometer per year in order for the financial benefits to outweigh the costs of the measures (Figure 2.14).

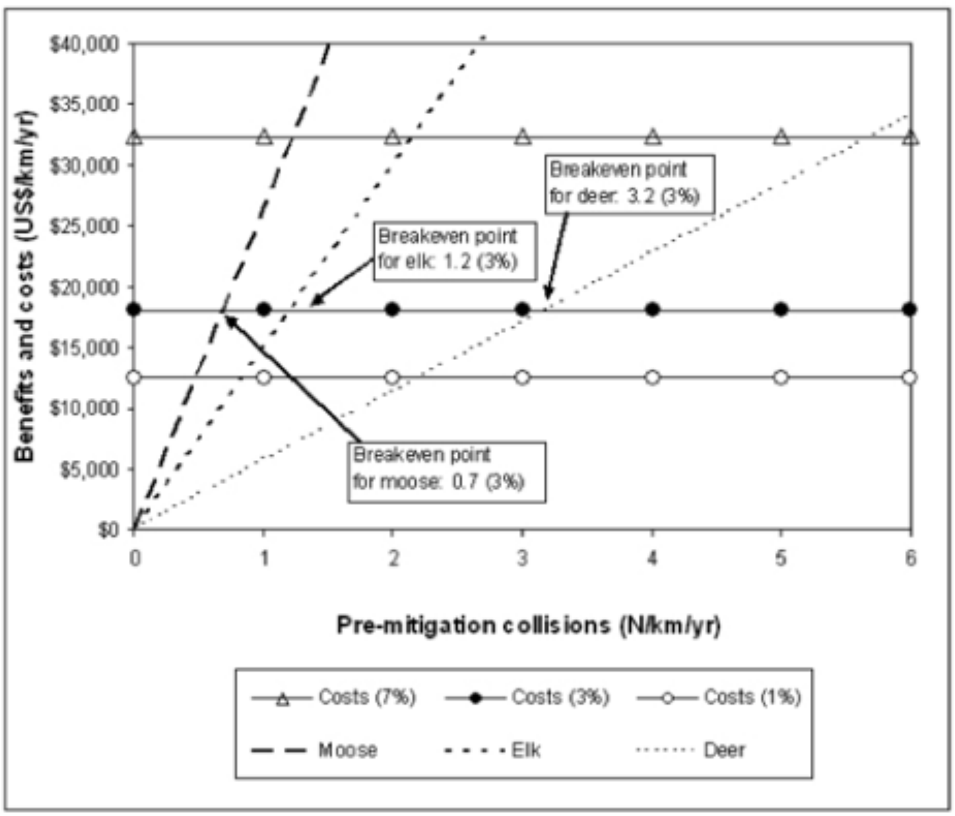


Figure 2.10: Based on CBA, the number of moose-, elk-, and deer-vehicle collisions that would have to occur per kilometer per year in order for the benefits of installing exclusion fencing and underpasses to outweigh the costs at varying discount rates (7, 3, and 1%) over 75 years (Huijser et al., 2009)

Lee, Clevenger & Ament (2012) also use CBA to prioritize 10 previously identified areas of need for WMSs along the Trans-Canada Highway in the Bow River Valley of Alberta. They also reflect on the success of a previously constructed wildlife underpass and fencing, determining that the measures resulted in a decrease of ungulate-vehicle collisions and a respective decrease from an annual cost of $128,300 to $17,500 (2012).

Similar in principle to CBA, Polak et al. (2014) use a decision science framework to determine the best option for koala conservation in south-east Queensland. They define decision science as “a rational and transparent way of determining the best action given multiple objectives…which allow managers and policy makers to arrive at ‘optimal’ decision on how to apply conservation efforts within social and financial constraints” (pg.2). In their study they determined that the tradeoffs between budget, koala population size, and best outcome are relatively linear, meaning there is no best solution in terms of low cost with high conservation value. Instead, the higher the budget, the higher the conservation benefits (2014). The mathematics of their study is beyond the scope of this research, but it is important to note that there are various forms of decision-tools available. Polak et al. (2014) emphasize this when stating that the main purpose of their analysis was not to find a specific solution for koala conservation, but instead to illustrate how decision science can be utilized in the field of road ecology.

All of the aforementioned tools are extremely beneficial to decision-making but often only represent part of the process. In contrast to this, the Transportation Research Board’s National Cooperative Highway Research Program has developed a tool specifically designed to aid the process of installing wildlife crossing structures across North America (Bissonette & Cramer, 2008). The tool is designed as a web-based interactive decision-guide that takes practitioners through each step in the process: from initial planning, through implementation, and finally to methods for adaptive management (Figure 2.15).

With regards to the human factors of decision-making, the tool does involve various components. These include the need to identify the following:

- road authority
- current planning process
- policy and legal requirements
- appropriate project team
- land ownership
- cost and benefits to society
- an implementation liaison to ensure effective communication and problem solving between stakeholders

- an effective monitoring and reporting plan in order to share results with other practitioners and the public to increase awareness and expertise (Bissonette & Cramer, 2008).

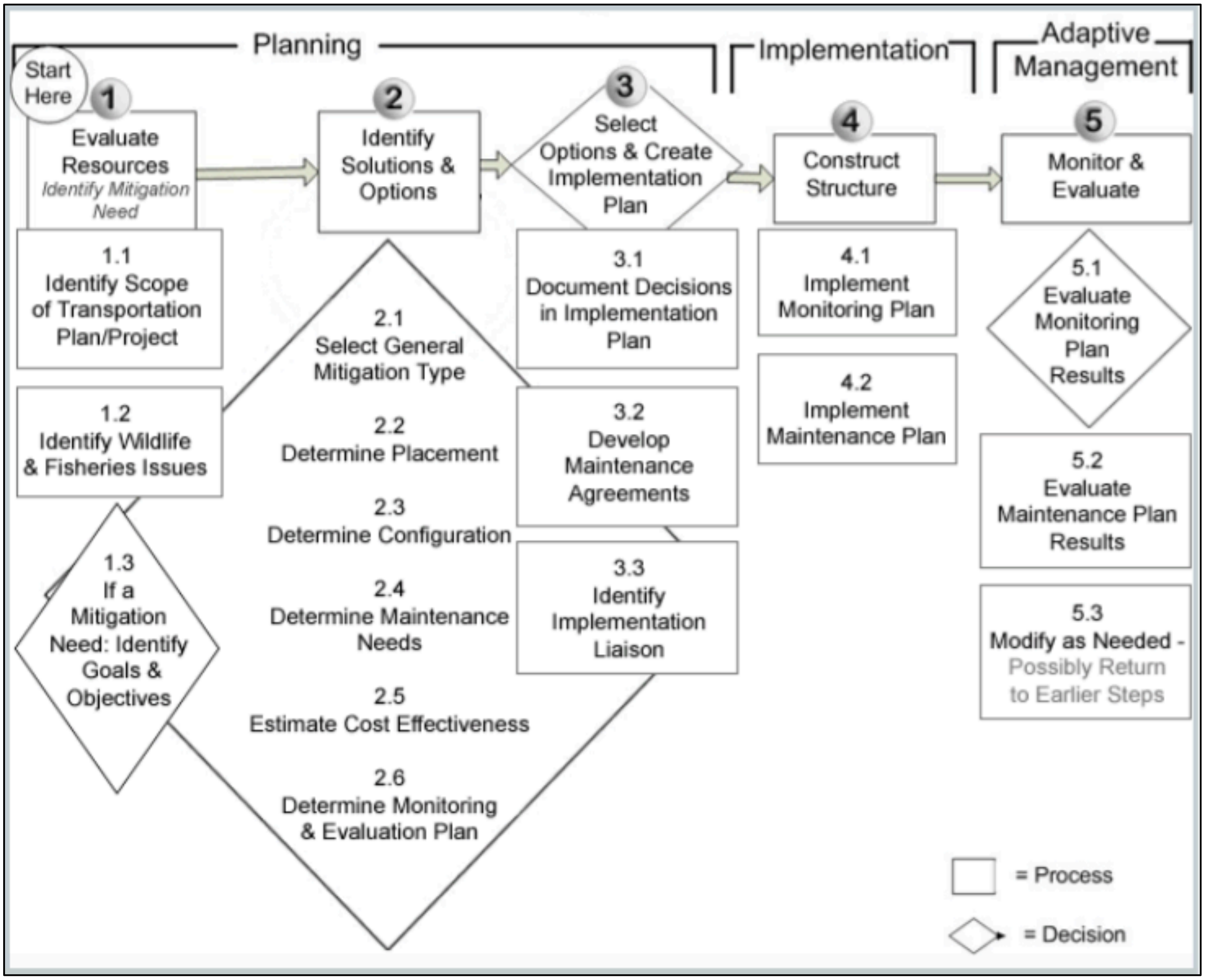


Figure 2.11: Wildlife and Roads Decision-Guide developed by the National Cooperative Highway Research Program (adapted from Bissonette & Cramer, 2008).

The guide, which is publically available on the projects website (www.wildlifeandroads.org), is accompanied by an inventory of current crossing structures, a research database and search engine for publications on the topic. Overall, the NCHRP's Wildlife and Roads Decision-Guide is the most holistic tool available for aiding wildlife crossing structure incorporation. Although designed with wildlife crossing structures in mind, the general components and processes it outlines could easily be applied to other WMSs. This being said, the main criticism after reviewing this tool in detail is that although doing an excellent job of identifying the kind of information practitioners should be looking for, it does not discuss the implications of that information. In other words, once the practitioners have the information they need, the tool does not inform them of how that information affects the decision-making process and the potential success of the initiative.

2.6 Critical Success Factors

The concept of critical success factors (CSF) originated in the business and industry management fields in the 1960's and 1970's. The original idea can be traced back to Daniel's (1961) discussion of the management information crisis in industry, in which he states that in order to be successful a company must focus on doing well at a select number of factors that are most important for success. In 1972, Anthony, Dearden, & Vancil expanded on this in emphasizing the need to tailor management control systems to the specific industry, company, and managers given that no two are alike (Rockhart, 1979). The last foundational piece of the CSF background came from Rockhart (1979) who refined the term and its definition. Rockhart's (1979) CSF was developed by the MIT Sloan School of Management as a means of addressing 'managerial information needs' and forms the basis of the CSF definition today:

> Critical success factors thus are, for any business, the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization. They are the few key areas where "things must go right" for the business to flourish. If results in these areas are not adequate, the organization's efforts for the period will be less than desired.
>
> As a result, the critical success factors are areas of activity that should receive constant and careful attention from management. The current status of performance in each area should be continually measured, and that information should be made available.
>
> …critical success factors support the attainment of organizational goals. Goals represent the end points that an organization hopes to reach. Critical success factors, however, are the areas in which good performance is necessary to ensure attainment of those goals (Rockhart, 1979, p. 11)

Since its development, the study of CSFs has expanded beyond its managerial roots to include project management applications within the construction, manufacturing, utilities, environmental, defense, education, healthcare, and pharmaceutical fields (Belussi & Tukel, 1996). As a result of this, the literature surrounding CSFs appears to be organized around two focus areas: identifying CSFs in specific fields and identifying CSF commonalities across fields to generate better working knowledge of project management in general. Identifying individual CSFs within specific fields is the predominant theme in the literature. For example, Sanvido et al. (1992) determined that, in the construction field, four factors are critical to success:

1. Having a well-organized, cohesive facility team with common goals and activities
2. Contracts that encourage those involved to behave as a team, without conflicts of interests or goals, and ensure fair allocation of risk and rewards from the project
3. Experience with similar projects
4. Optimization information (information used to integrate expertise) that is timely and valuable

The authors found that projects with these four factors were able to adapt and persevere through obstacles such as incomplete information and program changes while those without these factors could not (Sanvido et al. 1992). Within the environmental field, Zutshi & Sohal (2004) investigated the CSFs for adopting and maintaining company environmental management systems to address the impacts of their products and services. They state the primary obstacle to successful implementation is resistance and challenges by employees and stakeholders; however this can be minimized if managers can arrange their projects around the CSFs they identify and categorize (Table 2.9).

Table 2.9: Critical Success Factors for implementing environmental management systems, as determined by Zutshi & Sohal (2004)

Management Leadership & Support	Learning & Training	Internal Analysis	Sustainability
• Top management commitment • Cultural change & organizational vision • Allocation of resources • Appointment of Champion • Avoidance of personal clashes	• Learning from other experiences • Reference to standards & guidelines • Employee induction & training • Training/awareness for other suppliers & stakeholders	• Cost-benefit analysis • Initial environmental reviews & gap analysis • Identification of impacts/setting of objectives & targets • Internal & external audits • Document control system • Integration of existing management systems	• Life-cycle analysis • Design for disassembly • Employing industrial ecology principles

Although individual identification is important, this traditional examination of CSFs faces some criticism, namely that: 1) it does not consider the interrelationships between the factors, which can be as important as the factors themselves, and 2) it views the factors as static, when in reality they are part of a dynamic process and can have varying levels of importance at different stages (Fortune & White, 2006). This has been addressed by various authors who have used the comparison of CSFs to develop conceptual frameworks.

One of the first CSF frameworks was developed by Belassi & Tukel (1996) who classify common CSFs into groups and identify the relationships between them to inform how they affect project performance (Figure 2.16). They identify four groups: factors that relate to 1) the project, 2) the project manager and team members, 3) the organization of the project, and 4) the external environment. They emphasize the distinction between true CSFs and system responses: elements that are effects resulting from CSFs. They rationalize that it is easier to identify general groups and their interrelationships than to attempt to identify all existing CSFs given the high diversity of projects. Having an understanding of the framework of CSFs improves project evaluation for a number of reasons: 1) by guiding project managers to investigate critical areas that may be overlooked, 2) enabling adaptation to changes in CSFs as circumstances change over time, and 3) providing insight into a factor's effects even without perfect knowledge because it is easier to relate a factor to a general group than to pinpoint its specific effects individually (Belassi & Tukel, 1996).

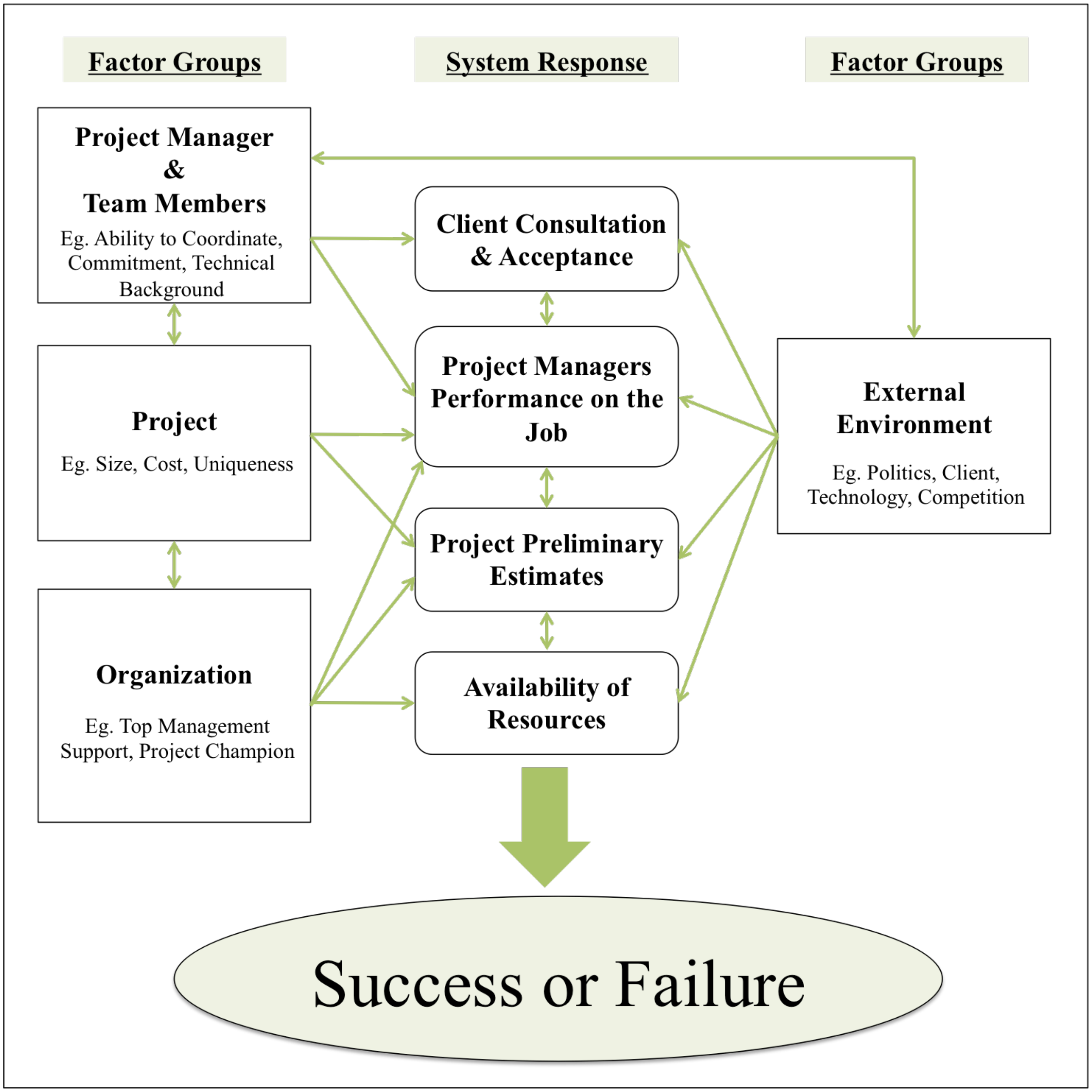


Figure 2.12: Belassi & Tukel's (1996) framework depicting the critical success factor groups and system responses (adapted from Belassi & Tukel, 1996).

Specific to the construction field, Chan, Scott, & Chan (2004) reviewed 43 journal articles pertaining to CSFs in construction management and developed a conceptual framework based around five main categories of CSFs: 1) Human-related factors, 2) Project-related factors, 3) Project procedures, 4) Project management actions, and 5) External environmental factors (Figure 2.13).

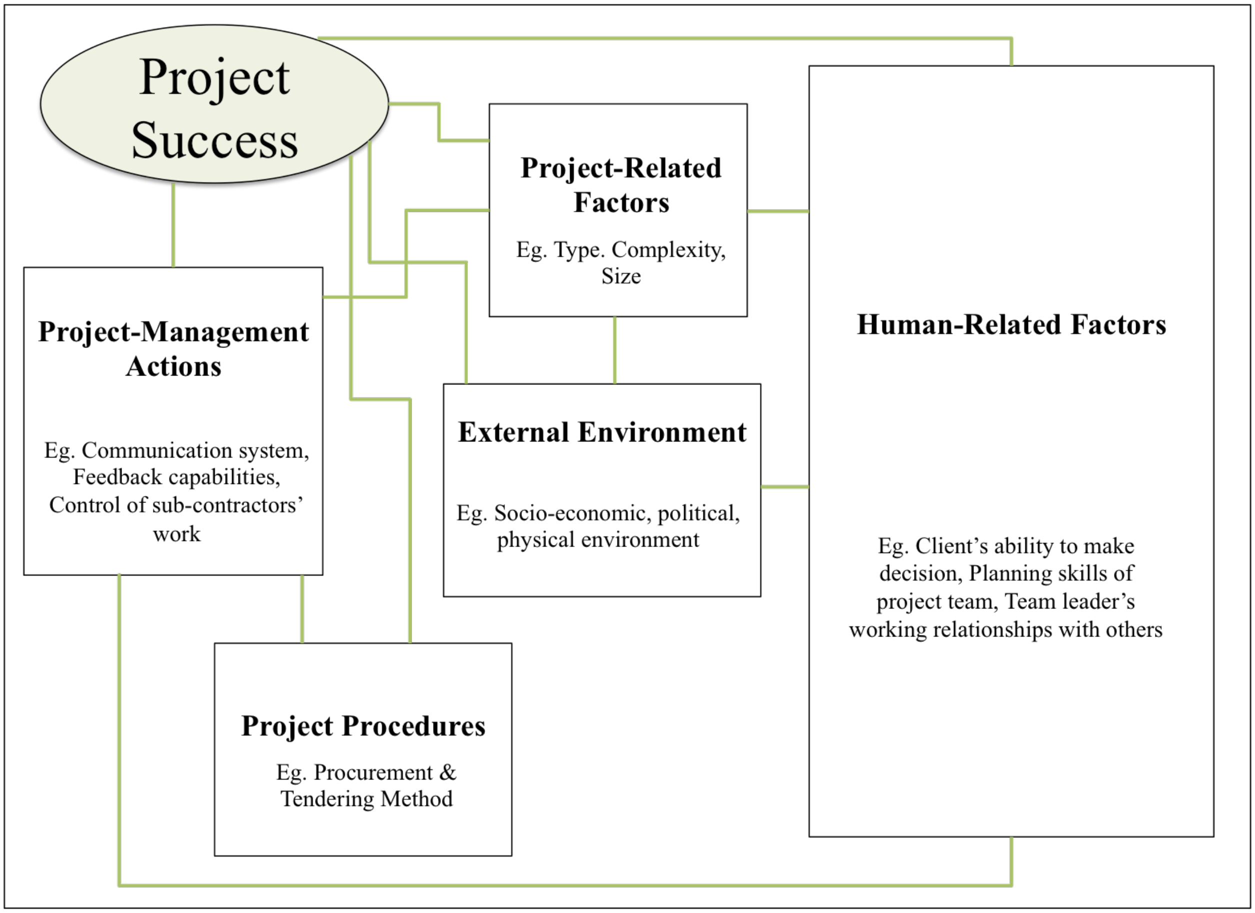
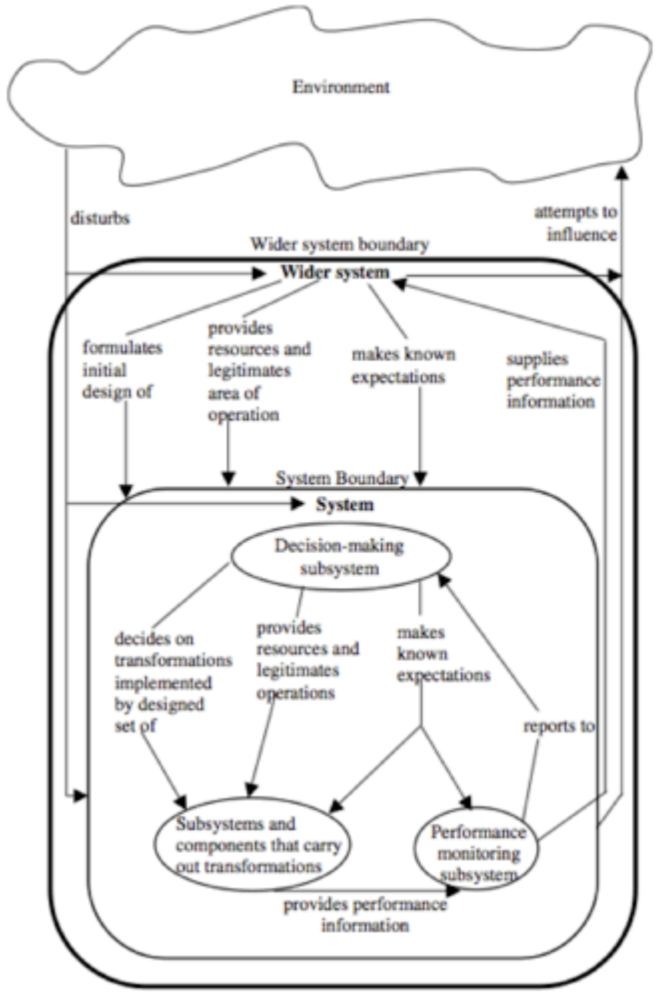


Figure 2.13: A framework for the Critical Success Factors in the construction field, developed by Chan, Scott, & Chan (2004).

