Moose Vehicle Collisions: Solutions for Reducing the Number of Accidents on Newfoundland's Highways

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Introduction

The world today is becoming increasingly urbanized; this is the cause of many new challenges that previous generations have not had to face. Some of the most obvious and crucial problems are air and water pollution. As cities grow, the need for more cars and related industrial activities increases leading to an increase in air pollution, the same can be said for water pollution as areas become increasingly urbanized it becomes more difficult to manage waste leading to dangerous runoff into rivers and streams. Along with these troubling environmental problems, urbanization can also lead to a many social problems such as increased poverty and crime as well as the development of slums in underprivileged neighborhoods. With the persistence of these huge environmental and social problems it is easy to see how one major by-product of urbanization may get overlooked, and that is the increasing amount of interaction between humans and wildlife.

Conflicts between humans and wildlife have always existed, but the frequency and severity of these conflicts are increasing. It is commonly believed that expanding human settlement is the main reason for the increasing interaction. As Manfredo (2008) states "driven by population pressures, economic growth, and the expanding global demand for natural resources, humans occupy more and more places. As this occurs, it destroys or fragments habitat, forcing humans and wildlife into confrontation" (p.6). These interactions between humans and wildlife can occur on a variety of scales, it could be something as insignificant as mice or squirrels invading your home, ranging to a legitimate threat to human safety such as being attacked by bears or wolves. The financial impacts of these conflicts can also reach astronomical figures. In a study by Conover (2002) it was estimated that conflicts between humans and wildlife cost up to $22.3 billion in total losses per year in the U.S alone, these losses range from urban damage caused by mice and squirrels to deer-vehicle collisions. Human-wildlife conflicts are an issue that have a wide range of effects ranging from financial to physical and social, so it is pertinent that a solution be found to mitigate the negative impacts of these conflicts in a way that is both feasible and makes the environment safer for both humans and animals. This is an issue that also hits close to home in the province of Newfoundland and Labrador, where, in the last few years, there has been considerable public concern regarding large and increasing moose populations, and consequent moose-vehicle collisions (MVC).

While moose are not native to the island of Newfoundland they have certainly flourished here. There is an estimated 125,000 moose in the province currently (Dept. of Environment, 2014). This large population all started from a population of four which were introduced in 1904

from New Brunswick (Mercer & McLaren, 2002). With no natural predators on the island, the population steadily grew to become one of the densest populations of moose in North America (Dept. of Environment, 2014), because of this incredibly dense population is it only natural that human-wildlife conflicts will occur. In Newfoundland these conflicts usually occur in the form of automotive accidents and according to some estimates there are approximately 700 moose-vehicle accidents occurring every year. The province has taken some steps to try to reduce the number of moose-vehicle collisions by installing experimental moose detection systems, installing experimental fencing, and by implementing new awareness and ad campaigns. Public frustrations came to a boil in 2011 when a class action lawsuit was filed against the provincial government on the grounds of serious negligence regarding the implementation of appropriate policies to curb the number of moose accidents in the province (CBC News, 2014). While the lawsuit has since been dismissed, it has still brought this issue into the public consciousness as a topic that needs to be discussed and identified as a management priority by the provincial wildlife division. Through this research I will determine what feasible options are available to the province to control the number of moose-vehicle collisions occurring on provincial roadways. By examining what other jurisdictions have done to control vehicle collisions with large animals I hope to gain a clearer understanding of how this form of human-wildlife conflict can be mitigated and controlled.

Methods

Content Analysis

An important part of this study involves a review of current efforts by the provincial government to reduce the number of moose-vehicle collisions. Accessing this information required close reading of relevant plans and press releases issued by the provincial Wildlife Division and the overarching department of Environment and Conservation. These documents were obtained from the provincial news release website and other government websites. Documents were also examined from other jurisdictions that have attempted to address issues relating to large animals on roadways to explore whether alternate solutions could be applicable to Newfoundland. To effectively liberate the required information from these documents the research method of content analysis was used. This systematic method has been defined as a "a phase of information-processing in which communication content is transformed, through objective and systematic application of categorization rules, into data that can be summarized and compared" (Paisley, in press as cited in Holsti, 1969). In this case the categorization rules that will be applied relate to the efficacy of various strategies to reduce large mammal-vehicle collisions and the feasibility of their application in this province.

