Evaluation of Moose-Vehicle Collision Mitigation Pilot Initiatives

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Newfoundland Labrador

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Executive Summary

With the goal to reduce the number and severity of moose-vehicle collisions (MVCs) in the province, the Government of Newfoundland and Labrador dedicated $5 million to a series of MVC mitigation initiatives, including the expansion of existing measures and the implementation of two new pilot projects. One pilot project involved the installation of two break-beam moose detection systems on the Trans Canada Highway (TCH) that trigger a set of warning lights when a moose enters the right of way. One of these systems was installed on a 1.5 kilometre stretch of road near the Salmonier Line (Route 90) interchange on October 13, 2011, and one system was installed on a two kilometre stretch of road just east of Grand Falls-Windsor on November 7, 2011. Another pilot project involved the installation of 17 highway kilometres of wildlife fencing and boulder fields along the TCH west of Gallants Road (Route 402) junction to east of Barachois Pond Provincial Park, and on Route 460 near Black Duck Siding, on July 15, 2012. The effectiveness of the pilot projects to mitigate MVCs in Newfoundland and Labrador, and in turn reduce the number and severity of MVCs, was assessed in this evaluation.

To determine the necessity, sustainability, and effectiveness of the two pilot projects, a number of methods were employed. Jurisdictional reviews and academic literature reviews were conducted to examine the success of these measures and to identify any potential issues related to the performance of the initiatives. An analysis of vehicle speeds inside and outside the pilot project areas pre-implementation and post-implementation was completed to determine if any changes in vehicle speeds were associated with the installation of the pilot projects. In addition, traffic volumes in each pilot area were assessed to determine the number of motorists who were impacted by the pilot initiatives. The number of days the moose detection systems were non-functional was compared to the number of days they were functional to assess the reliability of the systems. An analysis of the number of MVCs pre-implementation and post-implementation in all of the pilot project locations was conducted to determine if there was a reduction in MVCs in these locations. Finally, a financial analysis was performed to determine the cost-effectiveness of the MVC mitigation initiatives.

Based on the results of the analyses conducted utilizing the methodologies above, with regards to the moose detection systems, it is evident that this technology is ineffective in the climate and terrain of Newfoundland and Labrador. It is therefore recommended that this pilot project not be expanded to other areas of the province and that the removal of the existing systems be considered.

Mixed results were found in the present evaluation with regards to the moose fencing pilot initiative, demonstrating that wildlife fencing could potentially be effective in mitigating MVCs as it provides a barrier to moose, but a number of caveats should be considered, including the significant expense associated with wildlife fencing, when deliberating the sustainability of this initiative. In the interim, data collection and performance monitoring should be continued before concluding that this MVC mitigation measure is effective in reducing the number of MVCs in Newfoundland and Labrador.

Background

In recent years, the prevalence of MVCs in Newfoundland and Labrador has been growing, with approximately 4,400 MVCs recorded by the Department of Transportation and Works (TW) between 2000 and 2010. Included in this number are 900 injuries and 18 fatalities. Typically, about 70 per cent of MVCs occur between May and October. These accidents usually happen on straight stretches of road between dusk and dawn. Due to the increasing prevalence of MVCs in the province, this issue was addressed by the Government of Newfoundland and Labrador.

In 2005-06, TW and the Department of Environment and Conservation (ENVC) launched a MVC mitigation strategy. As part of this strategy, a multi-year public awareness campaign was established. This included radio ads, which ran from May to September, and television ads, which ran from June to August. Billboards were also installed on sections of the TCH and bumper stickers encouraging people to be mindful and observant of moose on the province's highways and major trunk roads were distributed. A moose alert hotline, which allowed drivers to alert other travelers of moose on or near roadways, was established with the assistance of VOCM/CFCB and K-Rock radio stations. In addition, TW and ENVC created webpages dedicated to educating the public on moose awareness. ENVC also collaborated with the Motor Registration Division of Service NL to instate a moose awareness component to the province's Road User's Manual and to the graduated driver courses, including Safety Services Newfoundland and Labrador and Young Drivers of Canada.