Speaking more to the improvement of CSFs based on its criticisms, Fortune & White (2006) compared the CSFs from 63 publications and applied their analysis to the established Formal Systems Model, a framework used to investigate failures by conceptualizing the situation at hand (Figure 2.18). The authors were able to match 23 of the 27 identified CSFs from the literature to components of the Formal Systems Model, and in doing so, argue for the use of the model as a more effective method of CSF investigation (Fortune & White, 2004).



Component of FSM/ project attributes	Critical success factors from literature
Goals and objectives	Clear realistic objectives Strong business case/sound basis for project
Performance monitoring	Effective monitoring/control Planned close down/review/acceptance of possible failure
Decision-maker(s)	Support from senior management Competent project manager Strong/detailed plan kept up to date Realistic schedule Good leadership Correct choice/past experience of project management methodology/tools
Transformations	Skilled/suitably qualified/sufficient staff/team
Communication	Good communication/feedback
Environment	Political stability Environmental influences Past experience (learning from) Organisational adaptation/culture/structure
Boundaries	Project size/level of complexity/number of people involved/duration
Resources	Adequate budget Sufficient/well allocated resources Training provision Proven/familiar technology Good performance by suppliers/contractors/ consultants
Continuity	Risks addressed/assessed/managed
*Not Categorized	User/client involvement Different viewpoints (appreciating) Project sponsor/champion Effective change management

Figure 2.14: The Formal Systems Model (left) and the Critical Success Factors categorized into its components (adapted from Fortune & White, 2006).

One thing from the CSF literature is clear: the factors that impact a project's success are diverse and not always obvious. Only focusing on one or two areas of a project can result in an incomplete understanding of the system at work and in turn, decrease the project's likelihood of success. In addition to the individual CSFs, the relationships among them are just as important; only with an understanding of the relationships can the cumulative effects of the CSFs be determined.

2.7 Moving Forward

This literature review has described the current state of knowledge and research concerning the ecological and societal impacts of wildlife-road conflict, mitigation strategies and their objectives, legal requirements, current tools available to aid WMS incorporation into road infrastructure, and critical success factors.

Individually, these each represent important pieces of the puzzle when it comes to reducing WRC. However, they have not yet been connected. As such, the research moving forward will aim to connect these pieces using the application of the concepts surrounding CSFs as the unifying idea. By examining the factors that critically effect the incorporation of wildlife management strategies into road infrastructure, this research will uncover the relationships between the information already available as well as identify any key information that has been overlooked. Integration of this knowledge and demonstrating its applicability are fundamental steps in improving the process of WMS incorporation.

Chapter 3 Methods & Materials

This chapter explains the methods utilized for data collection and analysis. Qualitative methods utilizing elements from qualitative content analysis (QCA) and grounded theory methods (GTM) were employed. A description of the methods and justification for their use will be discussed.

3.1 Core Concepts

3.1.1 Qualitative Methods

Qualitative research is described as "a means of exploring and understanding the meaning individuals or groups ascribe to a social or human problem," (Creswell, 2009, p.4). This is in contrast to quantitative research, which aims to test preconceived, objective theories by examining relationships between measurable variables (Creswell, 2009). In general, qualitative research "…involves emerging questions and procedures, data typically collected in the participant's setting, data analysis inductively building from particulars to general themes, and the researcher making interpretations of the meaning of the data," (Creswell, 2009, p.4). A key element within this is that the research be *inductive* rather than *deductive*, in that the data is used to build an understanding of the relationships at play from the bottom-up, rather than starting with a predetermined theory and working top-down to prove it using collected data (Figure 3.1). Another key element of qualitative research is that it is interpretive; the researcher examines the data and provides their interpretation of it.. It is acknowledged that the researchers' own experiences and worldviews will impact their interpretation; they cannot be separated. Therefore, various interpretations of the same phenomenon can exist if multiple people, each with their own experiences, interpret it differently (Creswell, 2009).

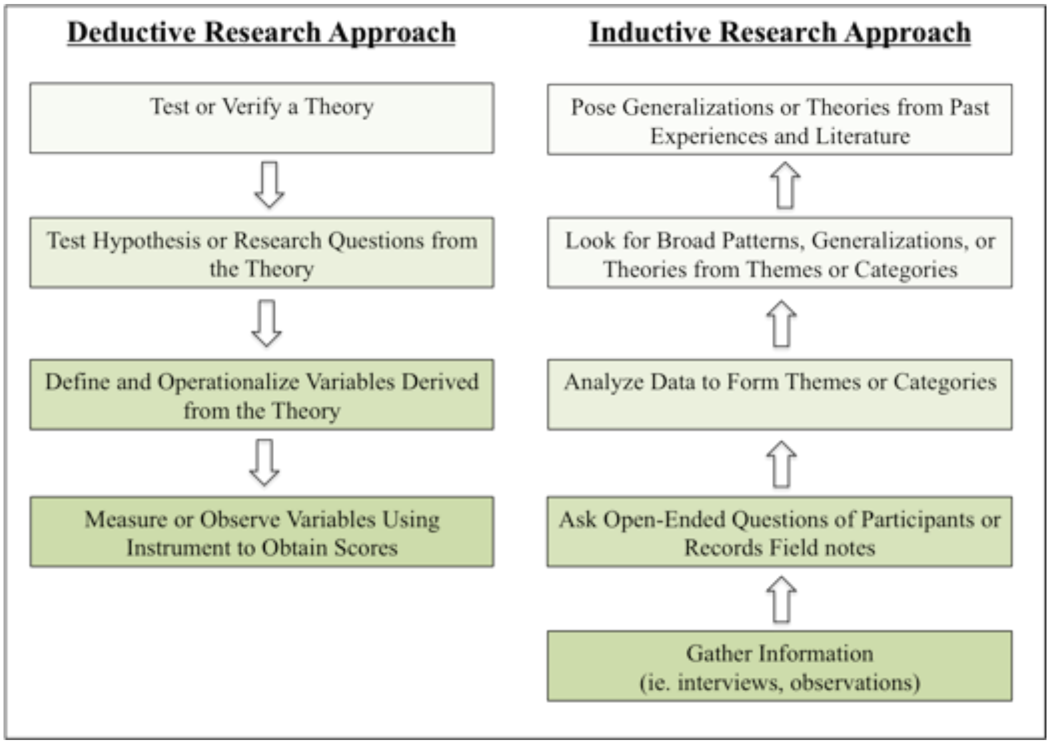


Figure 3.1: The deductive and inductive research approaches (adapted from Creswell, 2009)

3.1.2 Qualitative Description & Qualitative Content Analysis

Within qualitative research, there are various methods available to researchers. One of these methods is Qualitative Content Analysis (QCA), a form of qualitative description. Qualitative description is a form of naturalistic inquiry, meaning it studies phenomenon in their natural state and without predetermined variables to investigate or theories to adhere to (Sandelowski, 2000).

Often erroneously criticized as being a ‘weak’ form of analysis, qualitative description is merited for its low-interference interpretation of the data in comparison to other qualitative methods (Sandelowski, 2000). It stays closer to the data by only focusing on the ‘surface’ of the words and events being analyzed. Sandelowski (2000) provides as apt description: “[i]n qualitative descriptive studies, language is a vehicle of communication, not an interpretative structure that must be read,” as it often is with other qualitative methods (p. 336). As a result of this low-interference, there tends to be more consensus amongst researchers regarding the ‘facts’ of the phenomenon being explored (Sandelowski, 2000). Qualitative description is also merited for its ability to “answer questions of practice and policy in everyday terms," (Forman & Damschroder, 2008, p. 41): an aptitude not many academic activities can claim.

QCA is the predominant strategy when conducting qualitative descriptive research (Sandelowski, 2000). Being a form of content analysis, it is "a systematic, rule-guided [technique] used to analyze the informational contents of textual data," (Forman & Damschroder, 2008, p.39). Modeled after *quantitative* content analysis, a method of sorting data into predetermined categories and analyzing using frequency analysis, QCA sorts data using categories that are derived from the data itself (and inductive approach) and does so via close reading of the text rather than computerized algorithmic search processes (Sandelowski, 2000; Kohlbacher, 2006; Forman & Damschroder, 2008). QCA developed in response to various criticisms of quantitative content analysis; Kracauer (1952) states that it neglects "the particular quality of texts" and that "it is not by counting and measuring that "patterns" or "wholes" in texts can be demonstrated but by showing the different possibilities of interpretation of "multiple connotation"," (Kohlbacher, 2006, p.11). Mayring (2000) summarizes the criticism when describing quantitative content analysis as "a superficial analysis without respecting latent contents and contexts, working with simplifying and distorting quantification," (p.2).

With regards to the procedure for QCA, Sandelowski (2000) speaks to the fact that there is no "pure" use of particular methods in qualitative studies; rather, they are often "variously textured, toned, and hued," in that they incorporate techniques associated with other approaches such as grounded theory or ethnographic studies (pg. 337). However, there are some common attributes used to guide the process. First and foremost is the notion that the aim is to develop an understanding of the phenomenon at hand rather than use it as a sample to make generalizations about a population (Sandelowski, 2000; Forman & Damschroder, 2008). To do this, minimal to moderately structured, open-ended data collection techniques are used, often in the form of interviews and/or observations of events and documents (Sandelowski, 2000; Forman & Damschroder, 2008). The aim of data collection is to gather "information-rich" cases that provide depth and detail rather than simply measurement (Sandelowski, 2000; Forman & Damschroder, 2008). Analysis is conducted using a step-by-step, rule-based process that is centered around a category system (Kohlbacher, 2006). As described by Titscher, Meyer, Wodak, & Vetter (2000):

> The core and central tool of any content analysis is its system of categories: every unit of analysis must be coded, that is to say, allocated to one or more categories. Categories are understood as the more or less operational definitions of variables. (p.58)

There are three phases of analysis when conducting QCA: data immersion, reduction, and interpretation (Forman & Damschroder, 2006). Data *immersion* refers to engaging with the data as a whole by beginning to analyze the material immediately after it is collected. Viewing the material holistically before breaking it down into units of analysis can help researchers make connections and gain insights they would otherwise likely miss. The second phase is the *reduction* of the data, which is where the systematic approach of categorizing the data is developed and conducted. The goals of this phase are to reduce the amount of raw data, divide data into manageable themes, and to reorganize the data into categories that are relevant to the research questions being asked. This is done through a coding process that involves a mix of deductive and inductive coding: deductive codes developed a priori are applied to the data at the onset of analysis as a starting point for investigation, followed more extensively by inductive codes developed from the data. Finally, *interpretation* of the data concludes the process. It involves re-organizing the categorized data in order to identify patterns and relationships, test preliminary conclusions, and develop an analytic framework: all with the goal of developing a comprehensive understanding and explanation of the data (Forman & Damschroder, 2006). It is important to note that the organization and understanding of the data is not definite; the QCA process is reflexive and should involve re-visiting and revision of the data as new information and insights arise (Sandelowski, 2000; Forman & Damschroder, 2006; Kohlbacher, 2008). This is facilitated via simultaneous data collection and analysis (Sandelowski, 2000; Forman & Damschroder, 2006).

Finally, an additional component of QCA described by some researchers (Sandelowski, 2000; Kohlbacher, 2008) is the use of some form of *quantitative* method to count the number of responses and number of participants that are sorted into each category. The inclusion of what can be referred to as a quasi-statistical analysis technique is not meant to undermine the significance of the QCA results; rather, it is a supplementary form of checking and confirming the patterns and relationships identified (Sandelowski, 2000).

3.1.3 Grounded Theory Method

Developed and advocated by Barney Glaser and Anslem Strauss in their 1967 publication *The Discovery of Grounded Theory*, the aim of the grounded theory method (GTM) is "to build a theoretical explanation by specifying phenomenon in terms of conditions that give rise to them, how they are expressed through action/interaction, the consequences that result from them, and variations of these qualifiers," (Corbin & Strauss, 1990, pg.9).

GTM is comprised of a set of components that set it apart from other qualitative methods (2006). First and foremost the processes of data collection and analysis are to occur simultaneously, allowing for the analysis of one source of data to guide the collection of another (Corbin & Strauss, 1990; Charmaz, 2006). In this way, the theory is advanced continuously throughout each step of data collection and analysis. Secondly, rather than approaching the data with a predetermined hypothesis with which to examine the collected data, the themes and codes used for analysis are instead constructed *from* the data and are considered to be emergent. They can, and should, develop continuously during data collection and analysis (Corbin & Strauss, 1990). This aspect of GTM is of particular importance in that it is what 'grounds' the results of the analysis within the data; in other words, the researcher does not approach the data with preconceived notions of what it might detail, therefore eliminating biased analysis and developing a 'true' theory based purely on the data. GTM also distinguishes itself through the cyclical nature of the comparisons it makes between the data (Charmaz, 2006). Comparisons are made during each stage of the analysis, returning to previous data sources when new concepts arise or re-examining previously constructed concepts when new data is obtained (Corbin & Strauss, 1990). The idea behind this is to always be verifying the developed theory against itself, particularly in light new data or concepts.

Finally, regarding data collection, GTM is different from other qualitative methods in that sampling is done with the objective of theory construction in mind *not* population representativeness (Corbin & Strauss, 1990; Riley, 1996; Charmaz, 2006). Referred to as theoretical sampling, GTM looks to achieve a "representativeness of concepts", not people, specific groups, or periods of time (Corbin & Strauss, 1990, pg. 9). As such, findings from a grounded theory study often cannot be generalized to a larger population the same way other qualitative or quantitative methods provide for.

3.1.4 Combining QCA & GTM: Justification for Method

From the previous description of QCA and GTM, many similarities can be identified, however the main difference is that GTM seeks to interpret the data extensively and produce a robust theory whereas QCA seeks to identify and present the facts of the phenomenon with as little interpretation as possible. As such, it may seem odd to want to utilize both methods, yet, as described by Sandelowski (2000), qualitative description often employs elements of GTM. This study combines the two methods by following the general process of GTM as a guide for simultaneous data collection, analysis, and comparison, yet following the analytic framework of qualitative description and QCA.

Even though the components of qualitative description and GTM are similar, the decision to use GTM as a procedural guide came from the fact that the steps are more clear and solidified within the literature. The decision to use QCA as the analytic framework, and to not develop a theory as with GTM, stems from the fact that the topic being explored has remained largely uninvestigated. Given that this study will form the basis of understanding and information on WMS incorporation into road infrastructure, it was deemed that an overly interpretive analysis would be inappropriate. As stated previously, QCA is regarded as resulting in information that is more easily agreed upon: the facts of the matter at hand that remain the same regardless of their interpretation (Sandelowski, 2000). Providing a minimally interpreted body of knowledge to act as the starting point for further exploration seemed the best course of action. Also, Sandelowski (2000) states that qualitative description is particularly useful in "obtaining straight and largely unadorned (i.e., minimally theorized or otherwise transformed or spun) answers to questions of special relevance to practitioners and policy makers," (p.337). Considering that one of the objectives of this research is to aid road ecology practitioners with future projects, this strength of qualitative description was the deciding-factor in choosing to use QCA as the analytic framework.

3.2 Study Specifics

3.2.1 Study Location

This study was focused geographically on Southern Ontario. Although 'Southern Ontario' traditionally refers to the region south of the District of Parry Sound, for the purposes of this research it will be expanded to include any location south of Sudbury, Ontario (Figure 3.2). This decision was made because Sudbury is the last relatively large urban area before entering what is considered the 'heart' of Northern Ontario, and therefore faces similar WRC as more southern urban areas. This being said, in the Sudbury region the population of larger wildlife species (eg. ungulates) is greater and therefore poses more of a threat to human safety and requires more extensive mitigation strategies. As such, the definition of 'Southern Ontario' was modified so that this research could include examination of perspectives dealing with these issues in more detail than only focusing on the traditional boundaries of Southern Ontario could provide.

As urban growth extents to accommodate population increases, Southern Ontario is becoming more and more fragmented. Already home to the highest concentration of roads in Canada, its road network is only continuing to grow. As such, more and more negative interactions between wildlife and roads are occurring. Fortunately, WMSs for roads are starting to gain traction in the province and their timing and scattered incorporation provides an excellent opportunity to examine the opportunities and challenges being faced. This alone would make Southern Ontario an excellent case study, but the addition of the Endangered Species Act, 2007, and its required protective actions add an interesting element not found elsewhere.

Despite its merits as an excellent case study, little research has been done specific to the area. Significant WMSs targeted at keeping wildlife off roads have been conducted in the Rocky Mountain region, as well as the United States and Europe, but Ontario’s situation remains relatively uninvestigated. Therefore, Southern Ontario presented a novel opportunity to investigate how and why the wildlife management strategies are beginning to grow in number and magnitude.