Interviews

A second research method which was to be applied in this study was stakeholder interviews. Interviews were to be conducted with both provincial wildlife division staff and representatives of the advocacy group: Save Our People Action Committee (SOPAC). By comparing the information provided by professionals in the field of wildlife management to that provided by public groups it was hypothesized that an interesting contrast of opinion would be

revealed, which would further enrich the quality of information provided by this research. Unfortunately, perhaps due to the controversial nature of this topic, no requests for interviews were approved in time for the preparation of this paper. Despite the fact that no data from interviews were available for this report, proposed interview questions are listed below (Table 1) for the benefit of future researchers who may wish to engage in a similar study. Interviewees were to be asked a series of questions regarding moose management in the province.

Question 1	What are the most effective ways to reduce the number of moose-vehicle collisions in the province?
Question 2	Which strategy has been the most effective? Why?
Question 3	Have the methods being used by the province been effective up to this point?
Question 4	What are some of the challenges/barriers in implementing more effective ways to reduce the number of moose-vehicle collisions in the province?
Question 5	In your opinion what are the main benefits and drawbacks of pilot projects like the moose detection system and highway fencing?
Question 6	What do you believe the next steps in preventing moose-vehicle collisions in the province should be?

(Table 1: Proposed Interview Questions)

Literature Review

Global Environmental Challenges

We live in a world that is becoming increasingly urbanized, with this increased urbanization a number of key environmental issues have been pushed to the forefront of many people's minds. These issues have been summarized into "five key environmental problems" by Miller & Hackett (2011). These general categories are listed as follows: 1. Biodiversity depletion, 2. Air pollution, 3. Water pollution, 4. Waste production, 5. Food supply problems. Miller and Hackett (2011) then go on to list a number of factors that have contributed to these environmental problems such as rapid population growth, unsustainable resource use, not including the environmental costs of economic goods and services in their market price, and trying to manage and simplify nature with too little knowledge about how it works. Each of these issues will now be looked at in more depth, in doing so it will help frame the issue of MVCs in the larger body of Environmental Studies literature.

Biodiversity Depletion

Biodiversity depletion is a global issue that effects a wide range of species, while it is commonly believed that the loss of rare or endangered species is the most important issue in biodiversity loss it is the loss of common species that can have the most serious effect on

ecosystems. In an article by Gaston and Fuller (2008) they discuss the impact that common species can have on their environment "in addition to threatened species, conservation biologists need to pay more attention to the depletion of common species, and in doing so it has several important implications, including the need to identify, monitor and alleviate significant depletion events" (p.14). They then go on to describe two key characteristics that make common species crucial to their environments, the first is "that even relatively small proportional reductions in their abundance can remove a large number of individuals from assemblages and can impact across large geographical areas, because these species are typically also widespread" (Gaston & Fuller, 2008, p.15). The second characteristic is "commonness is itself rare, the few most abundant species usually account for most individuals in an assemblage and often a large proportion of the biomass and function" (Gaston & Fuller, 2008, p.15). Much like environmental issues in general the causes of biodiversity depletion can be summarized into five issues 1. Human population growth, 2. Habitat destruction, 3. Pollution, 4. Growth of agricultural sector, 5. Global warming (Rainforest conservation fund, 2015). It is clear that human population growth is the driving force of biodiversity depletion so it is crucial that a balance is found that allows the human population to grow but also allows the planet's biodiversity to be sustained.

Air Pollution / Water Pollution

The relationship between air and water pollution is quite significant, both have become increasingly important issues as the world's population has increased and become more urbanized. The amount of air pollution in an area also effects water quality greatly, this pollution occurs in the form of atmospheric deposition. "Atmospheric deposition comes from emissions of air pollutants from natural and human-made (anthropogenic) sources" (EPA, 2001, p.5). These pollutants can travel great distances and affect waterbodies many kilometers away from the source. The deposition of theses pollutants occur in the following four distinct forms: direct deposition, indirect deposition, wet deposition and dry deposition. While the forms of these pollutants differ, the ultimate effect is the same, water quality is impacted and species are harmed. In a study by Guy Brun et al (2004) which looked at the level of Polycyclic aromatic hydrocarbons (PAHs) (a type of semi volatile organic compounds dispersed through atmospheric deposition), they found that from the years 1980-2001 the observed levels of these pollutions have been decreasing. They attribute this decline to "the implementation of air pollution abatement programs in Canada, the United States, and elsewhere, switching to cleaner sources of energy and improved technology during the past few decades" (Brun et al, 2004, p.1946). While this is a positive sign the overall levels of air and water pollution still have room for improvement, particularly as we as a society become increasingly urbanized and produce more fossil fuels.