In 2006, TW budgeted $2M to initiate a brush cutting and herbicide treatment of roadside vegetation program. Brush cutting is an efficient way of clearing the rights-of-way along highways and major trunk roads. As well, one to two years after brush cutting has occurred, a herbicide treatment (Tordon-101), which prevents the re-growth of brush and promotes the growth of grass, is applied to the highways and remains effective for about ten years. Often, mechanical brush cutting is used in areas of high moose population and heavy brush growth. TW currently dedicates $1 million of its annual budget to mechanical vegetation control initiatives (in Budget 2014, this budget has been increased to $2M).

In 2011, ENVC made several changes to the moose licensing system and to the length of the hunting season. These changes consisted of a substantial increase in the number of moose licenses issued, including those available to not-for-profit groups and those available in the big game draws in Terra Nova National Park and Gros Morne National Park. Most of the new licenses were for either sex and were added to moose management areas (MMAs) near the TCH and major trunk roads. ENVC also extended the moose hunting season by a total of four weeks, which gave hunters who were not successful in harvesting a moose earlier in the season more time to hunt, and promoted hunting in more remote areas that could only be accessed by snowmobiles.

In 2012, TW replaced its SAS Accident System, which dates back to the 1980s, with a new Collision Data Management System (CDMS). Unlike the previous system which could only locate accidents by road segments, the new system uses Global Positioning System (GPS) technology so that all accidents, including MVCs, can be recorded precisely. This, along with new Motor Vehicle Accident (MVA) forms that allow RNC and RCMP officers to report accidents in greater detail, allows for the identification of specific areas with high volumes of MVCs and a better understanding of the severity of MVCs.

On July 6, 2011 Government announced $5 million for a series of MVC mitigation initiatives, including the expansion of existing initiatives as well as the launch of two new pilot projects. One pilot project was the installation of two moose detection systems in Fall 2011 at a cost of $1.5 million. One system was installed on a 1.5 kilometre section of the TCH near the Salmonier Line (Route 90) interchange on October 13, 2011; the second system was installed on a two kilometre section of the TCH just east of Grand Falls-Windsor on November 7, 2011. The second pilot project was the installation of wildlife fencing and boulder fields along a 16.5 highway kilometre stretch of the TCH running west of Gallants Road (Route 402) junction to east of Barachois Pond Provincial Park, as well as an additional 500 highway metres of fencing on Route 460 from the TCH toward Black Duck Siding. The fence was completed on July 15, 2012 at a cost of approximately $2 million. A map showing the location of the pilot projects, as well as roadways that have had vegetation control since 2008, can be seen in Figure 1. Details on the two pilot initiatives are provided in the following section.