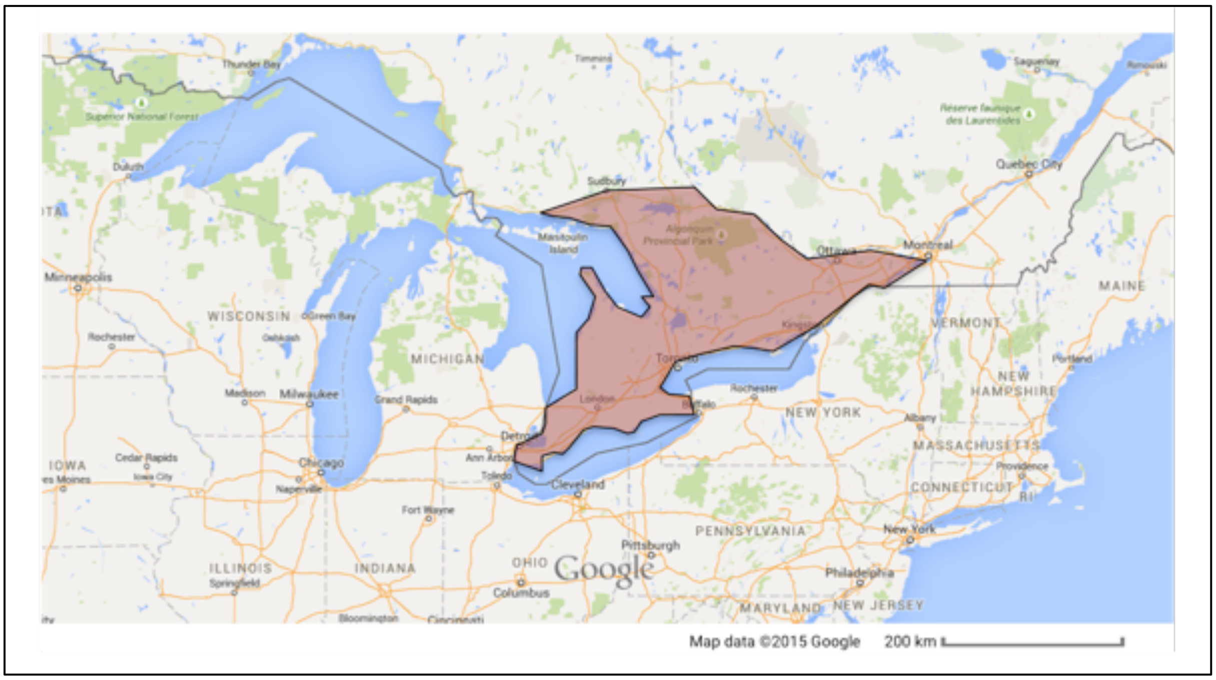


Figure 3.2: Map of study location, as indicated in red (https://www.google.ca/maps)

3.2.2 Sampling & Recruitment Technique

A preliminary list of WMS projects was compiled. This was done using web-based searches, with multiple keyword qualifiers such as “wildlife AND roads AND Ontario” or “wildlife collision AND mitigation”. This technique proved laborious as much of the information was difficult to locate and ultimately only found in obscure places such as small-town newspaper articles, larger road project plans, and award announcements. In some cases, projects were brought to attention through word-of-mouth, but further details and contact information for potential interviewees still had to be scrounged from online sources. Chain-referral sampling also contributed to the list of potential projects once interviewing began. Projects that were previously unknown to the researcher were brought to attention and in some cases, interviewees provided contact information for other projects that were potentially relevant. Some interviewees even contacted people they thought may be interested on the researcher's behalf.

From the list of potential projects, convenience sampling guided the decision as to which projects were actually included in the interview process. This was based on project suitability, response, and interviewee availability.

Recruitment of interviewees was done via email, using a standardized recruitment email briefly describing the research (Appendix C.1). If contacts chose to participate, an information letter and consent form were sent back to them and arrangements were made to conduct the interviews at the interviewees' convenience (Appendix C.2). This process was approved by the University of Waterloo's Office of Research Ethics under the application number ORE #19752.

3.3 Data Collection

3.3.1 Data Source

Two types of data sources were utilized for this research: semi-structured interviews and participant observation.

3.3.1.1 Semi-Structured Interviews

The primary method of data collection was semi-structured interviews conducted with decision-makers, project managers, and major stakeholders involved with the chosen projects. Questions were open-ended and focused on the experiences had with regards to project development, implementation, and execution. Charmaz (2006) details the merits of interviewing for grounded theory development because the approach is "open-ended but directed, shaped yet emergent, and paced yet flexible," (pg. 28).

All of the interviews were conducted in person. They were recorded using the Zoom H1 Handy recorder and lasted on average between 40 minutes and one hour. The interviews were conducted at either the interviewees' place of work or the project site. In two cases, the interviews took place in an office setting followed by a tour of the project site. A total of 12 interviews were conducted, with 16 participants in total, and included discussion of specific WMS projects, strategy development, and general experiences (Table 3.1).

Table 3.1: Interview Characteristics, including interviewee and project descriptions

#	Interviewee Position	Type	Type of Measures	Main Problems	Main Advocate	Road Authority
1	Project Coordinator	Retrofit	-culverts -stream crossing -small animal exclusion fencing	-general road mortality (reptiles/ amphibians)	Expert Group	Region
2	1. Sr Env Planner- MTO 2. Sr Policy Analyst, South & Vibrations- MTO	New Road Development	-deer exclusion fencing -underpass -road alignments adjustments	-human safety due to high deer populations	MTO	Provincial
3	Env Planner- MTO	New Road Development	-overpass, underpass, culverts -deer exclusion fencing	-human safety -wildlife habitat connectivity -Species At Risk	MTO	Provincial
		Retrofit	-deer exclusion fencing	-human safety -WVCs	MTO	Provincial
		New Road Development	-deer exclusion fencing; tied into multi-purpose culvert	-human safety -WVCs	MTO	Provincial
4	Sr Policy Analyst, Env Policy Office- MTO	---	-developing wildlife mitigation strategy for Provincial roads	-need for efficiency via guidance on how & where to implement strategies	MTO	Provincial
5	1. Sr Env Planner- MTO 2. Private Env consultant	New Road Development	-exclusion fencing -underpasses -road alignment -stream crossing enhancements	-environmental responsibility -public concerns re: deer -SAR (redside dace)	MTO	Provincial
6	Terrestrial & Wildlife Resources Analyst- CA	Road Improvement	-wet & dry culverts -elevated road design	-general road mortality -turtles, amphibians, snakes	Expert Group	Region

7	Project Manager- Region	New Road Development	-underpasses -amphibian crossing -exclusion fencing -road alignment	-connectivity between natural areas (i.e. 16 Mile Creek)	Region	Region
8	Manager/Main Veterinarian- Turtle Trauma Centre	---	-collaboration with other experts for research & turtle exclusion fencing projects	-turtle injury & mortality	---	---
9	Senior Terrestrial Ecologist- CA	Retrofit	-seasonal temporary road closure	-SAR (Jefferson salamander) mortality from WVCs	Expert Group	Local (City)
		Road Improvement	-underpass -deer exclusion fencing	-anticipated future WVC hotspot (deer)	Expert Group	?
		Road Improvement	-culvert -retaining wall	-SAR (Jefferson salamander) present on both sides of road	Expert Group	Region
10	Principle Planner, Stewardship Planning- Region	Retrofit	-artificial turtle nesting sites	-turtle mortality from WVCs	Public/ Region	Regional Road; Private Land
		Road Improvement/ Modification to existing plans	-culverts and exclusion fencing	-general road mortality	Region	Region
11	1. Head of Natural Lands 2. Conservation Projects Employee	Retrofit	-exclusion fencing for small wildlife	-general road mortality; particularly turtles	Expert Group	Local (City)
12	1. Terrestrial Ecologist 2. Aquatic Ecologist	Retrofit	-exclusion fencing for small wildlife	-general road mortality; particularly turtles	Expert Group	Local (City)

3.3.1.2 Interview Questions

A preliminary set of questions was developed prior to beginning the interview process as a guide to help spur conversations regarding different aspects of the projects (Appendix D).
This guide was utilized more in the initial few interviews as themes and concepts for further exploration were still emerging. It is important to note that this was not an exhaustive list of the questions asked throughout the whole interviewing process; instead the nature of the topics discussed evolved as the interviews continued and new information and ideas emerged through the simultaneous analysis.

3.3.1.3 Supplemental Data Collection

Recognizing that the number of formal interviews conducted for this study may be considered low, supplementary data was collected to strengthen the findings. The researcher attended two conferences where they were able to interact and engage with road ecology practitioners. The first was the *Pathways 2014 Conference: Integrating Human Dimensions Into Fisheries and Wildlife Management*, where the researcher had the opportunity to present preliminary findings and compare this to the experiences of other practitioners through discussion. The second was the Ontario Road Ecology Group (OREG) conference *Road Ecology: A National Agenda for Canada*. It was comprised of multiple interactive and discussion-based presentations on various other road ecology projects that the researcher had not had the opportunity to interview. Also, various conversations with other attendees at both conferences acted as informal interviews. Based on these interactions, the researcher was able to extract information about the different practitioners' experiences with WMS incorporation without a directed interview setting.

3.3.2 Theoretical Data Saturation

Following the procedures of grounded theory, and qualitative research in general, there is no set number of interviews required to complete a study (Riley, 1996). Instead, the notion of achieving 'theoretical data saturation' is used as the marker for determining when data collection may cease (Glaser & Struass, 1967; Mason, 2010). This refers to "the point at which gathering more data about a theoretical category reveals no new properties nor yields any further theoretical insights about the emerging grounded theory," (Charmaz, 2006, pg. 189). Although no particular number of samples is required, various estimates on the number of interviews that are needed to achieve theoretical data saturation are available: Riley (1996) notes that between 8 and 24 interviews has been the common point at which theoretical saturation is achieved, Mason (2010) determined the average number of interviews for PhD studies utilizing grounded theory was 32, and Creswell (1998) recommends between 20 and 30.

Repetition in the data occurred early on and theoretical data saturation was suspected after the ninth interview: three more interviews were conducted after this point to confirm that all concepts had been explored. Despite feeling that data saturation had been achieved, there was doubt whether the relatively low number of interviews would withstand academic scrutiny. As such, the researcher reached out to Dr. Creswell via email at the advice of my advisor to gather his input. Personal communication was had with Tim Guetterman, a researcher working with Dr. Creswell at the CEHS Mixed Methods Academy, who confirmed the validity of our reliance on theoretical data saturation over reaching a specific number of interviews (T. Guetterman, personal communication, November 18th, 2014, Appendix E).

3.3.3 Transcription

Each interview recording was transcribed for later analysis. Two methods were utilized: the first consisted of using the free software ExpressScribe to transcribe on my own computer. The second method consisted of listening to the interviews in ExpressScribe and editing out any parts that were deemed irrelevant to the research to create a new file which was then sent out to Transcript Divas Transcription Services. It was chosen to contract out the transcribing for the purpose of saving time. A confidentiality agreement was signed to ensure security of information in line with the requirements of the Office of Research Ethics.

3.4 Data Analysis

The following sub-sections will detail how this research went about using the steps of QCA to analyze the collected data. Again, it should be noted that the analysis process was occurring simultaneously with data collection.

3.4.1 Research Journal & Memos

Memo-writing is considered a vital step in both the grounded theory and qualitative description process and must occur throughout its entirety (Charmaz, 2006; Forman & Damschroder, 2008).

Throughout the research process a research journal was kept to keep track of ideas, explore relationships between concepts, and identify questions that still needed to be answered. In addition to acting as a step in the research process, this journal acted as a form of academic audit trail to be used to trace concepts and ideas backwards through their evolution.

3.4.2 Informal Concurrent Analysis

Throughout the data collection period, informal analysis was constantly taking place. This was primarily in the form of memo writing but also included informal discussions with other researchers to review the data and discuss ideas. This is encouraged by Corbin and Strauss (1990), who state that discussions with peers can lead to new insights and increased theoretical sensitivity by being able to test the analysis against other people's perceptions of the data. The memos and notes from this process are what enabled the data immersion below.

3.4.3 Data Immersion

Prior to the formal coding process, the informal analysis through data immersion was used to create a preliminary set of critical factors. This was done after conducting the ninth interview when data saturation was suspected. The factors that are critical to WMS incorporation and the relationships between said factors were explored visually in the form of a decision-tree structure. The aim of this exercise was to explore the relationships and influence of each factor in relation to the others in a hierarchical form.

3.4.4 Data Reduction: Coding

Data reduction using formal codes was used to break down and categorize the data. First a set of deductive codes was applied to the data. These codes were developed a priori from a general understanding of project-decision making and used as a starting point for analysis. Very quickly, inductive codes were developed from the data and subsequently applied to the following interviews. When a new inductive code was identified in later data, the previous data was re-examined for the new code, as per the cyclical nature of GTM and QCA. For this research, the qualitative data analysis software NVivo was used to assist with the coding process. The transcriptions of the interview recordings were inputted into the software as ‘Internal’ documents. Each transcription was read line-by-line and coded into different ‘Nodes’, the term the software uses for codes.

3.4.5 Data Interpretation

Data interpretation involved two steps. The first was re-organizing the categorized codes to identify relationships and patterns. This involved sorting the categories of data into different groups as a means of identifying the factors that influence WMS incorporation. This coding was also done using the NVivo software to nest codes into parent nodes at the conceptual level. This process identified a first set of critical factors. These factors were once again explored and further nested into each other based on their relationships.

The second step of data interpretation was to develop a concept diagram to depict the relationships between the factors. In particular, the aim of the diagram was to illustrate the influence each of the factors had on the others and the WMS incorporation process as a whole. This was done by first identifying how each of the factors were related to the others, and then representing these relationships visually through trial-and-error.

3.5 Analysis Validation

Finally, in order to validate the research, interview participants were contacted once again and provided a summary of the results and analysis. They were encouraged to review the summary to ensure that their experiences were reflected and make recommendations. These recommendations were then incorporated into the final version of the analysis.

Chapter 4 Results & Analysis

Throughout the data collection process and subsequent analysis, nine factors were identified that are critical to WMS incorporation into road infrastructure in Southern Ontario. They are:

1. Category of Project
2. Main Proponent
3. Environmental Assessment Process
4. Species At Risk
5. Data Availability
6. Knowledge Availability
7. Public Support
8. Funding
9. Bureaucratic Process

They are arranged in order of general importance with regards to the amount of influence they have on the incorporation process. This being said, the particular amount of influence a factor has can vary depending on the context surrounding the project. Each factor is described in the following sections, along with various supporting quotations.

4.1 Category of Project

Early in the research process it became apparent that a key distinction between the various projects being examined was the timing and way in which the WMSs were incorporated into the road infrastructure. There are two different categories of projects based on this distinction: 1) wildlife-specific retrofits to existing road infrastructure and 2) mitigation measures that are incorporated during a larger road infrastructure project, whether it be road improvements or an entirely new road. Of these, mitigation measures that are part of larger road projects are the most common in Ontario.

This research determined that wildlife-specific retrofits are more challenging than mitigation measures incorporated during larger road projects. Many of the challenges faced by larger road projects are exacerbated when dealing with wildlife-specific retrofits. The primary example of this is funding. Specific funding must be acquired from external sources, often charitable, in order to do the work because the costs cannot simply be rolled into the pool of money set aside for infrastructure. In addition, costs may be higher because all of the equipment must be brought in to do the work that would otherwise already be there for a larger road project.

"…we had to go out and literally earn, apply for every dollar and never knew from one year to the next because a lot of the funding was one year only… ." (I-1)

"Plus it's a retrofit project as opposed part of a-, I mean if this was part of rebuilding this road entirely, putting the culverts in and the fencing would be like a tiny proportion of the budget and stuff." (I-1)

This point was also supported during discussions with practitioners attempting to retrofit the I-70 highway at the Vail Pass in Colorado with large-scale wildlife-crossing structures. They stated funding as their primary issue. In fact, funding had been arranged in 2012 but was ultimately re-delegated after flooding destroyed miles of highway in the state.

Another challenge surrounding retrofits is the need to plan the mitigation within the constraints of what is already there. In this case, one does not have a 'clean-slate' to work with and cannot plan the roadway and mitigation measures simultaneously for optimal effectiveness.

"When you're retrofitting to existing highways you can't just put it [exclusion fencing] everywhere because there's a lot of challenges, primarily entrances. Anywhere where there's access to your highway you run into major issues because you're way inside your fence."(I-3)

Hence it is easier to 'piggy-back' WMSs onto larger projects than it is to undertake a completely separate wildlife-specific retrofit.

"…the road is being ripped up anyway, so you have a chance to put stuff in the ground and it doesn't cost as much. But if you're going in just specifically to do that, then to get all that equipment and get everything mobilized like just to do conservation, it's crazy…" (I-9)

"You don't have to go tear up the road or anything, just to drop the culvert in. They're doing all that anyways. So the cost of an extra culvert is peanuts compared to a rebuild." (I-10)

Wildlife-specific retrofits are also challenging from a public and political awareness standpoint because attention is focused solely on the mitigation measures. The measures being undertaken during wildlife-specific retrofits receive more backlash than those that are part of a larger infrastructure for a variety of reasons. Alarmist reactions to the cost of the measures can occur because it is being seen separately and without perspective on general infrastructure costs. For example, many people would be shocked and skeptical in hearing that a wildlife bridge was being installed on a road with a cost of $1 million; however, if the same people were told that a new road was being installed for $10 million and would include a wildlife bridge, few would question the bridge itself. Another explanation for the backlash towards wildlife-specific retrofits is the idea that they are perceived differently than larger infrastructure projects from a psychological standpoint; retrofits can be seen negatively as 'doing something to the roadway' whereas mitigation measures that are a part of larger infrastructure can be seen positively as measures to 'reduce the impact' of the larger project components.

Finally, there is more backlash as a result of the resistance to new and unknown practices as well as differences in ideologies. This problem is exacerbated for wildlife-specific retrofits because they cannot "fly under the radar" as they would as part of a larger infrastructure project.

"So we got some of that blow-back, that, that innate, that uh rural suspicion of a new idea…." (I-1)
I was in public relations for years, and this has been one of the most challenging things I've ever done because we've been, we've been dealing with rumour, ignorance, misunderstanding of science, misunderstanding of the taxation system and stuff," (I-1)

For these reasons, wildlife-specific retrofits are less likely to be successfully incorporated into road infrastructure than WMSs that are tied into larger road infrastructure projects.

4.2 Main Proponent

Another key distinction amongst the projects is the advocating party for the project. This research identified three different groups of advocating parties: 1) provincial government agencies, 2) municipal government agencies, and 3) expert groups. Provincial government agencies refer to the various divisions of The Ontario Ministry of Transportation. Municipal government agencies include both regional and local-level governments. Expert groups is the term, as chosen by the researcher, to describe the group of advocates that includes Conservation Authorities, non-governmental conservation organizations, volunteer committees, and any other proponent that has established itself as a proficient source of ecological knowledge.

It is important to note that this distinction is not solely for data organization purposes; rather, who the advocating party is impacts how the various elements outlined in the following sections interact with each other to influence the success of incorporating WMSs into road infrastructure. This differs from the other factors that can all both influence the outcome directly as well as the process.

Also unlike the other factors, *Main Proponent* did not come to light through specific cases or quotations. Instead, the understanding of its role as a critical factor was developed by stepping back from the individual cases and examining all of the cases collectively through a wider lens. By doing so it was determined that cases advocated for by similar groups shared similar experiences. For example, expert groups advocating for WMSs all discussed the notion of having their voices heard: sharing their expertise and getting decision-makers to act on it is easier with data. On the other hand, while data is important for projects advocated for by local and provincial governments, interviewees from these groups expressed that it is not as crucial to success. This is because if the advocate and road authority are the same group, they do not need 'hard' data to prove to themselves that they should undertake the project; they are clearly already convinced that it is worth pursuing.

4.3 Environmental Assessment Process

The environmental assessment (EA) process is another major component in the project development process. It is often during the EA process that the need for wildlife management strategies is first identified, either through the investigative process itself or the required consultation with stakeholders.

"When they start though it's like okay got to fix that road. Only got this much money, right. Got to meet engineering standards. Well the EA process also makes us look at the environmental factors and all the other legislation that goes around that." (I-4)

"Yeah, partially what started off this whole thing was - so there was an EA process going on that was looking at geometric deficiencies in the road… So they said okay well we'll just - the intent going forward was just to widen it a little bit just to bring it up to like even standard lane width. I don't think it was even standard lane width. And then this was kind of like a mitigation that they were willing to put into place for doing that work." (I-9)

When undertaken in a positive way, stakeholder consultation often leads to positive collaboration between the proponent of the road infrastructure project and stakeholders. For example, including the stakeholders early and meaningfully throughout the EA process makes for much smoother project planning and better working relationships among the parties involved.

"We actually had a wildlife biologist go out and do a deer survey and one of the open people from the open house, who was a hunter, had volunteered his services and he went out with the biologist to quantify the population and he showed them where, the areas where he knew that they lived as well." (I-2)

"One of the big disconnects that we see in planning is the fact that people have ideas and they spend time and energy developing them and then they bring in other disciplines who say, well this isn't going to work

and this isn't going to work and then there's frustration because they've already invested time. All it really takes is for somebody in that original thought process to be at least aware of enough." (I-6)

The EA process can also virtually guarantee that WMSs will be incorporated into a road infrastructure project. This guarantee arises when legal commitments are made within the EA approval which projects are required to follow through on. These commitments can emerge as conditions for approval placed by the approving body or voluntarily included by the proponent of the project, perhaps in response to stakeholder concerns. Either way, once the commitments are made it is very hard to back-out of them without penalty. Therefore, WMSs will be successfully incorporated despite any implementation challenges (i.e. financial, resistance) that may arise in order to avoid this penalty.

"And the best way to really sell it is getting it- making commitments in your environmental assessment, so when you have the push to do something, you put out those documents and those final area reports that says you're going to do something, well you've got to go do it or somebody's going to hold you accountable, because people are aware of what the commitments we make, especially in terms of wildlife crossings and things like that." (I-3)

"...if you have a commitment or a condition that says you shall do that – if you want your highway you have to do this too, put it in as a commitment or a condition and then that gives you a little bit more oomph when you're trying to fight this." (I-5)

For these reasons, the EA process often acts as the primary platform for the discussion of WMSs and in some cases, can ensure the success of incorporation into the project.