Urbanization

Urbanization is one of the most significant drivers of environmental problems today, urbanization has contributed to increased air/water pollution, increased waste production and food supply problems. In a paper by David Satterthwaite (2009) the argument is made which suggests that it is not population growth which drives the growth in greenhouse gasses and climate change "but rather, the growth in consumers and in their levels of consumption" (p.545).

This is an interesting argument as it is commonly believed population growth and climate change are closely linked but this study shows that most population growth occurs in low-income areas which contribute little to climate change and GHG emissions. “If most of the growth in the world’s population is among low-income households in low-income nations who never “get out of poverty”, then there is and will be little connection between population growth and GHG emissions growth” (Satterthwaite, 2009, p.557). This is not to say that urbanization does not affect the environment, in an article by Seto et al (2010) they explain some of the effects that urbanization can have on the environment “urbanization creates the most human-dominated landscapes and drives local and regional environmental changes by transforming land cover, hydrological systems, and biogeochemistry” (p.167). The article then describes the decades-old debate regarding whether urbanization could actually have a positive effect on the environment “High population densities and compact urban design are required to support walkable neighborhoods and mass transit alternatives to the automobile. Compact urban development coupled with high residential and employment densities can reduce energy consumption, vehicle miles traveled, and carbon dioxide (CO2) emissions” (Seto et al, 2010, p.168). The opposite side of this debate is the focus on “the increase in consumption of resources and energy associated with urbanization, irreversible environmental degradation, or even the existence of pollution havens” (Seto et al, 2010). No matter which side of the argument you side with the increase in urbanization occurring around the globe is a key environmental issue that needs to be addressed.

Urbanization and Human-Wildlife Conflicts

With all these major environmental issues occurring around the globe it is easy to see how one important by-product of urbanization could be forgotten, and that is the increasing number of human-wildlife conflicts (HWC) occurring around the globe. As the world becomes increasingly urbanized and natural environments are degraded to make way for human infrastructure, wildlife are often forced to come into contact with humans. Consequently, the number of HWCs is increasing. Manfredo (2008) states a number of reasons why this increase is occurring “driven by population pressures, economic growth, and the expanding global demand for natural resources, humans occupy more and more places. As this occurs, it destroys or fragments habitat, forcing humans and wildlife into confrontation” (p.6). When these inevitable conflicts arise the most common human reaction is to kill or extirpate the species deemed to be a nuisance, “wildlife perceived as ‘problem animals’ are killed both legally and illegally, by private individuals, informally organized communities, bounty hunters, and local and national governments. In developed countries the most common methods are shooting, trapping and poisoning” (Woodroffe et al, 2005). This killing of ‘problem animals’ can lead to the extinction of an entire species but it is more likely to result in the “massive contractions of their geographic ranges” (Woodroffe et al, 2005), a good example of this is the grey wolf in North America which following efforts to eradicate the species are now confined to only small portions of the continent.

Human-Wildlife Conflicts

Human-wildlife conflicts occur around the globe and can have many different effects on humans in regards to the scale and also the positive and negative impacts these interactions can have on the surrounding environment. The scales that these interactions can occur on range from something as benign as a bird eating seed on your front lawn to a genuine threat to human safety such as being attacked by bears or wolves. "From the human perspective, our interactions with wildlife are often positive – we gain material benefit from harvesting species for food or other animal products. In other situations, however, human interactions with wildlife are negative" (Woodroffe, et al, 2005, p.13). The negative interactions with wildlife range from obvious conflicts such as property destruction and attacks causing death, to less obvious conflicts such as the transmission of diseases from wildlife to humans and livestock.