4.4 Species At Risk

The presence of Species At Risk (SARs) at the site of a planned road infrastructure project positively affects the likelihood of getting mitigation measures implemented. Their presence affects this in two ways. Firstly, if it is demonstrated that the particular SARs being dealt with is affected by road infrastructure, mitigation is legally required under provincial or federal Acts. Because the majority of roadways in Ontario fall under Provincial or Municipal jurisdiction, the Ontario Endangered Species Act, 2007, is the most relevant to this research. Similar to EA commitments, because of this legal requirement often times the decision is made for the project planners to incorporate WMSs given that they do not have any other option.

"So you mentioned species-at-risk: if we had barn swallows here, yes for sure we would be doing a barn swallow kiosk somewhere. There's no question." (I-2)

"One is our legal obligation to get approval to do our projects we need to demonstrate that we're having zero of minimal impact, or at least try to mitigate our impacts on endangered species." (I-3)

"…it [the Endangered Species Act, 2007] was meant to be the strongest piece of legislation in North America. And oh my gosh, was it ever." (I-4)

"There's an EA going on for [name removed] Line. And we're getting a crossing installed there as well because there's Jefferson salamanders on both sides of it." (I-9)

The influence of SARs as a critical factor was strongly supported by an experience had at the Ontario Road Ecology Group (OREG) Conference: during a presentation by a consultant discussing a road expansion and wildlife culvert project, the researcher was able to ask a question regarding the city's motivations for the WMSs. The consultant giving the presentation explained that the city was very willing to incorporate WMSs, for intrinsic reasons. However, right after this, a city official from that project raised his hand and stated that he wanted to clarify the answer to my question. He stated: that in fact, the city would never have done the WMSs if it hadn't been for the Species At Risk legislation that had been introduced during the planning process and the presence of such species.

The second way in which the presence of SARs positively impacts mitigation likelihood is that if projects are being required to mitigate for a SARs, often times they will expand the scope of the measures to benefit other species as well. For example, if a box culvert is required for turtles in the area, but it is known that there is also high road mortality for other non-endangered species as well, the plans may expand to increase the size of the culvert and put in taller exclusion fencing. The thought process is that if they are already doing some mitigation it requires minimal extra work and resources to 'tack on' extra measures in exchange for larger increases in other benefits such as driver safety, overall conservation benefits, or project recognition. This is the "give a little, get a lot" concept.

4.5 Data Availability

Data availability plays a large part in the decision-making process and manifests itself in three different ways: as previously identified need, pre-existing data and/or available resources to collect data.

Previously identified need refers to when a road infrastructure project is being planned for an area that has already been identified as an area for future wildlife management strategies. In most cases this would arise when a conservation organization or government has devoted resources to evaluating a large area to prioritize the location of future mitigation measures. This is beneficial because when new road infrastructure projects begin, all parties are in agreement and the measures can be planned in from the beginning. None of the projects examined for this research fit this scenario but many of the interviewee's expressed a desire for this type of system. They also believed it would be more efficient than having individual projects investigate need on their own, particularly from a time and money standpoint.

"So if we have basically a map of all the areas where mitigation would be warranted, and how we could prioritize it so that we can, you know, try to tackle it in an efficient and cost effective manner, then, you know, we could also actually put the signs up everywhere and say okay those are markers for future mitigation." (I-4)

"…if we know right now that it's a problem, we can say, you know, start putting money aside for this now because we're going to be asking for something really good at this crossing. Because right now every EA that crosses my desk it's a standard like, you know, must consider road ecology issues kind of thing. But once we have this kind of prioritization in place, I won't have to say that for every single one. So I'll be able to say no, this one, like I want top [shelf] for this one, this one, you know, not so much." (I-9)

Pre-existing data differs from a previously identified need in that it is not necessarily agreed upon or known that WMSs need to be incorporated, rather just that some form of monitoring has been conducted that indicates so. This is because having "hard data" rather than anecdotal evidence is preferred by most decision-makers, particularly in government, as a means of justifying their decisions in the midst of backlash.

"…for the past six, seven years it's just been me doing it and I'm learning a lot but it's just anecdotal. I can't convince people based on my own learned knowledge," (I-3)

"…once we presented the numbers to the region, there was very little opposition…the data spoke for itself. We were surprised and everyone was surprised how many animals we found…So I think that [the data] was the big factor in this going through the way it did. I think without the data it would have been a much harder sell." (I-6)

"So like you're not seeing carcasses smeared all across the road right now, but a few years down the road once all these different projects happen…And you know you're reconstructing the road now. So put it in now. You know, be proactive about it. When you have no data it's really hard to get anyone to be proactive. Like you just - you can't." (I-9)

This benefit of having "hard" data was echoed by many practitioners at the OREG conference, such as one group who were able to use pre-existing data from the Ministry of Transportation on SARs presence and existing culvert locations to help justify the need for mitigation measures along Hwy 401 at the Frontenac Arch. Another practitioner aptly stated that "squished salamanders speak louder than words".

Having pre-existing data is particularly helpful when it is an expert group advocating for mitigation measures on a project under someone else's jurisdiction. Expert advice is not enough to "prove" something must be done.

"Nobody's going to believe you until you kind of scientifically can quantify it." (I-1)

"I don't know where this would have gone if we didn't have the data," (I-6)

"Yeah, I guess the biggest thing that I've come across is just having a lack of data to support my feelings if something requires mitigation" (I-9)

Finally, if pre-existing data is not available, then it is important that the advocating party have the resources available to collect the data they need to help convince decision-makers. Resources in this case refer to the finances, manpower, and time required.

"So one of the previous wildlife biologists or wetland biologists sort of suggested that maybe there be an increased impact to wildlife that we should bring that up as part of the plan of view process and at the time, I mean there wasn't; we agreed but we didn't have any data to support that, even that recommendation. So, we just did a quick study of our own," (I-6)

Time is of particular importance. This is because it can take a considerable length of time, sometimes up to years, to collect sufficient, meaningful data and if not commenced early enough, the project planning process will likely have progressed too far for mitigation measures to be included. Because of this, many interviewees emphasized the need for advanced notice of future road infrastructure projects so that they themselves can plan accordingly. This is particularly true of expert groups given that they usually do not have jurisdiction over the project and, as such, are often notified later in the planning process. This was the case for one project where the local conservation authority was made aware of the plans to widen a road very early during the proposal stage. They were then able to collect road mortality data over the course of the following two summers to support their recommendations that the region include WMSs in the design.

As with time, manpower is of particular importance to expert groups. This is because they tend to have less staff or are volunteer-based. Wanting to collect data, but simply not having anyone to do it was a common theme discussed by interviewees.

“It’s really hard when you’re volunteers. I mean, your resource base is pretty thin, right? I mean, if you were doing it as a government agency, or some big organizations like Green Peace, or NCC, you’ve got staff and everything,” (I-1)

“…we don’t have opportunity to go out.
Respondent 2: We haven’t done hotspot surveys on local roads. Yeah.
Respondent 1: Only based on staff. Like, we just don’t have the staff.” (I-12)

Expert groups that did have the resources available to collect the data spoke of their situations with rather incredulous and appreciative tones, which suggest that it is quite rare

4.6 Knowledge Base

Knowledge base refers to the sources of information available to those attempting to incorporate WMSs. The information being sought is the general ‘know-how’ to incorporate the strategies. The knowledge base element is composed of three themes that emerged from the data: lack of central body of knowledge, learning experience, and knowledge sharing and collaboration.

4.6.1 Lack of Central Body of Knowledge

Many interviewees expressed the desire to have a central body of knowledge that they could go to when they had questions, stating they were unsure what to do next after deciding they wanted to include mitigation measures.

“We wanted to do something. We kind of had to see what was out there, and there wasn't a lot.” (I-1)

It should be noted that the information is often out there, but that it is piecemealed and scattered across various government, academic, and ‘in practice’ sources making it laborious and time-consuming to find.

“The information is out there- it's borrowing it from other places and you know, making it fit here” (I-2)

“So at the time, we didn’t have any- there was no protocol. There is no protocol for doing road surveys. So some of it was just what we thought made sense.” (I-6)

"...there's just such a need to have a central repository for all this stuff" (I-9)

In some cases the information is tucked away within larger documents with an alternative focus, such as EAs or infrastructure plans, making it very difficult to find unless you are made aware that there is a wildlife management component within them. These sources of information can also be hard to access and/or difficult to interpret.

"Yeah, because I mean none of this stuff ever gets published anywhere. It's just stuff that's in - buried in the EA documents on a shelf somewhere or in someone's head, so." (I-9)

It is very inefficient overall to have each individual project doing the investigative leg-work to find the knowledge they need, expending resources and time that could be put toward the measures themselves. Instead, a centralized body of knowledge that is easily accessible needs to be developed. Like the importance of pre-existing data, the need for such a knowledge base was widely expressed by practitioners at the OREG conference: one practitioner expressed that the lack of knowledge transfer is a huge barrier to WMS incorporation while another emphasized the need for a "clearing house" of information.

4.6.2 Learning Experience

Given the lack of a central body of knowledge, many looking to incorporate WMSs are left to sort out the information and process on their own. Interviewees often described their projects as a learning experience, with ups and downs.

"This whole thing is just one rolling learning experience from the scientific side, but also from the community relations, public relations side and all that type of thing," (I-1)

"It's an experiment to be sure. You know, you've done as much background research as you can to try and make sure the things you suggest, like the meter high wall will be effective." (I-6)

"It's kind of like a methodology, we just kind of winged it," (I-10)

"Yeah, we learn from this and move forward, right?" (I-12)

One theme associated with learning experience is the notion that any subsequent projects are easier and proceed much more smoothly, with those involved feeling more prepared and capable.

"The first one [deer fence] in 2006 was kind of the first one in the province, and it was pretty much kind of like a trial site to see how well it worked. We've since fenced two other sections," (I-3)

"…if we can get this one going and we can see positive change then the next time it gets brought up, as improving a culvert, it might be just that much easier to sell," (I-6)

"So I'm really glad that the first project has been positive so far. If it hadn't been positive we might never be able to do this again." (I-6)

4.6.3 Knowledge Sharing & Collaboration

One way to get around the lack of central knowledge base is through knowledge sharing with those who have completed similar projects and collaboration with those who have different areas of expertise. Connecting with a group that has previously completed a similar project and having them share their experiences helps reduce the about of leg-work that has to be done. It also helps eliminate the chance of making a mistake that has already been made by someone else, therefore increasing efficiency by not wasting resources.

"The planners do talk to each other about you know "I know you've done this, I need this...what have you done, how did it work?" Definitely a lot of information sharing," (I-2)

"But certainly, you know, whatever information we have that could support the decisions that need to be made that would be available. We wouldn't keep that to ourselves," (I-4)

"I went to their board a month ago now and did a full presentation on turtles and what we know and all of this, that will help unlock the staff's ability to move it [their own WMS project] along," (I-11)

This point was reinforced at the OREG conference; multiple cases were discussed where consultants and municipalities reached out to OREG to provide assistance and peer-review plans when those tasked with incorporating WMSs were unsure of what to do.

In some cases formal arrangements for knowledge sharing have emerged that have benefited the expansion of road ecology knowledge. One example is the South Central Ontario Conservation Authorities Natural Heritage Discussion Group:

"So we meet - the ecologists meet about four times a year and talk about natural heritage systems planning. And we've had little subgroups over the years…There's a little subgroup dealing with terms of reference for environmental impact studies, because every CA was doing things slightly differently. And it was like, you know, what size buffers are you getting from significant…because we're getting this much

and you're getting that much. And so we get together quite regularly to compare notes on these kinds of things…And we had a little - a kind of mini session on road ecology. We've gotten together a couple of times actually," (I-9)

Collaboration with other groups doing projects or with those who have different expertise in the field aids in project success. Collaboration can take various forms, including paid contracted help, inter-organizational, or across jurisdictions.

"…but of course we also knew we didn't know anything. So, we worked with the county just because of their expertise in tendering and put out a tender and hired a company [name removed] and retained them to do a feasibility study to put some, you know, the benefit of their engineering and ecological experience around the ideas that we had about what we could do about the causeway." (I-1)

"We had a two or three day workshop with the agencies and we brought someone up from Florida that was familiar with building structure on swamps and we had engineers there, drainage engineers, civil engineers." (I-5)

"It's a very large project and because of the natural heritage system, the natural environment played a very big role in that and the mitigation and the protected of the natural environment, so I think there was a lot of support I think, like, as a project team with the conservation [name removed] and to work the Ministrry of Natural Resources to figure out what we could do to support the wildlife in this area and what types of features should we consider." (I-7)

One of the main themes of the OREG conference was to discuss the future of the organization and how it will shape road ecology in general. One of the main points that came out of this discussion was the need to acknowledge its area of weakness which is that the majority of those currently involved are not engineers/economists/marketers/etc. Given the inherently multidisciplinary nature of road ecology problems, there is a significant need to reach out to practitioners and experts from various different fields if road ecology is to advance further.

Positive collaboration amongst the parties involved creates a sense of 'togetherness' on the project, rather than a more authoritarian atmosphere with one party telling another that they *must* do something. Positive collaboration also increases the resiliency of projects; when challenges arise, those involved are more likely to persevere to find a solution if they a) agree with the project in principle and b) feel supported and that the other parties involved appreciate their contributions.

"MTO has really stepped up to the plate, like it's amazing," (I-5)

"Respondent 2: I actually prefer working with MTO because they are far more responsible and they understand what needs to be done. And they do what needs to be done… I would rather it in their hands than the developers," (I-5)

"I understand it or from what I see anyway, we're partners with the region. The region is our funder. They fund us. We're not interested in trying to subvert their goals. We don't want to let the environment go to degradation either. I think we just work together. We try to come up with compromises," (I-6)

"…it kind of takes a bunch of people working together and not just sort of trying to impose it on somebody, right? So again, we work with the engineering folks and they say, "Yeah, there's no reason why we can't do it."…So then it makes it easier," (I-10)

Collaboration innately contributes to the overall project experience, which, if positive, is more likely to lead to future projects than if the experience was a negative one. On the other hand, lack of collaboration can hinder a project by making it harder to acquire knowledge and expertise, limiting resources, and contributing to a sense of futility for the project.

"[Name removed] County is at best a reluctant partner in this. You know, you would think that they would go, well here's some citizens who want to do something that's actually going to make our community look world-leading, and they're raising all the money and doing all the research, and we don't have to do anything other than kind of help them because it's our road, because we know stuff about roads that they probably don't. What's not to like? And still we're getting this kind of, hmmmm," (I-1)

"We did engage them [road maintenance people] at the very beginning of the project before we did the first year to see if we could get them on board to keeping track [of roadkill] and they were not interested at all. They basically told us where to go. It was not there job and we said, well we'll print off maps for you. Just when you pick something up could you just draw a point on a map…Nope, not our job," (I-6)

"Like I say, some of them [people in design and construction department] are more willing to try some of that [WMSs] than others…So if you can get a project manager who's interested and they start thinking that way, then it's not so hard," (I-10)

Although positive collaboration is beneficial to anyone advocating for WMSs, its importance is heightened for local governments and expert groups. For local governments this is because they often have fewer resources to begin with, particularly specialized staff who can provide the needed expertise internally. For example, a small rural municipality likely will not have a designated environmental planner, let alone a wildlife ecology expert.

"A lot of these [funding] programs are asking non-professional, not-for-profit volunteer organizations to do this kind of work, and treating them as if we're x-, treating us like we're XYZ Corporation with all the equivalent resources of staff and that," (I-1)

"Yeah, because we - well we provide planning, technical planning advice to our member municipalities, so - because they don't have any ecologists on staff. So they send us all their EAs and planning applications and we give them comments and recommendations," (I-9)

For expert groups, collaboration is particularly essential because they generally advocate for a mitigation measures to be placed on a road within someone else's jurisdiction. In most cases they are approaching the local government, but it can also be the provincial government or even private landowners. As such, the expert groups either needs permission to do the mitigation measures themselves or have to convince the road owners to implement measures, both of which are extremely difficult without positive collaboration.

4.7 Public Support & Recognition

The element of public support is interesting in that its effect on the success of WMS incorporation varies considerably depending on who is advocating for the project. With large road infrastructure projects, public support for WMSs does not have much influence. This is because WMSs often go unnoticed by the public, making public support irrelevant.

"Interviewer: Do you think that because they kind of fly under the radar that you get less opposition from people? Respondent: Probably…Yeah, because people don't question putting in culverts, right? You don't have to tell them it's a dry culvert, there's nothing going through but critters." (I-10)

As such, public support rarely affects WMS's at the provincial level because these measures are almost always part of larger infrastructure projects. However, in the event the public notices the plans for WMSs, whether or not they are supported still will not affect the project in any significant way. This is likely because the support for the strategies, either good or bad, does not affect the job security or re-election potential of those making the decisions. There are so many levels of governmental organizations involved in the decision-making that public support, or lack thereof, is often diluted and cannot penetrate the decision-making process effectively.

The exact opposite is true for WMSs at the local government level. Any public support or opposition can be easily focused and delivered directly to councilors and mayors, both of which are concerned with pleasing the people to get re-elected.

"…they went to council, a group in Guelph. I mean, they went in with a bunch of frogs nailed to a-, dead frogs on a board, pinned on a board, and took it to council, said, this is what we collected on our street this week. Do something," (I-1)

"You drove over a new culvert and you had no idea it was there. Right?" (I-3)

"…one guy, one just general public guy found 12 dead Blanding's. Took it to his - took it to his whatever, whoever it was political in charge and said look at this. Do something. They said okay. Well let's talk to the MTO. Let's do this. Okay there's a culvert. Well that's a good - that's very fortunate. Put it in. there was no formal study, there was no nothing. It was put in. It's successful, done, great." (I-8)

In a telling example of local governments' understanding of this power, one city official attending the OREG conference spoke of how his city made the conscious choice *not* to include WMSs to keep deer off the highway for fear that it would set a precedent in the public's eye that would require them to mitigate on all roads.

For expert groups advocating for WMSs or attempting to incorporate their own, public support can provide the extra backing needed to influence the road authority's decision.

"We had mentioned that in the past that we should put turtle crossing signs up here even though I don't know how effective they are… [the] region had said no because they don't want to clog this up with signage. Then, I don't know a year or year and a half ago someone sent a letter to a politician saying, why isn't there a sign there and a sign went up," (I-6)

Recognition is another element related to support that influences the success of WMS incorporation. Although not a main factor in decision-making, recognition can sometimes act as the swaying factor for those uncertain about the project. Various forms of recognition exist including awards, media coverage, and acknowledgement as "leaders".

"Well, another factor that worked in our favor on this project was [name removed] Region, on their St. John side road; they had done an upgrade for the wildlife passage and they have received some award for it… And you know the regions are always sort of slightly competitive with each other and so when we mentioned that to the, well, the project manager has since changed but the project manager at the time, his eyes lit up as though we might be able to garner some attention for this. I mean that, in and of itself was as important as anything else," (I-6)

"Being green is very cool these days, so. And then the more that it's talked about, the more credit you give them and the more they're going to do it again," (I-8)

"We got a lot of e-mails actually. Like we got e-mails from as far away as Calgary from municipal staff out there that were like, you know, I wish my municipality would do this kind of thing," (I-9)

"We're hoping to get the municipalities kind of playing off one another. Because Burlington's got a bunch of awards for this, right. So yeah, we're kind of trying to do that in a subtle way," (I-9)

It should be noted, however, that media can considerably harm a project's success if the coverage is negative and the information misinformed.

"So then oh, you know, these guys, they want to chop down the trees, and I mean, so the rumour mill started. I mean, it was hilarious because they were accusing the Biosphere Reserve of wanting to chop down trees. Well the Biosphere Reserve had planted nearly a million in [name removed] County at that point. So we could hardly be labeled this, you know, anti-tree, like, but again, it didn't-, hypocrisy and irony is lost on some people in their zeal to be-, to protest, right?... So you become basically an amplifier of misinformation, and that is not the media's role?" (I-1)

4.8 Funding

Lack of funding is commonly believed to be a major barrier to the widespread incorporation of WMSs into road infrastructure. Indeed, this research has determined that funding is a complex element in the decision-making process: its influence differs depending on the various other circumstances surrounding the project. However, this research also indicates that, in general, funding has considerably less impact on the decision-making process than most assume.

"Respondent 2: I feel like the question comes up a lot about how much does it actually cost on top of a project either an existing or repairs on a roadwork or something to even just incorporate the little extra feature, you know, because it doesn't have to be that expensive, I don't think. And so I feel like I keep encountering these perceptions that it's really expensive....
Respondent 1: Yah, that's a bizarre one...
Respondent 2: And like, the cost of putting this fence in compared to the regular construction costs of a lot of day to day things that happen- it's not really that much.
Respondent 1: Yah, that is a big problem: the lack of appreciation for how much in the rest of the world costs compared to [inaudible] put this up," (I-11)

For WMSs that are part of larger road infrastructure projects, funding for the WMSs is usually simply considered part of the infrastructure cost, the same way guardrails or sound walls would be.

"Down here, and there's going to be a lot of wildlife crossings on this corridor, they get tied in with the expansion budgets...So if your contract is-, if you're putting out a contract that is a hundred million

dollars, now your culvert might be one million dollars, that's only one per cent of the contract. So it's just sort of included in that package, right?" (I-3)

"Interviewer: So, this one, obviously it's a new project, do the costs for the wildlife mitigation measures, are they folded into the cost of this overall project?
Respondent: Yeah…And I got to tell you, it's a tiny dot compared to- in this instance it's all rolled up into it, that's for sure," (I-5)

One city official recognized this benefit and advocated for a change in practices to include standard funding for WMSs within the funding 'envelope' of projects.

In many cases, when asked about the sources of the funding for the WMSs, interviewees had to stop and think, suggesting how insignificant the funding issue is in most cases: one interviewee even shrugged and brushed-off the topic indicating her lack of concern for the issue. Because the majority of projects in Ontario looking to incorporate WMSs are of this variety, it can be concluded that funding is not the main barrier it so often gets the blame for. This being said, funding will always come into consideration at some point but it is usually when deciding on the extent of the measures, not whether or not to do any form of WMS.

"The culverts, there's already three passages are already existing culverts. So it's not really a lot of money to make them bigger. The only new one will be that one there," (I-6)

"So I mean, again, the selling point for financially was that we were getting rid of a couple ones [originally planned culverts] and making this bigger. So certainly it costs more to do a span here…. There must be pieces that come prefab that are certain price that they can kind of, they're not spending too much money because it's not too custom. They'll figure it out so that they can do it as reasonably as possible…"(I-6)

"…they give you the Cadillac version, ideally what you do is you excavate it and fill it with this and with that but anything will probably work. I can't remember if she said to me but, "These turtles obviously aren't looking for a certain size of gravel or a certain depth because they're going on roadside shoulders and digging holes and laying their eggs." …You do what you can, right? It's whatever your funding allows and I guess the more extravagant you go, probably the less maintenance you may have to do later on with weeds coming through and stuff like that," (I-10)

Where funding can pose an issue is during smaller projects at the local government and expert group level. In some cases, the projects do not have large infrastructure budgets that can absorb the WMSs costs outright. Nevertheless, this does not necessarily pose a threat to the WMS component of the project, as demonstrated by many of the projects investigated. Instead, these projects utilized alternate forms of funding, including various conservation grants, external government funds, and crowd sourcing, in order to circumvent the issue.

"The Nature Conservancy of Canada, God bless them, said, if you guys can raise money from the federal and provincial governments, we'll match it," (I-1)

"But we'll put some permanent fencing hopefully. I think I have some private funding for that. So yeah, wherever we can for sure," (I-8)

"Interviewer: So, was there specific challenges with that [financing a retrofit] or?
Respondent: No, because we have a community environmental fund… So this fell right into a bunch of categories that qualified for that," (I-10)

"…we basically there was no budget. We didn't have a budget for our fence. And we said, look, this is we have this mapping. It's a hotspot. RBG's doing it on that side. Wouldn't it make sense to do it on our side. So went to our, we have a foundation like a non-profit and he said, well, I'll try. I'll put it up. We've never done before, I'll put up on the website because we needed $1,000 basically for the fence and some food for the volunteers and, yeah, basically. And he said, okay, I'll put it up on the website and we eight hun … $1,000 or somewhere around there anyway…Not very much. So within five days?...We had it," (I-12)

Wildlife-specific retrofits must also acquire their funding separately from any larger road infrastructure costs, however unlike WMS's incorporated during larger infrastructure projects, this poses a more considerable challenge for retrofits. As mentioned previously, wildlife-specific retrofits can cost more than WMSs that are part of larger infrastructure projects but they can also face other challenges that use up their limited funds. This includes having to hire private companies to do the work when they do not have the available staff or construction expertise. Also, considerable time can be spent navigating the approval process; this exacerbates the funding issue if the group is relying on grants that require deliverables or expire after a certain length of time.

"So these things, you can't necessarily do it in a year. So fortunately, some of the, the funding organization started to realize that these things don't necessarily fit the federal or provincial fiscal year and stuff. So they started giving it two and three years' funding. So you had some time horizon because a one-year time horizon- especially, you'd apply in November. They'd tell you in June…You've got the money, but they wouldn't give you any money because you had to get the contribution agreement done, which that would be done in August. So meanwhile, you're already almost half way through the fiscal year and you've had no money to do anything," (I-1)

Overall, wildlife-specific retrofits are more susceptible to having funding as a primary concern than other projects for the main reason that, when challenges arise, they use up funds that could otherwise be going to the actual WMSs themselves.

"So we ended up spending over 30 percent of our budget on…approvals and the EA and stuff. On a regular construction project it's like maybe 15 percent. It was just one thing after another. At points I thought, we're never going to build anything because there won't be any money left to build anything. We'll just have, you know, the tower of paper and stuff…we don't have any money left to do anything," (I-1)

4.9 Bureaucratic Process

Lastly, whereas the previous elements discussed were suspected to arise, bureaucratic process is an element that was unexpected and arose purely from the data analysis. It is interesting in that it can work as either a success factor or a barrier to WMS incorporation, depending on the situation. The benefits to WMS incorporation are seen when the required process is what triggers the discussion of WMSs. In most cases, this process is the environmental assessment required of larger road infrastructure projects.

"…we always come back to our process," (I-3)

"We had an open-house and quite a few people came out and one of the concerns expressed was the deer population," (I-5)

"So, if there's a certainty, the process moves a lot faster and a lot easier…If there's a certainty we know exactly – we have a one to one commitment for the Bobolink or we have this, we have that and it makes our lives a lot easier from a species at risk perspective. And I think that's something we'll strive towards, we're not there yet. We'll strive towards," (I-5)

"We're lucky because the Navigable Waters Act came in there somewhere. So this was going to have to be changed anyway," (I-6)

Despite its benefits in some cases, the bureaucratic process can hinder WMS incorporation if it is inefficient, muddled, and/or redundant. These states are brought on by an over-reliance on the process in the absence of an understanding of road ecology and its implementation. For instance, one interviewee reported having to conduct multiple studies to prove they wouldn't be harming the natural environment, despite the fact that the intent of their project was to improve the ecological functioning of the area.

"…the MNR asked us, we had to do a study to have this evaluated because they have some stupid reporting format checklist thing. We had to hire a consultant to come down and decide that this was suitable SAR habitat, SAR turtle, snake habitat, right? So the guy gets here, I meet him, and he goes, geez, he says, I don't know why I'm here. I said, well what do you mean? He says, well, anyone would know this

is a typical Great Lakes coastal wetland dominated by cattails, da, da, da, thus, and probably has species at risk in it," (I-1)

"Interviewer: If there was anything within this project that was going to make you throw your hands up and say, okay, we're not doing this anymore. Like, we can't do it. What would that be?
Respondent: That would've been, that would have probably been dealing with the regulatory burden," (I-1)

"No, it's more of a process thing. At first species at risk was "oh it's new, an issue, what do we do?" It was more onerous. Now they've got the process down. It's more refined at the MNR and the mitigating measures are set pretty much for the species, unless something new comes up, then it's a little bit of a learning curve," (I-2)

"So we run into this issue continually of where is mitigation warranted. Like, what is the threshold for when you should do it? There's no real-, you know in engineering industry we need those types of- everything we do is in a manual or a policy," (I-3

Paradoxically, it appears as though it was the lack of a specific process for WMS incorporation that led to the bureaucratic process weighing down the group's efforts. This challenge was echoed by a practitioner who expressed frustration with institutional barriers to WMS incorporation, lack of direction, and the "silo" effect in which government departments remain segregated and unwilling to cross departmental boundaries despite the problems being faced requiring such an approach.

4.10 Interrelationships & Process

Fortune & White's (2006) criticism that most investigations into critical factors lack a vital understanding of the relationships between said factors is concerning when considering that Belassi & Tukel (1996) maintain that critical success factors usually do not affect the outcome of a project individually, but rather that it is different combinations of CSFs that impact a project. Therefore, it was important that this study to go beyond simply identifying and describing the factors, and instead provide insight into their relationships as well. The process diagram in Figure 4.1 was developed as a means of exploring and illustrating the effects each of the nine identified factors has on the others' influence on the WMS incorporation process. Belassi & Tukel's (1996) concept is certainly demonstrated in the case of WMS incorporation, as all nine of the critical factors identified proved to be interrelated in some way.

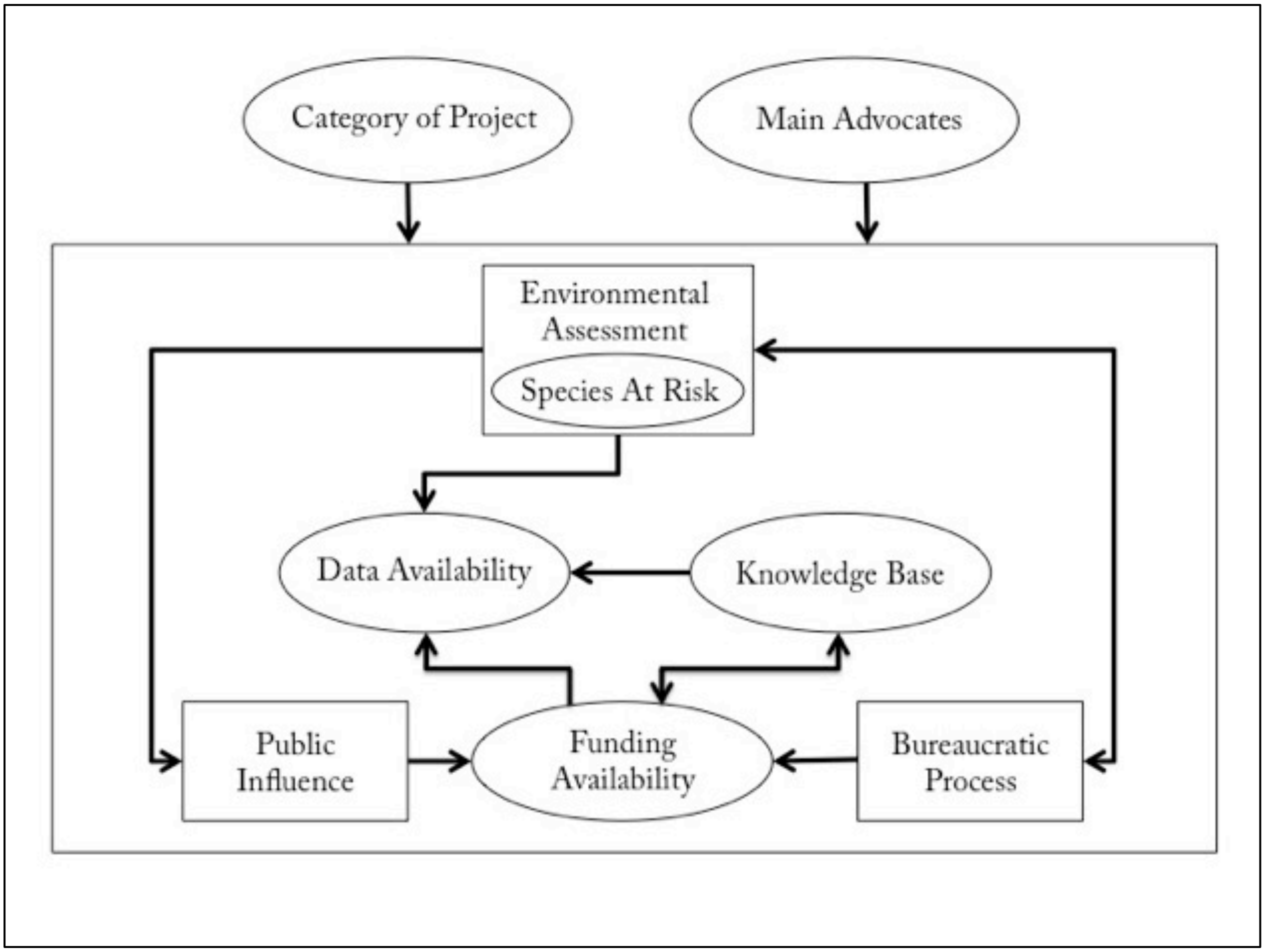


Figure 4.1: Process diagram illustrating the interactions between each of the identified nine critical factors. Factors encased within a circle are concrete, in that they are a determinate. Factors within a box are process, in that are fluid and less finite.

4.10.1 Description of Influences

Both *Category of Project* and *Main Advocate* are separated from the rest of the factors. This is because they each influence how all of the other factors interact with each other while not being influenced themselves by anything else. The box encasing the remaining factors represents the interactive nature of the factors within it as a process.

The *Species At Risk* (SARs) factor is represented within the *Environmental Assessment* (EA) process for two reasons. First, because the two are inherently linked: the presence of SARs will trigger the EA process, while any EA process will lead to the identification of SARs if present. Secondly, the two impact all of the same factors individually, making their amalgamation an efficient means of visually representing their influence on the other factors. Of these factors, they impact *Public Influence* because the EA process requires public consultation, providing a formal avenue for public participation in the decision-making process. The EA process and SARs influence the *Bureaucratic Process*, given that they are both regulatory components, and inversely the bureaucratic process influences the EA process and SARs identification because it is often an adherence to the bureaucratic process that triggers the completion of an EA. The EA process and SARs factors also influence the *Data Availability*, in that data is often collected through the EA process.

Knowledge Base also influences data availability for example, if there is pre-existing data that is known about and accessible, the data collection process becomes easier. It also influences *Funding Availability* by providing an understanding of various funding sources and how to qualify for them. In some cases, having this knowledge base can eliminate lack of conventional funding as an obstacle to WMS incorporation.

Conversely, funding availability affects knowledge base as well; in cases where external consultation is required, funds are required to hire that expertise. A lack of funding can therefore limit the available knowledge base. Funding availability also influences data availability, by enabling or limiting the resources to acquire said data. Finally, funding availability is affected by both the bureaucratic process and public influence. The bureaucratic process can lead to various government opportunities for funding or it can drain project funding by requiring steps that are considered redundant or unnecessary all together. Finally, public influence affects funds by providing alternate sources, such as private funding, or by triggering government financial support that might otherwise not exist.

4.11 'Smoothness' of Projects

Ultimately, each of the projects discussed in the interviews were successful in that they managed to achieve their goal of incorporating some form of WMSs into road infrastructure. This being said, some projects can be considered to be more successful than others when taking into consideration how smoothly the incorporation process went, along with how well the end results matched with the original plans. The best way of illustrating this is through the comparison of a 'smooth' and 'rough' project. A summary comparison of the differences with respect to the nine critical factors is presented in Table 4.1, followed by a detailed description of each of the projects.

Table 4.1: Smooth vs. Rough Project Critical Factors Comparison

Factor		'Smooth' Project	'Rough' Project
1. Type of Project		Part of Road Improvement	Wildlife-Specific Retrofit
2. Main Proponent		Expert Group- Conservation Authority	Expert Group- Environmental Committee
3. Environmental Assessment		Yes- included in process early	Yes- required to conduct
4. Species At Risk		Yes	Yes
5. Data Availability	**Previously Identified Need**	No	No
	Pre-Existing Data	No	No
	Available Resources to Collect Data	Yes	Yes: time No: man-power & funds
6. Knowledge Base	**Central Knowledge Base**	No	No
	Learning Experience	Minimal	Yes; extensive
	Knowledge Sharing & Collaboration	Yes; between organizations & departments	Minimal
7. Public Support & Recognition		Yes	No; extreme public backlash
8. Funding		Part of overall project budget	Had to arrange funding separately
9. Bureaucratic Process		Helpful	Hindered

'Smooth' Project

The best example of smoothly incorporated WMSs comes from interview #6. This project is part of a larger road improvement project for a regional road planning to be widened. The WMSs included wet and dry culverts and slight heightening of the road surface to create a barrier to small fauna. The main advocate (and interviewee) was a Conservation Authority (CA) staff member.

The road itself dissects a wetland and, as such, turtles are the primary concern in addition to various snakes and amphibians. It is adjacent to a conservation area, with Conservation Authority land on either side. The notion of incorporating WMSs into the project came about when the Region approached the Conservation Authority very early in the planning process for their input and expertise. The interviewee described the relationship between themselves and the region as a very healthy, reciprocal one where they work together quite well: the region recognizing the CA's ecological expertise and the CA's recognizing the Region's planning and project implementation experience. In this case, the region approached the CA for help proactively in developing their preliminary plans to accommodate for road ecology practices. This differs from the usual scenario of a CA having to interject to have their voice heard once plans are already underway.

Although no previously determined need or pre-existing data was available, by including the CA early in the process the CA was able to allocate man-power and have enough time to conduct road-side studies two summers in a row before formal planning processes began. These small studies confirmed the need for WMSs and having this quantitative data made it easier to 'sell' the idea to anyone who may have doubted it. It was also beneficial that the road in question is a popular biking route so the issue of high wildlife mortality due to wildlife-vehicle collisions is very visible to the public. When conducting the interview, one bicyclist stopped to ask what was going on and was thrilled to hear about the plans as he had often noticed the area had high mortality. In addition to the public support, the CA was able to bring to the region's attention that a previous region had gotten an award for such environmental endeavours, and the possibility for recognition if they too pursued WMSs. This apparently caught the attention of regional representatives.

With regards to the WMSs plans themselves, the CA was not advocating for extreme measures; rather relatively simple additions to the plans such as modifying existing culverts to accommodate wildlife and putting in one or two extra wildlife-specific culverts that would also happen to provide additional hydrologic benefits to the area. The costs for these WMSs are very low in comparison to the overall project costs and are simply rolled into that budget. Because of the positive relationship between the CA and region, when issues arose that would inhibit the original plans, all parties worked to develop amenable solutions for everyone: taking out one added culvert from the plans in exchange for widening a preexisting one that needed upgrades anyway. Overall, the final plans for this project are very closely matched to original plans.

'Rough' Project

The best example of a 'rough' project comes from interview #1, where the project is a wildlife-specific retrofit to a regional road. The main advocate is an organized committee that was created for the soul purpose of reducing wildlife-road conflict in that particular area. It is made up of various experts from environmental organizations adjacent to the area of concern and has a paid project coordinator (the interviewee). The original plan was developed via a contracted study to assess the area and make recommendations, and included 12 wildlife culverts both wet and dry.

Because the project is a retrofit, funding has to be raised independently. Finding potential funding sources was a process, but ultimately arranged with various government and non-government grant programs and different organizations' backing. The problem was that a very large portion of the funds raised ended up having to be used for wading through a complicated and redundant approval process. For example, they were required to conduct multiple environmental studies and assessments to demonstrate minimal effects even though the entire purpose of the project is to improve the ecological functioning of the area. The interviewee expressed significant frustration at the disconnects between different organizations and even across different branches of the same government agencies: for example, the committee was given money by the head office of the Ministry of Natural Resources to construct the wildlife culverts while the local branch of that ministry required them to spend some of this money to complete more studies. This ultimately takes away from the funds available for the actual WMSs.

Although collaboration between environmental groups interested in the project is strong, at the time the project began there was very limited information to help guide the process. The interviewee expressed that they were 'trail-blazing' the way for this type of WMS incorporation in Ontario and as a result spent a lot of time gathering the expertise they needed. In fact, they are now considered the experts and are approached quite frequently by people who have been referred to them for guidance. At the time of the interview, a group of planners from another district's conservation authority were visiting to learn how they could implement similar practices in their area.

Despite the interest from environmental professionals, the group struggled with getting the necessary regional support; both from the local government and the public. Because the group does not own the road, they had to have cooperation from the road authority: in this case, the local government. However, the interviewee described the region as a "reluctant partner at best", making it difficult to submit environmental assessments and receive approvals. This despite the fact that the committee was willing to do all the work and cover the costs while the region would likely receive extensive recognition and accolade.

In addition to the lack of support from the road authority, there was vehement opposition from the public. This was exacerbated by mis-understanding and the spread of inaccurate information regarding the details of the project, particularly in local media. The extent of the opposition was so great that a counter-organization was established to fight the project.

Despite these challenges, WMSs were eventually incorporated upon getting approval from the region. However the resources and time spent to get to this stage were excessive and the project was only able to install three of the twelve planned culverts as a result. The good news is that after these first culverts were installed, public opposition died down and support from the local government has increased after seeing the extensive recognition the project has received. The project has since received further funding and approval to add more culverts to the road, and the project team now are widely acknowledged as leaders in the field of road ecology in Ontario.

Chapter 5 Application

The final step in the research process was to develop a decision-support tool as a way of demonstrating how the knowledge amassed can be operationalized for application in real-world situations to assist future WMS incorporation into road infrastructure. The resultant tool is the culmination of the research process, presenting the analysis in a visual form to be used by road ecology practitioners (Figure 5.1-5.5). The following sections describe the tool and discuss its nuances and applications.

5.1 Purpose

The elements of the tool represent the various factors identified and how they interact with each other to influence the incorporation of WMSs into road infrastructure. Development of the tool was guided by one main consideration: that most decision-support tools, such as the National Wildlife Crossing Decision Guide Protocol developed by Bissonnette & Cramer (2008) discussed in the literature review, only identify the questions that need to be asked and neglect to provide the implications of the answers. As such, people in decision-making positions do not necessarily know how the information they collect about their potential projects affects the future outcome. With this in mind, the goal was to ensure that the tool to be developed filled this gap. Because of this, the tool is rather extensive and may be criticized as such; however, the researcher believed this to be justified in order to ensure the highest level of explanatory power possible.