Reasons for Increasing Human Wildlife Conflicts

Human-wildlife conflicts have been increasing in number (Manfredo, 2008). One theory about why the numbers have been increasing is that with the increase in wildlife protection, populations have been increasing resulting in more conflicts "because of these restrictions, many contemporary rural and urban environments are inhabited by much larger wildlife populations than were present a century ago" (Messmer, 2000, p.98). Some of the official statistics that show an increase in HWCs is presented in the form of scientific survey data (Messmer, 2000, p.99). An example of this data is found in a survey of US agricultural producers which shows that "over 89% of the respondents experienced problems with wildlife. Most (80%) experienced wildlife damage annually with 54% reporting losses from wildlife in excess of $500. Over 40% of all agricultural producers reported that wildlife damage was so severe on their farms or ranches that they would oppose the creation of a wildlife sanctuary nearby; 26% said damages reduced their willingness to provide wildlife habitat on their property" (Conover et al, 1995, p.409). This data shows that HWCs have been on the rise even though these agricultural producers have taken precautions to protect themselves from the effects of wildlife. For instance studies have shown "a mean annual expenditure of over 40 h and $1000 per farmer to solve or prevent wildlife damage" (Conover et al, 1995, p.410). Another important aspect of understanding why HWCs are increasing is to understand the role that humans play in these conflicts, "Many human–wildlife conflicts stem from differences in objectives between various stakeholder groups, especially where the wildlife in question is a resource that can be exploited for economic or cultural benefit, or where the conservation of wildlife is at odds with human population growth or development pressure" (White & Ward, 2010, p.623).

Human Dimensions of Wildlife Management and Human Wildlife Conflicts

"Human attitudes and values about wildlife vary both among and within different sectors of the society" (Messmer, 2000, p.99). This may seem like an obvious statement as people's attitudes about any subject vary within and among different sectors, but it can often be overlooked and is one of the key aspects of implementing strong wildlife management policies in a jurisdiction. In order to understand human responses to HWCs, Manfredo et al (2009) point to a number of well-established features of human dimensions theory, 1) wildlife values are

believed to take shape early in life and change slowly, meaning recent experiences rarely change basic values or beliefs, 2) a complex mix of individual, social, and environmental factors correlate with perceptions of environmental hazards and their management and 3) perceptions and attitudes are influenced by testimonials and entertaining stories that may reflect extreme events and imagination, long memories and a history of human-animal interactions, or experiences from a broad region (p.216). Given this information, it appears that including public opinion into a wildlife management situation would be a very difficult proposition, but Manfredo et al (2009) suggest that rather than assuming that all people are irrational when it comes to wildlife or are controlled entirely by social tradition and symbolism, researchers should assume a multivariate role of intrinsic (individual experience) and extrinsic (economic, social, and cultural) factors in shaping perceptions and attitudes (pg.217). This is important because it helps to ensure that wildlife management policies put in place are better suited to both the human and natural environment.

How to Decrease the Impact of Human Wildlife Conflicts

Knowing all the impacts and implications that HWCs can have on human and wildlife populations it is quite obvious that a solution to these problems is needed. Perhaps the most obvious way to reduce HWCs is to build a fence or a barrier between wildlife and whatever human infrastructure is deemed important (e.g: a farmer's field or a roadway). In a study done by Clevenger et al (2001), to determine the effectiveness of wildlife fencing in Banff National Park, they found that after wildlife fence installation, the number of wildlife-vehicle collisions (WVC) decreased by as much as 80% in some areas even despite annual increases in traffic volume (p.151). While wildlife fencing has become a proven method of decreasing wildlife-vehicle collisions, the cost of implementing it can be a major deterrent in many wildlife management situations. When comparing the cost-benefit analysis of various mitigation measures to reduce WVCs it was found that "Wildlife fencing in combination with underpasses and jump-outs, or a combination of under- and overpasses and jump-outs, have thresholds low enough to be met at many road sections that have a concentration of collisions with large ungulates" (Huijser et al, 2009). This study by Huijser and colleagues has shown that wildlife fencing can be a feasible option for many roadways across Canada and the U.S, but they also stress the importance of including safe ways for wildlife to cross roadways such as overpasses and underpasses. Another less direct way to decrease HWCs is to increase stakeholder participation in managing these conflicts. By increasing stakeholder participation it provides stakeholders with an increased opportunity to become more knowledgeable about management options and participate in the decision making process. Increased participation will ultimately result in more public ownership in the outcome (Messmer, 2000). By including stakeholders in the decision making process it brings increased awareness to the management issues in question and it gives the public a stronger voice in the management process.