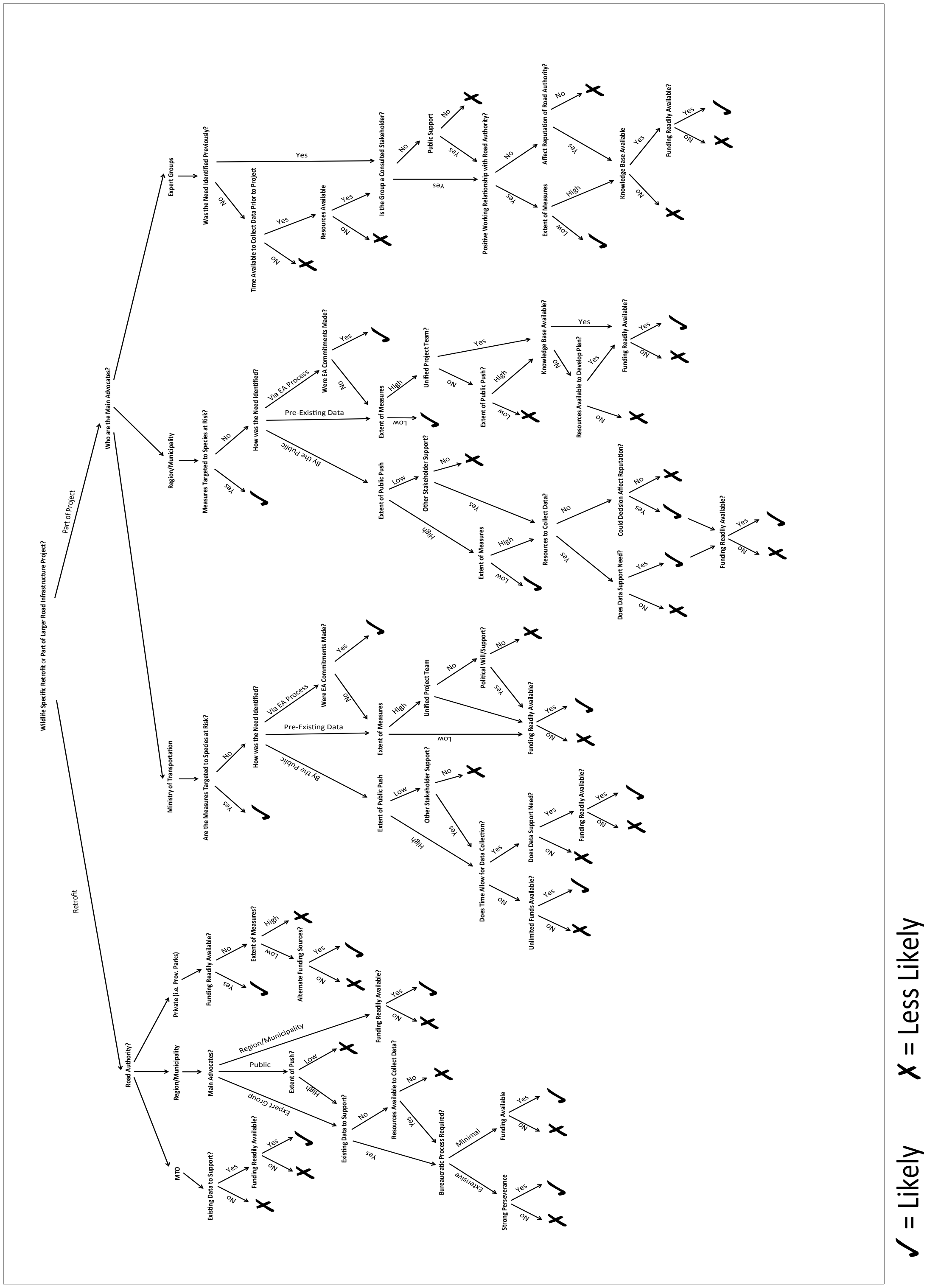


Figure 5.1: Complete decision-support tool for incorporating wildlife-management strategies into road infrastructure in Southern Ontario

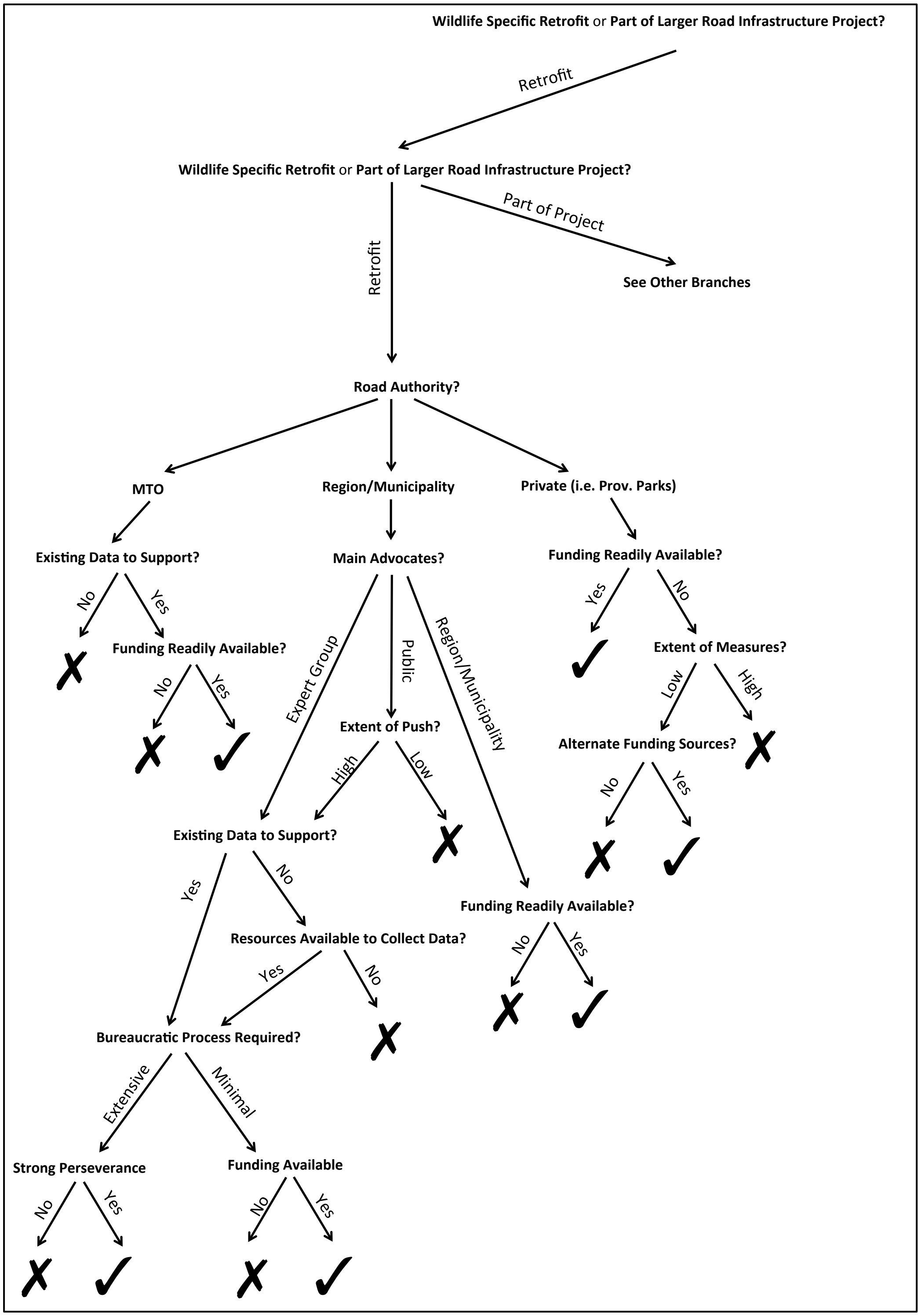


Figure 5.2: Retrofit branch of decision-support tool.

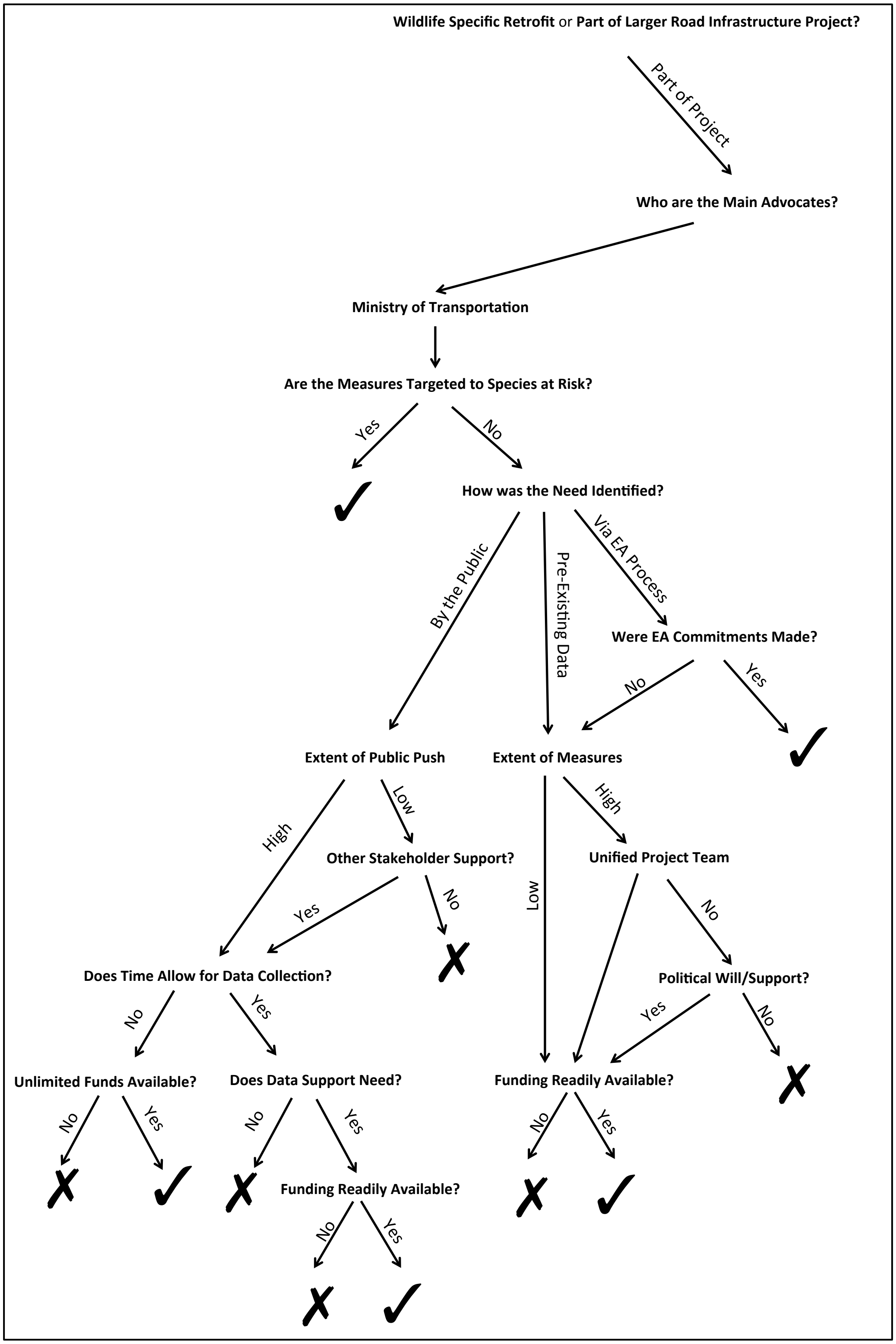


Figure 5.3: Provincial branch of decision-support tool.

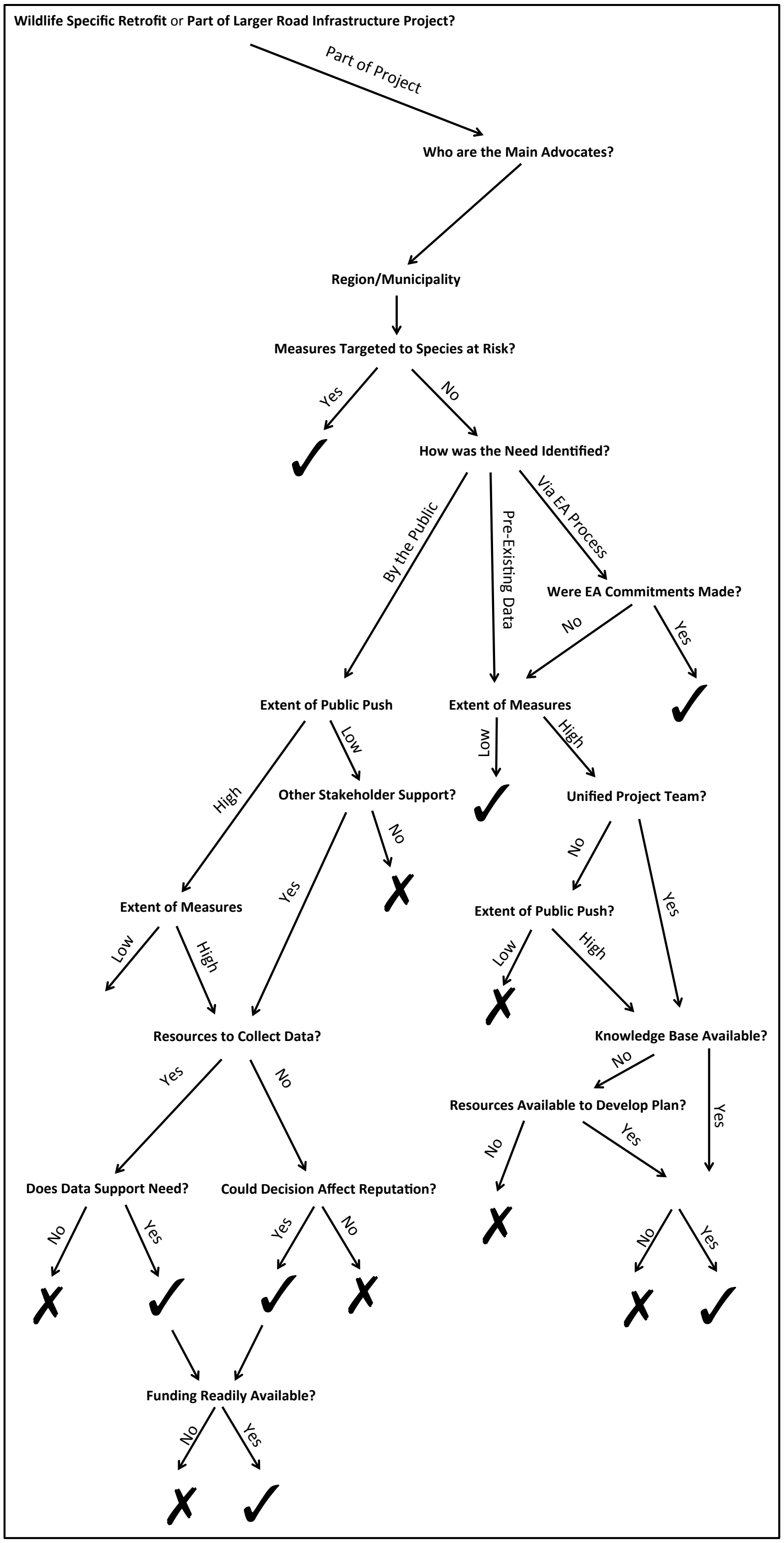


Figure 5.4: Local branch of decision-support tool.

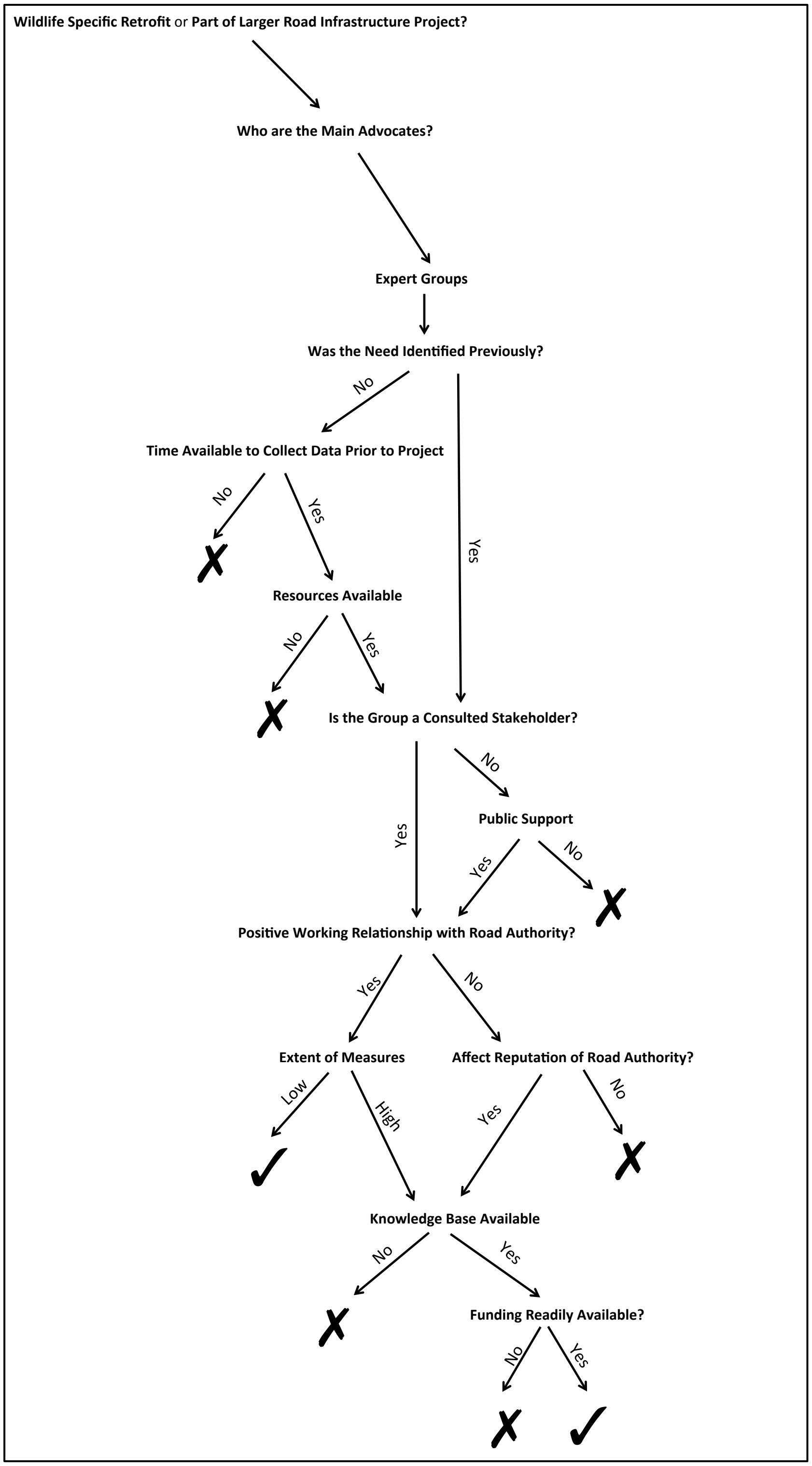


Figure 5.5: Expert Group branch of decision-support tool.

5.2 Decision-Tool Description

5.2.1 When to Use

The decision-tool should be used to determine whether or not it is worth pursuing a particular WMS incorporation project; it is a means of targeting the use of energy and resources towards the projects that have the highest likelihood of successful incorporation. The tool should be consulted when the idea of incorporating WMSs first arises to take stock of the factors that will need to be considered given the circumstances surrounding the project. Not only will the tool guide which factors should be investigated, it will provide the explanatory insight into how that information will affect the decision-making process. For example, if the Ministry of Transportation is trying to get WMS's incorporated into a road improvement project and they have made commitments within an environmental assessment to do so, the tool suggests that this will result in successful incorporation (Figure 5.3).

5.2.2 Interpretation

The tool is designed as a decision-tree with a top-down structure. The factors are arranged in hierarchical order, with those that have more influence on the decision-making process at the top. A higher order node, for example, is "Are the measures targeted to Species At Risk?". Species at Risk is a higher order node because the legislative requirements give it more clout in decision-making, as discussed previously. On the other hand, the answer to a lower order node such as "Knowledge Base", while important, is not as definitive as the higher order factors.

The number of nodes that appear in a particular branch provides insight into how much influence each of the factors has: the lower the number of nodes, the greater the overall significance of each factor when compared to a project with more. Put simply, if there is a project with only five nodes to consider and another project with ten, each of the five nodes in the first project make up larger pieces of the decision-making equation than the second project for which the decision-making equation is broken up into ten pieces. The main example of this in this decision-tree is the wildlife-specific retrofit branch: the relatively short branches and fewer factors than the other sections of the tree demonstrate that each factor has considerable influence on the decision-making process. This aligns with the data indicating that issues that arise during wildlife-specific retrofit projects have more clout than they would on a project where WMSs are incorporated during larger infrastructure projects.