Large Mammal Vehicle Collisions

One of the most significant forms of human-wildlife conflict that can occur is large mammal vehicle collisions. In North America these collisions occur most often with elk, deer, moose and bison. A collision with an animal of this size will undoubtedly result in vehicle

damage and possible injury or death to the human occupants of the vehicle. As an example of the impact that a collision with one of these large mammals can have it would be useful to examine the dollar value associated with a collision. In a study by Huiliser et al (2009) the economic impact of such a collision ranges from $6,617 for deer and up to $30,760 for moose. These estimates included a wide range of factors such as vehicle repair, human injuries and fatalities, and the loss in hunting value of the animal. By using these dollar values as a guide they can be an important measurement tool in determining just how significant a collision with one of these large mammals can be.

Impact of Large Mammal Vehicle Collisions

While the monetary impact of large mammal vehicle collisions is certainly one of the most significant and obvious by-products of WVCs there are also other less obvious impacts which are just as significant. An example of this is the ecological effect that these collisions have on the biotic components of an ecosystem. "In the United States, roadkill has surpassed hunting in its effect on vertebrate mortality" (Foreman & Alexander, 1998, p.207). Despite significant road kill losses for some species, others are impacted very little. An example of the latter case would be moose in Newfoundland and Labrador, Canada. While there are approximately 600-800 MVCs occurring per year there appears to be no real effects on the size of the moose population in the long run, this likely due to the high population of animals already located on the island which is an estimated 125,000 (Dept. of Environment, 2014). On the other hand an example of a species that has been significantly affected by vehicle collisions is provided in an article by Coffin (2007) "the Florida panther, which had an annual roadkill mortality rate of 10% of its population before 1991".

There are a number of reasons why roads have such a huge impact on wildlife populations, Harris and Scheck (1991) some of these impacts are; migration routes and other territories important to the species are bisected by roads; also an increase in WVCs are likely as wildlife move along open road corridors, and the roadside environment is also attractive to some species and serves as an "ecological trap" or habitat for some species. Through these observations it could be determined that the root cause of most large mammal vehicle collisions is "that animals are killed by vehicles are driven mostly by the spatial arrangement of resources. Animals die when they are struck while trying to reach resources (food, water, den sites, etc.)" (Coffin, 2007, p.399). This loss of wildlife also occurs because of the placement of human transportation corridors, "these corridors tend to be routed through lowlands that follow the natural contours of the land and often bisect or parallel prime habitat and natural routes traditionally used by ungulates and other wildlife for travel and migration" (Thomas, 1995, p.). This is an important impact of WVCs that often gets forgotten about as the focus is usually on the human/financial cost side of the collision.

How Other Jurisdictions Have Dealt With WVCs

Due to the severe impacts that WVCs can have on both human and wildlife populations many jurisdictions around the globe have sought ways to mitigate these effects. Among the most common methods used throughout the world are wildlife fencing and crossings, seasonal

signage, vegetation removal and population culling. While all these methods have been determined to have varying degrees of effectiveness they have all been used to some degree to deter wildlife from entering roadways.

An example of effective use of wildlife crossings in use here in Canada is in Banff National Park, "with 24 crossings in place and eight more planned. These crossings include overpasses, underpasses, and culverts for species ranging from small mammals to grizzly bear and elk" (Clevenger & Waltho, 2000, p.49). These wildlife crossings when used in conjunction with wildlife fencing can greatly diminish the amount of WVCs occurring on roadways, and even help save a species that has been adversely affected by roadways. An example of this would be the Florida panther; in 2010 the species was facing near extinction but with the installation of wildlife crossings and fencing it has started to show signs of recovery (Christy, 2014). In order for wildlife crossings to achieve their full potential to effectively reduce the number of WVCs, most jurisdictions use them in conjunction with wildlife fencing. Wildlife fencing has been proven to be the most effective way to deal with WVCs, in a study by Clevenger et al (2001) they discovered that after the installation of wildlife fencing in Banff National Park "the number of WVCs declined despite annual increases in traffic volumes". In this same study it was also determined that by using the combination of wildlife fencing and crossing structures "there has been 80% fewer accidents involving wildlife, which may be attributed to mitigation fencing and crossing structures" (Clevenger et al, 2001, p.649). An example of a jurisdiction in Atlantic Canada that has excelled in the area of WVC management is New Brunswick, in 2010 they surpassed their 2006 goal of having 300 km of wildlife fencing installed in the province (Prov of New Brunswick, 2010). This has set the bar high for other provinces in Canada. Jurisdictions such as Newfoundland, Manitoba and Nova Scotia have been in contact with the provincial government of New Brunswick to and gain insight on WVC mitigation strategies (Prov of New Brunswick, 2010).

While wildlife fencing has been proven to be one of the most effective and feasible ways to prevent WVCs there are other methods that have been experimented with as well. One of these methods is wildlife detection systems. "Animal detection systems use sensors to detect large animals as they approach the road. The two most common technologies for detecting animals in the roadway environment are area coverage sensors and break-the-beam sensors" (Gray, 2009, para.8). In most cases these detection systems have been used in conjunction with wildlife fencing as a substitute for typical wildlife crossing structures such as an overpass or underpass. Wildlife detection systems are most effective when used as part of a larger WVC management system. There are very few examples where detection systems alone significantly reduced WVCs on a roadway. Detection systems have been used effectively throughout the world as part of the wildlife management process, from Arizona to the Netherlands and have been experimented with here in Newfoundland. Some of the pros and cons associated with this system are "these systems are less restrictive to wildlife movement than fencing, and they allow animals to use existing paths to the road or to change them over time" (Gray, 2009, para.20), also "Unlike wildlife crossing structures, which usually are limited in number and rarely wider than 164 feet (50 meters), animal detection systems have the potential to permit safer crossing opportunities for large wildlife anywhere along the outfitted roadway" (Gray, 2009, para.20).

Some of the downfalls of wildlife detection systems are that it relies on sophisticated technology, which, when placed in harsh environments, requires a lot of maintenance and upkeep. This is an obvious disadvantage when compared to underpasses and overpasses which often require very little maintenance over their lifecycle. An important aspect of these detections systems is that they are largely dependent on the type of environment they are placed in "environmental conditions and the size of the species can influence the reliability of animal detection systems. Road managers should consider the site carefully and the size of the target species before selecting a system" (Gray, 2009, para.23).

Another slightly more controversial method of reducing WVCs would be wildlife population culling, this involves the hunting of individuals of the target species to reduce population sizes and, consequently, the number of WVCs. Culling has been used extensively in Iowa City, Iowa to control the number of deer collisions in the area. In a study by DeNicola and Williams (2008) they evaluated the effectiveness of a sharpshooting program designed to decrease the deer population and thus the number of deer vehicle collisions (DVC's). The results of the study showed that after 49 days over the 3 year period of sharpshooting at the Iowa City site, 950 deer were removed, with a culling rate of 19.3 deer per day" (DeNicola & Williams, 2008), this reduction in the population resulted in a decrease in deer numbers and the annual number of DVCs from 49% to 78% in the study sites (DeNicola & Williams, 2008). This drastic decrease in DVC's is likely attributed to the large segment of the deer population which was culled, for example in Iowa City the deer population density was reduced by 76%. While it may seem drastic to decrease a species population in an area by as much as 76%, it is a proven method to decrease the number of WVCs occurring on roadways.

Moose Vehicle Collisions in Newfoundland

The most significant HWCs in Newfoundland occur in the form of moose vehicle collisions. These collisions occur approximately 600-800 times per year (Clevenger, 2011), resulting in 2 deaths per year on average. In order to get a better sense of the impact that MVC's have on Newfoundland highways it would be useful to look at the economic valuation of a MVC. In a study by Huijser et al (2009) it was estimated that the average cost of a moose vehicle collision is $30,760 (in 2007 US$), using these figures as a guide Newfoundland experiences approximately $19,000,000 to $25,000,000 in total losses per year as a result of MVCs. Based on these dollar values alone MVCs are a significant problem in the province and it would be worthwhile to explore possible mitigation measures to decrease the number of collisions occurring on a yearly basis.