Another key aspect to note is that the check-marks and 'Xs' represent "likely to be incorporated" and "less likely to be incorporated" respectively; they do not represent a definitive 'yes' or 'no'. Also, working down the decision-tree, the check-marks and 'Xs' become less significant; in other words, an "X" at the top of the tree is more likely to spell the end of a project than an "X" lower down. This relates to the hierarchical structure and how some factors have more influence on the decision-making process.

It is also important to note that just because a factor appears multiple times and more than others does not mean it is more influential. The reoccurrence of a factor simply indicates that its influence varies depending on the other circumstances surrounding the project. The primary example of this is funding: although it shows up in the tree the most number of times, and in some cases multiple times within the same 'branch', it generally has little influence on the decision-making process.

5.3 Application of Research

The results of this research can be applied in two ways. The first is by providing a general outline of what can be expected when attempting to incorporate WMSs into road infrastructure in Ontario. Those advocating for the WMSs can refer to this research to identify in advance what factors they need to investigate and what information they already have available. This allows advocates to be proactive and prepared for any challenges they may face, ultimately increasing the project's resilience. Ideally, those planning to attempt incorporating WMSs in the future will consult this research and work to align the characteristics of their potential project with the successful determinants for incorporation.

The second application is a product of the decision-tree tool that was developed. Using the tool, practitioners can take stock of information known about their particular project and quickly see how those characteristics will likely influence the success of a project. Knowing this likelihood of success will enable practitioners to decide whether or not it is worth exerting the resources and effort on a project. For example, a proposed project has the following characteristics:

- It is a wildlife-specific retrofit
- On a municipal road
- Advocated for by an expert group
- No existing data to support the need, and;
- No resources to collect such data

The best course of action would be to save the resources for a project with a higher chance of actually making it through the decision-making process rather than wasting them on a project that is most likely futile (Figure 5.3). Finally, the same process can be used when practitioners have multiple WMS projects that they are interested in pursuing, but do not have the resources for all of them. The tool can be used to assess the characteristics of multiple projects in order to identify which ones have the highest likelihood of success. Doing so will ensure that the limited resources are put to best use.

5.4 Discussion of Decision-Support Tool

In addition to serving as an applicable form of the results gathered through this research, the decision-support tool also serves to address Fortune & White's (2006) second criticism: that traditional CSF examinations view project implementation as a static process when it is actually dynamic. A CSF can have varying levels of importance and influence at different stages of the process, and this reality must be acknowledged (Fortune & White, 2006). The decision-tree helps not only to get this message across, but also to provide explanatory insight into *how* the different factors vary in influence and importance.

This tool is designed to be representational of the information gathered throughout this research. However, it is important to note that the tool, as it is depicted, is likely more rational than decision-making in the real world. Although nuanced, it is still essentially a "black-and-white" system. The real world may have 'in-between' answers and see factors re-examined and change in importance as the project develops. Practitioners and decision-makers need to be conscious of this. The best way to use the information in this tool is to combine it with the process diagram presented earlier to get the best of both worlds: the process diagram depicting the interactions and relationships at play while the decision-tool provides the usable information for real-world applications. Decision-making is an inherently dynamic process and this cannot be overlooked despite the temptation to abandon critical thought in the presence of a simple tool.

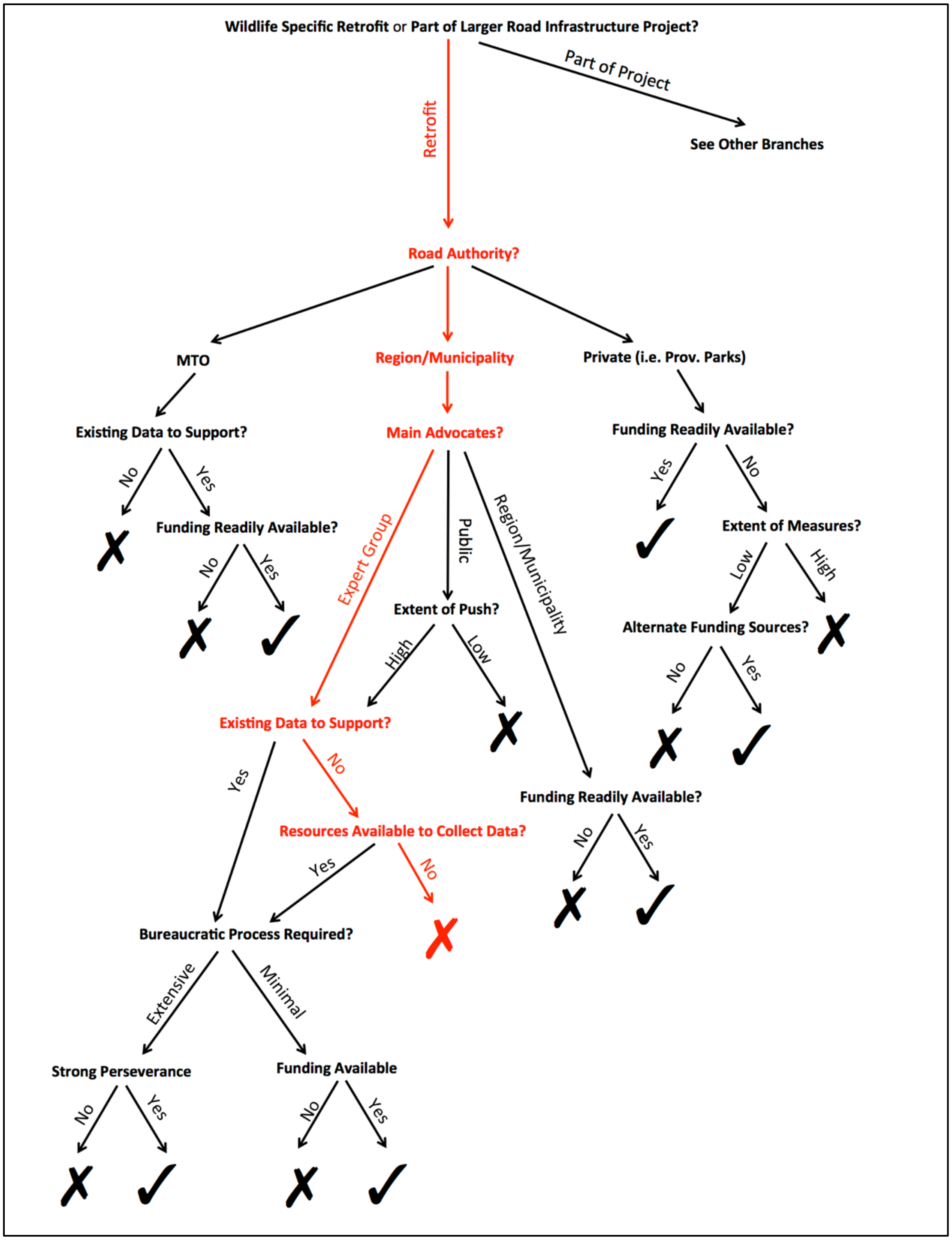


Figure 5.6: Example of how to use decision-support tool to assess likelihood of successful incorporation given knowledge of circumstances surrounding the project.

Chapter 6 Discussion & Conclusions

This chapter begins with a discussion of the process of combining road ecology and CSFs. It then discusses the research questions and experience, followed by a summary of the main critical factors for successful WMS incorporation and their contexts within the current road ecology knowledge and practice. The limitations of the data will be noted and finally, recommendations for future research and the field of road ecology will be presented.

6.1 Road Ecology and CSFs

The field of road ecology has long been looking for ways to optimize efforts to reduce the impacts of roads on wildlife populations. However, despite ample knowledge of the specific issues and an increasingly sophisticated understanding of how to mitigate for them, wildlife management strategies for roads remain relatively underutilized in the province of Ontario. This suggests that the conventional method of addressing wildlife-road conflict (WRC) is insufficient. As such, this research approached this problem from a new angle: by combining traditional WRC research with the concept of critical success factors (CSF). In retrospect, it appears as though traditional WRC work has almost unknowingly been dancing around the idea of approaching WRC using CSF: identifying contributing factors to the problem (Litvaitis & Tash, 2008), developing processes to guide mitigation planning (Huijser et al., 2008; Ministry of Transportation Ontario, 2006b), and creating tools to navigate the various stages and considerations that must be made (Bissonette & Cramer, 2008). Individually these efforts may not seem akin to the CSF process, but taken together they form a strong resemblance to the foundation for identifying and using CSFs to further the success of projects. What was lacking previously from traditional road ecology work to fully apply CSF concepts to the problem has been filled in by this research: the thorough understanding of the individual factors that are involved and how these factors influence project success as a result of various interrelationships. By applying CSF concepts to road ecology, this research has provided a way to operationalize road ecology information in order to actively optimize project incorporation.

Given that this is the first time CSF has been applied to road ecology, there is no available research to directly compare and contrast findings with. However, it is interesting to note that the CSFs identified within this research are very similar to those previously identified in the construction project industry. Sanvido et al.'s (1992) determination that successful construction projects have cohesive teams, contracts that enable teamwork and shared responsibility, experienced team members, and timely optimization information, very closely resembles the experiences of those interviewed for this research. In particular the emphasis on collaboration, learning experience, and knowledge sharing is shared by both construction and road ecology projects. This is logical considering that road ecology endeavours usually are, at their most basic level, construction projects. Similarly, Chan, Scott & Chan (2004) emphasize that construction projects are surrounded by uncertainties in technology, process, and budget, making both the industry and individual projects dynamic. As demonstrated by this research, this is certainly the case with road ecology endeavours as well and, therefore, it is reasonable that both construction and road ecology projects face the same challenges and opportunities.

6.2 Research Questions & Experience

This research set out to identify the factors that critically influence the incorporation of wildlife management strategies into South-central Ontario's road infrastructure. This was achieved by exploring the following sub-research questions:

a) What factors affected the incorporation of WMSs in previous cases?
b) Were these factors barriers or facilitators for the WMS incorporation?
c) How do these factors interact with each other to affect WMS incorporation?

When beginning this research it was thought that the experience of incorporating WMSs into road infrastructure would be relatively straight-forward: some interviewees would describe positive experiences while others described negative ones, and the barriers and facilitators to incorporation would be relatively concrete. This, however, was not the case. Although it was possible to identify the factors, they turned out to be much more nuanced than expected. While some could distinctly be identified as facilitators to incorporation (ie. Species At Risk) and others as barriers (ie. wildlife- specific retrofit), others could present themselves as either (ie. bureaucratic process). How the factors interact with each other is also considerably nuanced in that the interactions depend largely on the characteristics surrounding a project. Variations in the type of project and who the main advocates for the project are comprise the two main characteristics influencing this. Two types of projects were identified: wildlife-specific retrofits to existing road infrastructure, and projects where the WMSs are incorporated into a larger road project such as an improvement or new construction. Regarding the main advocates, they can be one of the following: the provincial government, the local government, or an expert group such as a Conservation Authority. These characteristics dictate the influence of the remaining critical factors, for example, whereas political support can have significant impact on a project being advocated for by a local government, its impact would be insignificant if the project were advocated for by the Ministry of Transportation.

It is important to note that the interrelationships between factors are not finite. Each project is different and will respond to critical factors in different ways as a result. Thus, the purpose of this research has not been to provide a perfect understanding of WMS incorporation but rather to highlight the general nature of the critical factors and their relationships. The intent is that these highlights be used as a general guide to indicate the elements practitioners should be focusing on. It also provides them with a starting point for understanding their own projects by presenting the kinds of interactions commonly seen with similar endeavours.

6.3 Critical Factors for WMS Incorporation

This research identified nine main factors that are critical to the incorporation of WMSs into road infrastructure: type of project, main advocates, Environmental Assessment process, Species At Risk, data availability, knowledge base, public support and recognition, funding, and bureaucratic process.

First, projects that aim to incorporate WMSs as part of larger road infrastructure endeavor are more likely to be successful than wildlife-specific retrofits to existing roads. This is especially true if the group advocating for the WMSs does not have authority over the road. This finding echoes the notion expressed by Huijser et al. (2008) in their wildlife-vehicle collisions Best Practices Manual in which they recommend taking an "opportunistic approach" to incorporating WMSs by pursuing endeavours on roads that are already scheduled for other maintenance.

Secondly, the main advocate of the WMSs does not determine whether a project will be successful or not; rather it affects the influence of the other factors. This is a discovery that has not been discussed previously in the existing literature. Perhaps this oversight is due to the fact that it seems relatively intuitive that different advocates would face different challenges and opportunities. However, given the extent of the main advocates' influence on the incorporation process it would be beneficial that the road ecology field formally acknowledge the influence.

The environmental assessment process is helpful to WMS incorporation in two ways: by providing a formal platform for the examination and mitigation of impacts to wildlife as well as requiring legally binding commitments to include WMSs into road infrastructure projects.

Similar to environmental assessments, the presence of Species At Risk is more likely to lead to successful WMS incorporation due to legal requirements that necessitate mitigating any effects to the species. This is also helpful because if a project is already required to mitigate for a particular Species At Risk, they are more likely to expand the scope of the measures to benefit other species as well. With regards to this component, it is important to note that none of the SARs affected by roads are large animals that could pose a threat to human safety (Table 2.7). As such, the mitigation for SARs is purely for ecological benefit and has very little, if any, significance for addressing the societal concerns surrounding human safety. What would be interesting to investigate further is the dichotomy between these two priorities: in particular, the reasoning behind a lack of legal requirement to mitigate for large animals, and the public's opinion on the matter.

Data availability is a strong facilitating factor for incorporation. This is because having scientific data to demonstrate that there is a problem has more sway over decision-makers than anecdotal evidence. This is particularly true if the main advocate for the WMSs is someone other than the road authority making the decisions. It is particularly beneficial if this data is collected strategically in advance so that when road projects come up, time and resources do not have to be wasted going through the motions of getting the data to prove the worth of adding WMS's into the plan. The good news is Ontario is beginning to see a shift towards this type of strategic data availability; the Ministry of Transportation is currently in the midst of developing a Wildlife Mitigation Strategy for provincial roads that will include an analysis of collision hotspots, prioritized locations for mitigation, and up-to-date data and research on available mitigation options. Likewise, the Town of Oakville is in the midst of developing its own Oakville Road Ecology Strategy, recognizing the need for a "defined process and toolbox for incorporating mitigation strategies," (Doyle, 2013).

Having a strong knowledge base is also a facilitating factor. Without it, projects can struggle to find the information they need, wasting resources on trial-and-error and missing funding opportunities. One example of a deficiency in the current knowledge base is the Ontario Ministry of Transportation's *Environmental Guide for Wildlife in the Oak Ridges Moraine* (2006). Although the content is made up primarily of useful information for dealing with wildlife-roadway conflict, its title does not reflect this. It also labels itself as only relevant to the Oak Ridges Moraine area, when in fact the majority of the information could be applied anywhere. It is clear that significant work went in to compiling the information for the document and its usefulness cannot be argued, yet it likely goes unnoticed by many road ecology practitioners. Having a formalized, accessible knowledge base would help eliminate this inefficiency.

Public support and recognition are interesting because their influence ranges substantially; they can be a barrier to incorporation, a facilitator, or have little impact at all. In general, public support will only have an impact on a project's success if the project is taking place at the local level due to the directness of local politics. The chance of positive recognition is a successful determinant at any level, however, general attention such as media coverage can hinder a project's success if the information is misinformed or negative.

The influence of funding, or rather the lack there of, was the most unexpected finding to come out of this research. Most believe that funding is the primary barrier to widespread WMS incorporation into road infrastructure. However, this research determined that this is not in fact the case in South-central Ontario, or at the very least, it does not have to be. WMSs that are part of larger road infrastructure projects often have their costs rolled into the capital budget, rendering the issue practically moot. In cases where funding is not automatic, alternative funding sources are available. Where funding does become an issue is when the other factors are not optimized. An example of this would be during large wildlife-specific retrofit endeavours, where substantial funds need to be raised for the measures themselves but also to hire external consultants to navigate a tedious bureaucratic process.

Finally, the influence of the bureaucratic process on WMS incorporation was truly unexpected. Similar to public opinion, it can be either a barrier or facilitator. On one hand, the process can help by triggering required discussion of the impacts to wildlife, particularly through the environmental assessment process. On the other hand, tedious and unnecessary bureaucratic requirements can hinder a project by using up valuable resources such as funding and time that could otherwise be put towards the WMSs themselves.

6.4 Limitations of Research

There are two limitations that should be noted of this research. The first is the conceivably low number of interviews that were conducted. Although data saturation is believed to have been achieved, it would have been preferable to include more interviews in the study for two reasons: first, to guard against academic skepticism and second, to further validate the theory by crosschecking it with additional interviews. Unfortunately the difficulty of identifying potential projects and interviewees limited the sampling pool. However, the use of informal interviews to collect supplementary data is considered to have bolstered this potential weakness.

The second limitation is in regards to the projects themselves: all were successful projects, either having been completed or, at the very least, the decisions had been made to proceed. No interviews were conducted regarding unsuccessful projects and as a result there is no data to illuminate the struggles that ultimately end such projects. In other words, there were no null cases. This absence is a result of simply not being able to identify any unsuccessful projects; identifying the successful ones proved difficult enough. It is unlikely one would be able to find these unsuccessful projects, if they do exist, because of the scattered state of road ecology knowledge and the fact that organizations and agencies do not tend to share and boast about their failures openly.

However this lack of null cases was not for lack of trying. The intent when beginning this research was to interview for both successful and failed projects to gain distinct perspectives on critical factors that helped versus hindered project success. Instead, the challenges to successful incorporation of WMSs had to be determined by extrapolating from the obstacles faced by projects that were ultimately able to overcome them. As discussed earlier, certain projects were considered more successful than others in that their incorporation process was ‘smoother’ overall and/or the end result met or exceeded their original WMS plans. The individual and cumulative differences between projects in this regard were the primary indicators to circumvent the issue of not having any null cases.

This being said, it is openly recognized that not having any failed cases was not the ideal situation and may be seen by some as a flaw in the research. On the one hand it does limit the ability to definitively state the helpfulness/hindrance of a factor. On the other hand, given the nuanced interactions of the factors and the circumstances surrounding projects, it is highly unlikely anyone would be able to conclusively state their nature even with null cases included.

6.5 Recommendations

This research has laid the groundwork for further research into WMS incorporation by holistically examining the process. Now that the pieces of the puzzle have been identified and shown to connect, it is recommended that each of the pieces be explored extensively on their own. Although this may seem to contradict the interrelated nature of the problem, it is by no means meant to circumvent the importance of their interactions. By focusing on each of the critical factors individually, a deeper understanding of their intricacies can be developed. This understanding can then be used to learn how to optimize the factors in favour of the project, ultimately increasingly the likelihood of successful incorporation.

With regards to the field of road ecology, there are multiple recommendations for both Ontario and in general. The first, and perhaps most obvious, is that the focus of efforts and resources should be on incorporating WMSs into road infrastructure during road improvement or new development projects, particularly if the WMSs are large and complicated endeavours, such as the construction of a wildlife overpass. By facing fewer obstacles than wildlife-specific retrofits to roads, these projects have a greater likelihood of successfully making it through to implementation.

The second recommendation is to proactively create an inventory of locations that are to be fitted with WMSs if and when road improvement or development projects arise. Doing so will ensure that opportunities for WMS incorporation are not missed. It will also increase the overall efficiency of road ecology efforts across the province by eliminating the need for each individual road project to expend the resource to learn about, explore, and justify the need for WMSs. Developing such an inventory will require its own resource expenditure but it would be considerably less than the cumulative resources needed to do things on a project-by-project basis. Ideally this would be done at a province-wide level, but even if done on a smaller scale, such as the area a Conservation Authority is responsible for, it would go a long way in increasing the efficiency of road ecology efforts

The third recommendation is likely the most complicated; that is, the development of a cohesive knowledge base for compiling and sharing road ecology research, learned experiences, information, and data. This knowledge base must be accessible, meaning three things: the knowledge must be located in one place and not scattered across multiple sources, the information must not be buried within larger, irrelevant documents, and it must be easily accessible and navigable by anyone interested in pursuing road ecology endeavours. The knowledge base must also be maintained over time to remain up-to-date. Given that road ecology is a relatively new field, particularly in Ontario, the amount of information will be increasing for years to come and it will be changing as research and best practices evolve. Having a knowledge base that is accessible but out-of-date will put those who rely on it at a disadvantage. Finally, the knowledge base must also be multidisciplinary and multifaceted. In addition to the ecological and technical expertise, it is important that it include any socio-economic and political information that is available. This may include, for example, academic research or anecdotal experiences with issues like public support, media coverage, and political involvement. It will also be essential to include different forms of information in addition to traditional research:

- List of previous projects and their characteristics
- Inventory of locations identified for future WMS incorporation
- List of potential alternative funding sources
- Database of road ecology professionals
- Contact information for those willing to share their expertise
- Compilation of media and recognition

6.5.1 Implementing Recommendations

Developing recommendations is one thing; implementing them in the real world is another. The logistics of implementing recommendation number one are fairly straightforward: simply save available resources for during larger infrastructure project instead of attempting retrofits as well. Recommendations two and three on the other hand, are more difficult: finding the funding and man-power to proactively develop an inventory of WMS locations and establish a knowledge-base is the main obstacle. The first step would be to connect road ecologists with each other to establish a baseline of what is currently available, however connecting a relatively scattered group of experts, who in many cases would not primarily consider themselves 'road ecologists', is a challenge in and of itself. Fortunately though, this has already begun. The Ontario Road Ecology Group (OREG) is an established network of people working on, or interested in, road ecology projects. This network provides an excellent starting point for implementing the above recommendations, particularly the sharing of knowledge and experiences. However, it is simply a network; a relatively small group of people lead by a dedicated few who facilitate connections and coordinate projects where intermittent funds and man-power allow. In its current state, OREG does not have the resources to tackle these recommendations alone.