Background Information on Moose in Newfoundland

Moose are not native to the island of Newfoundland, but they have certainly flourished here resulting in an estimated population of 125,000 on the island toady (Dept. of Environment, 2014). Moose were first introduced into Newfoundland in 1878 when a male and female from Nova Scotia where released into the wild (Pimlott, 1953). After this first attempt was deemed unsuccessful a second attempt was made in 1904 when a second group of four was introduced from New Brunswick, two male and two female (Mercer & McLaren, 2002). Since the

extirpation of the grey wolf in 1932 the only natural predator of moose in Insular Newfoundland has been the black bear (Pimlott, 1959). Due to the lack of natural predators and favorable foraging conditions on the island, the Newfoundland moose population eventually increased to be one of the highest in North America.

The person who is most often credited with the idea of introducing moose to Newfoundland is "Captain Richard Lewis Dashwood, a British Military officer and avid fisherman and hunter" (Dohey, 2013).The original purpose of introducing moose to Newfoundland was to stimulate the economy by attracting big game hunters from outside of the province. After all these years it appears as if this purpose has been achieved, the moose hunt has become a multi-million dollar business in the province as hunters have some of the highest success rates in the world (Newfoundland and Labrador tourism, 2015). The one major side effect of introducing moose to Newfoundland that was not accounted for was the potential conflicts that may occur between humans and this newly introduced species, which currently occur most often in the form of MVCs.

Steps the Province has taken to Decrease MVCs

In order to counteract the number of MVCs in the province, provincial government has implemented policies and programs to reduce MVCs and improve driver safety. Perhaps the most well-known example of this is the two animal detection systems that have been installed near St. Johns and Grand Falls-Windsor. These two systems were installed in 2011 as part of a $5 million pilot project that also included the installation moose fencing along the Trans-Canada Highway (Kohler, 2011). The 13.5 km of wildlife fencing is located along the Trans-Canada Highway (TCH) from west of Gallants Road (Route 402) junction to east of Barachois Pond Provincial Park (Dept of transportation and works, 2011). The two detection systems were discontinued in 2014 and have been deemed ineffective for Newfoundland, this has happened amid much public frustration regarding the project as there are claims that the system near St. Johns was out of order for nearly half of the projects lifecycle (CBC News, 2014). Prior to these projects the provinces main objectives for reducing MVCs included "(1) increasing public awareness and targeted prevention strategies such as driver education; (2) enhanced highway signage; and (3) clearing of roadside brush" (Clevenger, 2011, p. 2).

In addition to these methods the regulated provincial moose hunt also acts as a way to reduce MVCs, in 2012-13 the overall moose harvest quota was 32,810 (Environment & Conservation, 2012). Most of the initiatives that are listed above have been carried out in the last four year and the provincial government has devoted considerable time and effort into reducing MVCs as of late. This increase in effort could be due to the public criticism that not enough was being done to make Newfoundland highways safer. This public frustration reached its highest point in 2011, when a class action lawsuit was launched against the provincial government claiming that the provincial government was at fault for not taking steps to reduce MVCs on provincial roadways (CBC News, 2014). While the lawsuit was dismissed in 2014 it has helped

to bring the issue of MVCs into the public conscious, and has served notice to the provincial government that more work needs to be done to reduce MVCs on Newfoundland roadways.

Results

One of the goals of this research was to seek out how different stakeholder groups perceive the effectiveness of current efforts to reduce the number of moose-vehicle collisions in the province. The main source of information that was to be used to answer this research question was personal interviews with the Provincial wildlife division and the Save Our People Action Committee (SOPAC). Unfortunately these interviews were unable to be conducted, likely due to the political sensitivity surrounding the topic and the time constraints of the research. As a result of this, the current research relies solely on the in-depth content analysis of plans and press releases issued by the provincial government as well as studies and research done in other jurisdictions.

After conducting this content analysis it appears that the majority of the public perceive that not enough is being done to reduce the number of MVCS in the province. Evidence of this can be found in the class action lawsuit that was proposed in 2011 which shone a spotlight on the province's MVC management practices. Also the pilot project of the two moose detection systems was seen as a failure and a poor investment by the majority of the public, this was largely a result of reports that the systems was in constant state of repair (CBC News, 2013). It is unclear how the provincial government feels about the final result of the detection system pilot project, but it is likely that it may not have garnered the results they expected. It should however, be seen as a step in the right direction towards taking a more proactive approach to decreasing WVCs in the province.