One suggestion to solve this problem would be to formally partner with an agency that could provide these resources. The obvious suggestion would be the Ontario Ministry of Transportation. This is for two reasons: 1) they are the highest level of government actively involved in road ecology in the province and therefore can be seen to be in the best position to take on a leadership role, and b) they are the most likely to have resources to share. Despite the validity of these rationalizations, the main draw-back is the potential for the province to be seen as imposing its "governing hand" on yet another environmental organization. Although the MTO had proven itself to be rather forward-thinking on the issues of road ecology, there is always the chance of misguided perceptions that the government is puppeteering the organization's aims and objectives. Some local governments may even be deterred from exploring wildlife-management strategy options by the notion that this is just another provincial government object being left for them to deal with. An alternative to this is the use of various funding sources, such as crowd-sourcing, private funding, and grants. The best solution is likely a combination of these along with various government sources.

Once some funding is secured, the first goal of OREG should be to hire a full-time staff member to oversee its growth and endeavours. This person would be responsible for the coordination of networking and projects, development of the formal knowledge base (i.e. online repository), and the ongoing pursuit of funds. As these are achieved, the next steps would be a province-wide assessment for future WMS locations. This could be achieved manageably by working with local agencies to evaluate small parcels of land at a time (ie. Conservation Authority jurisdictions) and then combining the gathered data to develop a provincial road ecology strategy. Success at achieving each of these steps will lead to further confidence and advancement in WMSs within the province, ultimately positioning Ontario to become a world leader in the field of road ecology.

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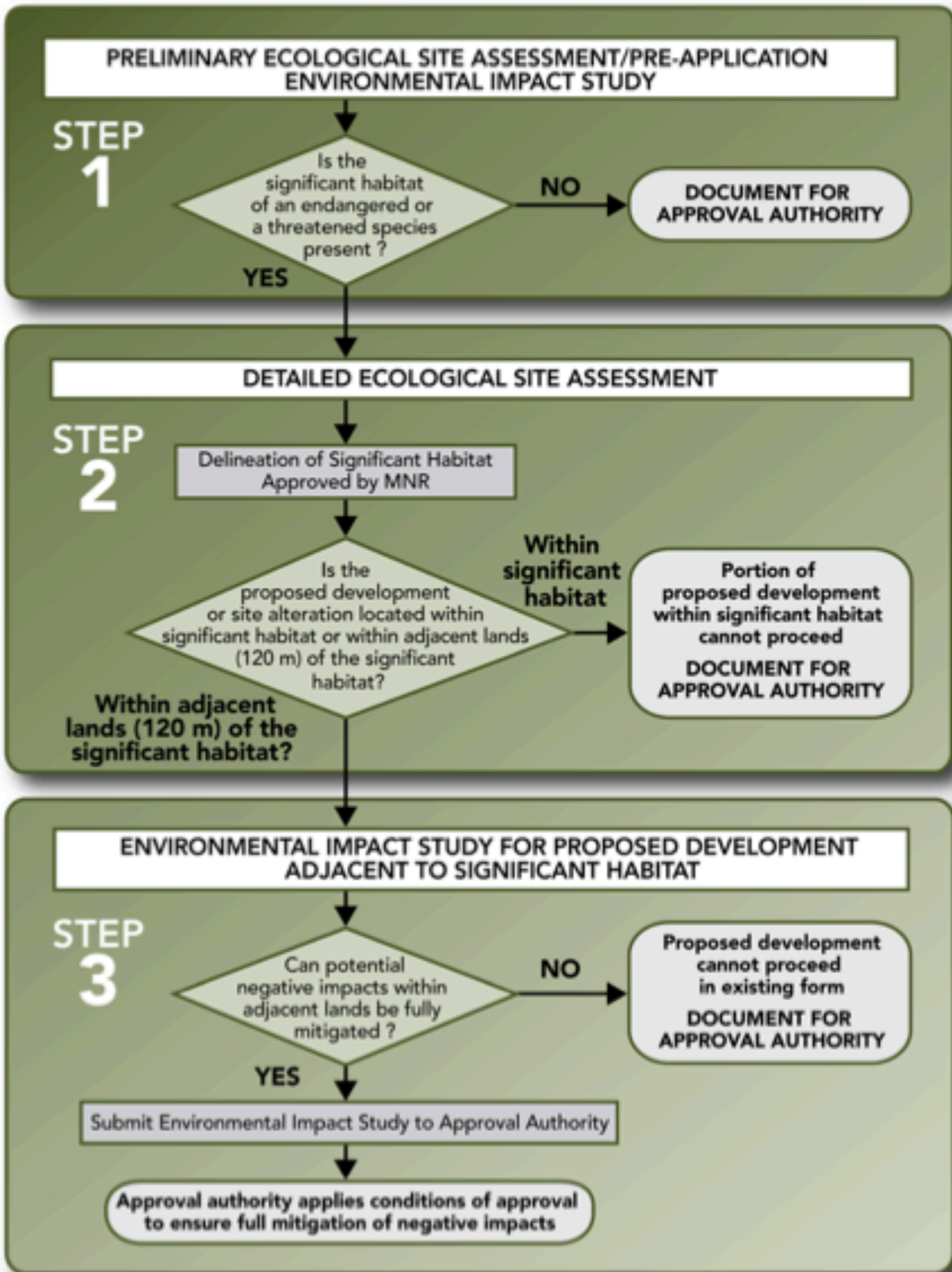
Appendix A

Ontario Ministry of Natural Resources Process for Identifying Species At Risk Habitat



(Ontario Ministry of Natural Resources, 2010)

Appendix B

Ministry of Transportation Ontario's Process for incorporating WMSs

Project Activity or Compliance Requirement		Applies (Y/N)	Documented in: Planning Documents	Terrestrial Ecosystems Report	TESR[2]	DCR[3]	Contract	Future Commitment[1]
PROJECT SCOPE								
	1. Was the Terrestrial Ecosystems (and/or wildlife in particular) Speciality identified in the Request for Proposals?		N/A	N/A	N/A	N/A	N/A	N/A
	2. Was wildlife identified during the course of the project?		N/A	N/A	N/A	N/A	N/A	N/A
GENERAL PROJECT ACTIVITIES								
Assessment								
Background Data and Field Investigations	3. Have the following been determined and mapped:							
	(a) Wildlife habitat including significant wildlife habitat areas?							
	(b) Wildlife species including species of conservation concern?							
	(c) Wildlife species and use of the area including migratory, over-wintering and nesting species?							
Determination of Significance	4. Has the significance and the sensitivity to disturbance of the following been determined:							
	(a) Wildlife and natural corridors?							
	(b) Significant wildlife habitat?							
Assessment of Impacts	5. Has loss of wildlife habitat been considered?							
	6. Has obstructing wildlife movement been considered?							
	7. Has wildlife mortality and/or interference during transportation project construction and operation been considered?							
	8. Have noteworthy species and habitats (including Species at Risk) been considered?							
	9. Have the potential permanent and temporary impacts been assessed in terms of:							
	(a) Highway design alternatives?							
	(b) Alternative methods of construction?							
	(c) Highway operation/maintenance?							
	13. Is the information collected adequate to enable the identification of resources/issues for the Valued Ecosystem Component criteria under CEAA?							
Environmental Protection / Mitigation								
	14. Has a preliminary mitigation strategy been completed?							
	15. Has a detailed mitigation strategy been completed?							

COMPLIANCE								
Environmental Protection Requirements[4]								
WLD-2	16. The destruction of migratory birds, their eggs or their nests is not permitted.							
WLD-2	17. Minimize the release of oil, oil wastes or any other substance harmful to migratory birds to any waters or any area frequented by migratory birds.							
WLD-3	18. Impacts on lands that provide critical habitat for listed migratory and aquatic species under the federal Species At Risk Act shall be avoided.							
WLD-4	19. Avoid habitat for species designated by regulation under the Ontario Endangered Species Act.							
WLD-5	20. Avoid, or if avoidance is not possible, minimize encroachment on significant portions of the habitat of threatened and endangered species.							
WLD-6	21. Protect other wildlife species identified in the schedules in the Fish and Wildlife Conservation Act.							
WLD-7	22. Avoid, or if avoidance is not possible, have no negative impacts on significant wildlife habitat, as defined in the Significant Wildlife Habitat Technical Guide.							
WLD-8	23. Maintain the diversity of wildlife habitat in an area and natural connections between them.							
WLD-9	24. Regard the policies, plans, strategies and programs at the local/regional level dealing with other wildlife species of local or regional significance and, in descending order of priority: 1) avoid; 2) minimize impact; and 3) mitigate/restore.							
Environmental Protection Requirements for projects on federal lands and/or with federal involvement. In addition to the requirements outlined above, the following Environmental Protection Requirements apply to projects involving federal land or receiving federal funding:								
WLD-1	25. Migratory Bird Sanctuaries and National Wildlife Areas in Ontario as listed by Environment Canada shall be avoided.							
WLD-1	26. Consider the conservation of wildlife on federal public lands that are administered by the Federal Minister of the Environment, and in any protected marine areas.							
WLD-3	27. Impacts on federal lands that provide critical habitat for listed wildlife species, and on other lands that provide critical habitat for listed migratory and aquatic species under the federal Species At Risk Act shall be avoided.							
Environmental Protection Requirements for projects in Designated Areas:								
Various	28. Have the special considerations for Designated Areas been addressed and the checklist completed for this factor? (see Section 13: Designated Areas of this User Guide).							

[1] A commitment has been made to address in subsequent stages of the transportation project (e.g., a commitment in the Preliminary Design stage to develop detailed mitigation in the Detail Design stage)
[2] Transportation Environmental Study Report including amendments
[3] Design Construction Report including amendments

[4] Unless otherwise stated (e.g., by terms such as "shall", "is not permitted"), the Environmental Protection Requirements (EPRs) are "as feasible" or "unless approved through the Environmental Assessment process". This is in recognition that transportation facilities cannot avoid all impacts and that some ERPs may not be feasible in every situation.

Appendix C

Ethics Materials

1) Recruitment Email

Dear Madam/Sir

My name is Kristin Elton and I am a Masters student working under the supervision of Dr. Michael Drescher in the School of Planning Department at the University of Waterloo. I am contacting you because of your involvement with the **(insert specific project here).** The reason that I am contacting you is that we are conducting a study that examines the factors that go into incorporating wildlife management projects into road infrastructure in Ontario. We are currently seeking volunteers who have played various roles in these projects as participants in this study.

Participation in this study would involve meeting with myself, ideally at the project site, to conduct a recorded interview. The interview questions will surround the topic of your experiences with, and perceptions of, the challenges and opportunities associated with this project. Emphasis will be placed on discussing the socio-economic and political aspects. Participation in this study would take approximately 1 hour of your time and can be arranged for a mutually convenient time. I would like to assure you that the study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee. However, the final decision about participation is yours.

If you are interested in participating, please contact me at kaelton@uwaterloo.ca. I will reply with further information and answer any questions you have may. Thank you in advance for your consideration.

Sincerely,

Kristin Elton

2) Information Letter & Consent Form

University of Waterloo

Date May 14th, 2014

Dear ________________________,

This letter is an invitation to consider participating in a study I am conducting as part of my Master's degree in the School of Planning Department at the University of Waterloo under the supervision of Professor Michael Drescher. I would like to provide you with more information about this project and what your involvement would entail if you decide to take part.

Our ever-expanding road infrastructure is having a profound impact on wildlife populations. Species displacement, habitat fragmentation, and individual animal deaths from wildlife-vehicle collisions are all contributing to the declining health of local wildlife populations. Not only an issue for wildlife, the conflict between wildlife and roads also has negative effects on the human population, including vehicle damage, increased insurance premiums, and human injury and fatality resulting from collisions. Large scale wildlife management strategies, such as fencing and wildlife crossing structures, have become very prominent in certain regions to mitigate these problems, such as the Rocky Mountains, where larger wildlife provides a greater threat to human drivers but until recently have remained relatively non-existent in the province of Ontario. Today, more and more road infrastructure projects are taking wildlife management into consideration: a primary example of which is the newly completed Hwy. 69 wildlife crossing structure. However, current decision-making tools are focused on the scientific aspects of implementing wildlife crossings, such as target species, optimal location, design etc, and exclude factors such as public participation, political budgets, and legislative considerations. Given that it is political decision-makers who have the final say over what public funds are used for in relation to roads, the decision-making process is much more complicated than simply considering the scientific facts. The purpose of this study, therefore, is to examine and understand the incorporation of wildlife management strategies into Ontario's road infrastructure projects in order to develop a model for successful implementation.

This research is in an examination of what is required to make wildlife management strategies work. Ample research exists on the merits of these strategies, but implementing them in the midst of a growing human footprint and limited financial resources is becoming increasingly difficult. In order for ecological strategies to be successful, we need to understand how to incorporate them in a way that balances the interests both environmental and societal interests. I would like to include your project as one of several to be involved in my study. I believe that because you were/are actively involved in the management and operation of this project, you are best suited to speak to the various issues, such as the reasoning behind the project and the challenges you may have faced.

Participation in this study is voluntary. It will involve an interview of approximately 1 hour in length taking place at the site of the wildlife management road project in question. You may decline to answer any of the interview questions if you so wish. Further, you may decide to withdraw from this study at any time without any negative consequences by advising the researcher. With your permission, the interview will be audio recorded to facilitate collection of information, and later transcribed for analysis. Shortly after the interview has been completed, I will send you a copy of the transcript to give you an opportunity to confirm the accuracy of our conversation and to add or clarify any points that you wish. At this point you may choose whether or not you be willing to be contacted further for a follow-up interview for further clarification or general discussion regarding feedback. This would take place by phone and would occur at your convenience.

All information you provide is considered completely confidential. Your name will not appear in any thesis or report resulting from this study, however, with your permission anonymous quotations may be used. Data collected during this study will be encrypted and retained for 3 years in a locked office in my supervisor's lab. Only researchers associated with this project will have access. There are no known or anticipated risks to you as a participant in this study.

If you have any questions regarding this study, or would like additional information to assist you in reaching a decision about participation, please contact me at (705)606-1974 or by email at kaelton@uwaterloo.ca You can also contact my supervisor, Professor Michael Drescher at 519-888-4567 ext. 38795 or email mdresche@uwaterloo.ca.

I would like to assure you that this study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee. However, the final decision about participation is yours. If you have any comments or concerns resulting from your participation in this study, please contact Dr. Maureen Nummelin in the Office of Research Ethics at 1-519-888-4567, Ext. 36005 or maureen.nummelin@uwaterloo.ca.

I hope that the results of this study will aid future decision-makers in determining the best and most efficient way to allocate resources, as well as help to bridge the gap between social and natural scientists in the broader research community

I very much look forward to speaking with you and thank you in advance for your assistance in this project.

Yours Sincerely,

Kristin Elton

CONSENT FORM

By signing this consent form, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

____

I have read the information presented in the information letter about a study being conducted by [**insert researcher names**] of the Department of [**insert department name**] at the University of Waterloo. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted.

I am aware that I have the option of allowing my interview to be audio recorded to ensure an accurate recording of my responses.

I am also aware that excerpts from the interview may be included in the thesis and/or publications to come from this research, with the understanding that the quotations will be anonymous.

I was informed that I may withdraw my consent at any time without penalty by advising the researcher.

This project has been reviewed by, and received ethics clearance through a University of Waterloo Research Ethics Committee. I was informed that if I have any comments or concerns resulting from my participation in this study, I may contact the Director, Office of Research Ethics at 519-888-4567 ext. 36005.

With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.

☐YES ☐NO

I agree to have my interview audio recorded.

☐YES ☐NO

I agree to the use of anonymous quotations in any thesis or publication that comes of this research.

☐YES ☐NO

Participant Name: ____________________________ (Please print)

Participant Signature: ____________________________

Witness Name: ________________________________ (Please print)

Witness Signature: ______________________________

Date: ____________________________

Appendix D

Interview Question Guide

Interview Themes and Example Questions

The semi-structured interview questions will revolve around the themes of project involvement, financial details, the extent of public involvement, and the challenges and opportunities that arose throughout the implementation process. Examples of questions are listed below;

Involvement

1. Who is primarily responsible for this project? (department, etc.)
2. Which level of government(s) has jurisdiction over this project?
3. Who initiated the idea? (i.e. Conservation groups, the public, MTO, etc.)
4. Which department/what groups have been involved?
5. Which government was in power at the time of approval?

Economics

1. What was the cost of this project?
2. Where is the money coming from/whose budget does this fall under?
    a. Is this the same body as those who are primarily responsible for the project?
3. Was there a pre-determined budget or did funds have to be located?
4. What was the budgetary state of the primary funding authority at the time?
5. What difficulties had to be overcome to secure funding?

Public Involvement

1. Describe the level and type of public involvement in this project.
2. What type of public outreach has taken place, if any?
3. Is this a publically well-known project?
4. How has it been received?
5. Was it difficult to get positive engagement from the public?

Implementation Process

1. What challenges did this project face with regards to being approved?
2. If this project goes above and beyond the requirements of SAR, 2007, what lead to the decision to do so?
3. Did the plans change at any time throughout the process? If so, why and in what way?

4. Was there any point when it was thought impossible to do? If yes, when and why?

5. Was there support from others who have completed similar project? (ie. advice, resources, expertise, staff, etc.)

6. Ultimately, what were the decisive factors that made this project successful?

Appendix E

Personal Communication with Tim Guetterman
RE: Grounded Theory Sample Size

From: **Tim Guetterman** tcguetterman@gmail.com
Subject: Fwd: Grounded Theory Advice
Date: November 18, 2014 at 7:47 PM
To: kaelton@uwaterloo.ca

Kristin:
I am a researcher working with Dr. Creswell. He asked me to respond to your note.

You are writing with a great question. First, do not be too concerned about the numbers. When he wrote the sample size suggestions, they were based on what he was seeing in the literature. We would advise anyone to think about it as a basis when planning research but to be flexible.

In grounded theory, the important part of sampling is theoretical saturation. You are doing this absolutely correctly. The determination of the size should be based on this notion of theoretical sampling and saturation in grounded theory. I have read recent grounded theories in the published literature with sample sizes ranging from 6 to nearly 150 participants. The ones that apply theoretical saturation (as you have) tend to have smaller sample sizes. There is nothing wrong with a smaller size. It will be important that you address your procedures to assess and reach saturation.

Hope this information is helpful. Do you have any additional questions or need clarification?

Thank you,
Tim

Tim Guetterman
CEHS Mixed Methods Academy
University of Nebraska-Lincoln

---------- Forwarded message ----------
From: **John Creswell** <jcreswell1@unl.edu>
Date: Mon, Nov 17, 2014 at 8:22 PM
Subject: Fwd: Grounded Theory Advice
To: Tim Guetterman <tcguetterman@gmail.com>

Sent from my iPhone

Begin forwarded message:

> **From:** Kristin Elton <kaelton@uwaterloo.ca>
> **Date:** November 17, 2014 at 8:00:46 PM CST
> **To:** <jcreswell1@unl.edu>
> **Subject: Grounded Theory Advice**
>
> Dear Dr. Creswell,
>
> My name is Kristin Elton and I am a masters student in the School of Planning at the University of Waterloo, Ontario. I am very familiar with your work on qualitative research methods and specifically, grounded theory. I am using a grounded theory for my graduate research and my advisor suggested I contact you with a problem we are facing.
>
> I know your recommendations are to have between 20 and 30 interviews when using grounded theory, but I have conducted 12 thus far and am finding I am now hearing the same things over and over; therefore I believe I have reached data saturation. I am also starting to get to the bottom of the pool of potential interview candidates- my research is on wildlife mitigation strategies and roadways in Ontario, a fairly new concept with relatively few projects- and don't believe I would be able to get 20 interviews even if I hadn't started to reach data saturation by then. I should also note that I am supplementing my interviews with media articles and reviews of policy and legislation.
>
> My advisor, Dr. Michael Drescher, suggested I contact you to ask for advice. One of my goals is to publish my masters research, but we are concerned that we would be scrutinized during the review process for only having 12 interviews. This being said, we are unsure how to proceed if we are convinced we've reached saturation and have no other leads for potential interviewees.
>
> If you have any advice or recommendations, it would be greatly appreciated. Thank-you very much for your time.
>
> Kristin Elton
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