The second major goal of this research was to seek out what methods other jurisdictions are using to decrease the number of WVCs on their roadways, and to determine if any of these methods could apply or be appropriate for use in Newfoundland. In order to determine this it would be useful to compare the cost-benefit that each of these methods provide. To help answer this question, information was taken from an article by Huijser et al (2009) which compared the cost and potential benefit that various WVC prevention methods. In this study it was determined that wildlife fencing has the highest threshold value. This means that "If a road section has costs or wildlife–vehicle collision numbers that exceed these threshold values, then the benefits of that mitigation measure exceed the costs over a 75-year time period" (Huijser et al, 2009, p.13). This threshold value represents the breakeven point at which a mitigation measure cost is equal to its benefits, in the Huijser et al (2009) study, the example of a roadway that averages 4.4 deer-vehicle collisions per kilometer was given, because the breakeven point for wildlife fencing with underpasses and overpasses is listed at 4.3, than these mitigation measures would be economically feasible. If this data for Moose vehicle collision per kilometer was available for sections of Newfoundland highways it would be possible to determine which stretches of highway are most at risk and also what mitigation measures would be most economically feasible. Wildlife fencing when combined with crossings are a proven method of reducing WVCs, with some studies showing as high as an 86% reduction in collisions after installation (Huijser et al, 2009). Approximately $20,000,000 in total losses occur each year in

Newfoundland due to MVCs, the estimated cost of installing wildlife fencing to both sides of a highway is $96,000 per km. So by using these rough estimates as a guide it would appear that wildlife fencing would be an economically feasible option for Newfoundland to pursue, at least initially along problem stretches of highway.

A worthwhile and achievable goal for the provincial government to pursue would be to decrease "serious injury" caused by MVCs in the province by 50%. A serious injury could be defined as "someone being admitted to a hospital as an inpatient" (Clevenger, 2011, p.8). The most likely mitigation measure to ensure this reduction is wildlife fencing, "fencing alone (or in conjunction with animal-vehicle detection systems or with crossing structures) has resulted in >50% reductions (and up to 90-95% reductions for ungulate species such as moose) in WVCs in numerous locations in North America" (Clevenger, 2011, p.8). This 50% percent reduction goal would be a good step for provincial government to take it would show that they are serious about decreasing the number MVCs on the island.

As a result of this content analysis, it appears that wildlife fencing is the most feasible solution to Newfoundland's MVC problem, as it offers a high reduction rate in collisions and, when combined with wildlife crossings, does not have a highly adverse effect to the natural environment. In order to pursue this idea further and to determine exactly how feasible this method is for Newfoundland, further cost-benefit analysis would need to be done specifically for Newfoundland using data provided by the provincial government.

Discussion

After examining the methods that other jurisdictions throughout North America have been experimenting with and implementing, it appears that Newfoundland is lagging behind with respect to implementing WVC reduction strategies. When compared to the advances made in New Brunswick, which has surpassed a goal set in 2006 of having more than 300km of wildlife fencing installed by 2010 (Prov of New Brunswick, 2010), there is significant ground to be made up. Considering that to date there has only been 13.5 km of wildlife fencing installed on Newfoundland island (Dept of transportation and works, 2011), for a problem that could be deemed more significant than the deer problem in New Brunswick there is still much work to be done. As has been stated earlier the average cost of a deer collision is $6,617 compared to $30,760 for the average moose collision (Huijser et al, 2009). When comparing these numbers it becomes clear that Newfoundland needs to become more on par with New Brunswick in terms of their wildlife management practices.

Another method that could provide Newfoundland with the opportunity to decrease the amount of MVCs in the province would be population culling. This could operate aside from the regulated provincial hunt which mainly eliminates animals which are located deeper in forests away from provincial roadways. Future research could be conducted to determine the range that the average Newfoundland moose travels, this would then show if decreasing the population by way of the annual hunt has any effect on decreasing MVCs on provincial roadways. Then a sharpshooting program as described by DeNicola and Williams (2008) could be a suitable option to pursue. This could be done by training wildlife personnel to travel along sections of highways

and kill moose located within a designated distance of the highways. While this may be seen as a controversial method is has been used effectively in other jurisdiction to control deer populations and has significantly lowered the amount of WVCs. The problem of MVCs in Newfoundland is one of the most significant environmental topics occurring in the province today, and while the province has made significant strides in implementing new measures to reduce MVCs there is still much work to be done. This research and future research on this topic should be used as guide to help the Provincial government invest in proven and effective MVC reduction measures.

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