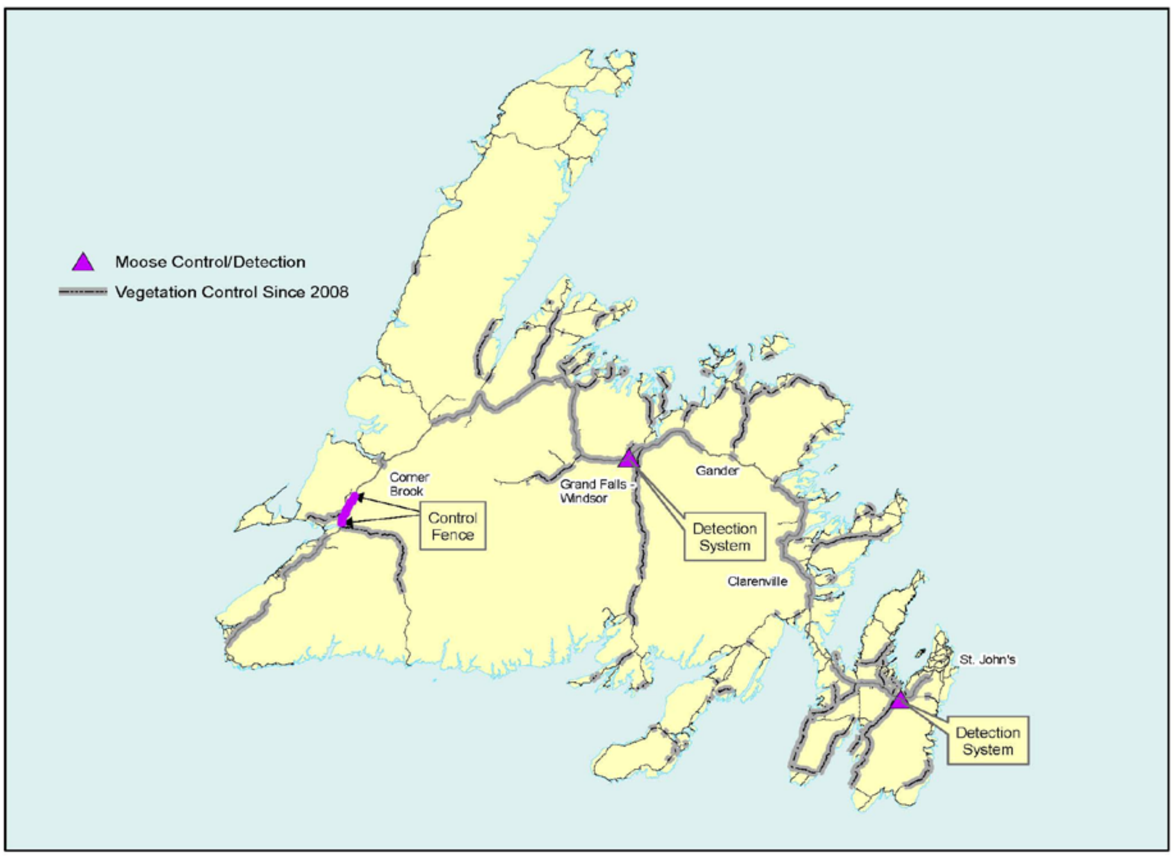

Figure 1. Map Depicting the Location of Pilot Initiatives

Pilot Project Profiles

Moose detection systems

Two moose detection systems that operate using break-beam technology were installed on the TCH by Safeguards of Canada Incorporated as part of the pilot project initiatives. These systems consist of a number of towers located on either side of the highway that contain two infrared beams at differing heights. For a detection to occur, the height of an animal must activate or "break" two of the infrared beams on a tower at the same time. This information is then sent to a central tower that notifies a set of warning lights to flash for three minutes and caution travelers of the presence of moose on or near the highway. The purpose of these systems is to alert drivers of the presence of a large animal on the road, which is anticipated to result in a decrease in drivers' speeds when the lights are flashing.

The locations of the two detection systems were chosen for several reasons. Both areas had higher than normal rates of MVCs, with 32 collisions confirmed between 2009 and 2011 within eight kilometres of the Salmonier Line detection system, and with eight collisions confirmed between 2009 and 2011 within 15 kilometres of the Grand Falls-Windsor detection system. The fact that both moose detection system areas have long straight stretches of road was also a deciding factor. High traffic volumes, geographic balance, and the absence of access roads and trails were also important factors in this decision.

Wildlife fencing

In Canada, wildlife fencing continues to be one of the most prevalent wildlife-vehicle collision prevention measures; New Brunswick, Ontario, British Columbia, Kootenay National Park and Banff National Park have used it to mitigate wildlife-vehicle collisions in their respective areas. This technique also employs bouldering, the creation of boulder fields at both ends of the fenced zone. Boulder fields help to deter moose from entering the fenced areas and becoming trapped inside.

The wildlife fence pilot project was completed on July 15, 2012. The location for the fencing was chosen for a number of reasons. The selected area had a higher than normal instance of MVCs, with seven collisions confirmed between 2009 and 2011 within a 15 kilometre section of the TCH and Route 460; there is an opportunity for wildlife to cross roadways through Trout River Culvert, eliminating the need to build additional wildlife crossing structures such as underpasses or overpasses. Other factors considered in selecting this location include geographical balance, and that vegetation control had been completed.

Pilot Project Goals

The goals of the two pilot projects are:

- To reduce the number of MVCs in Newfoundland and Labrador
- To reduce the severity of MVCs in Newfoundland and Labrador

An outline of the program's logic model is presented in Figure 2

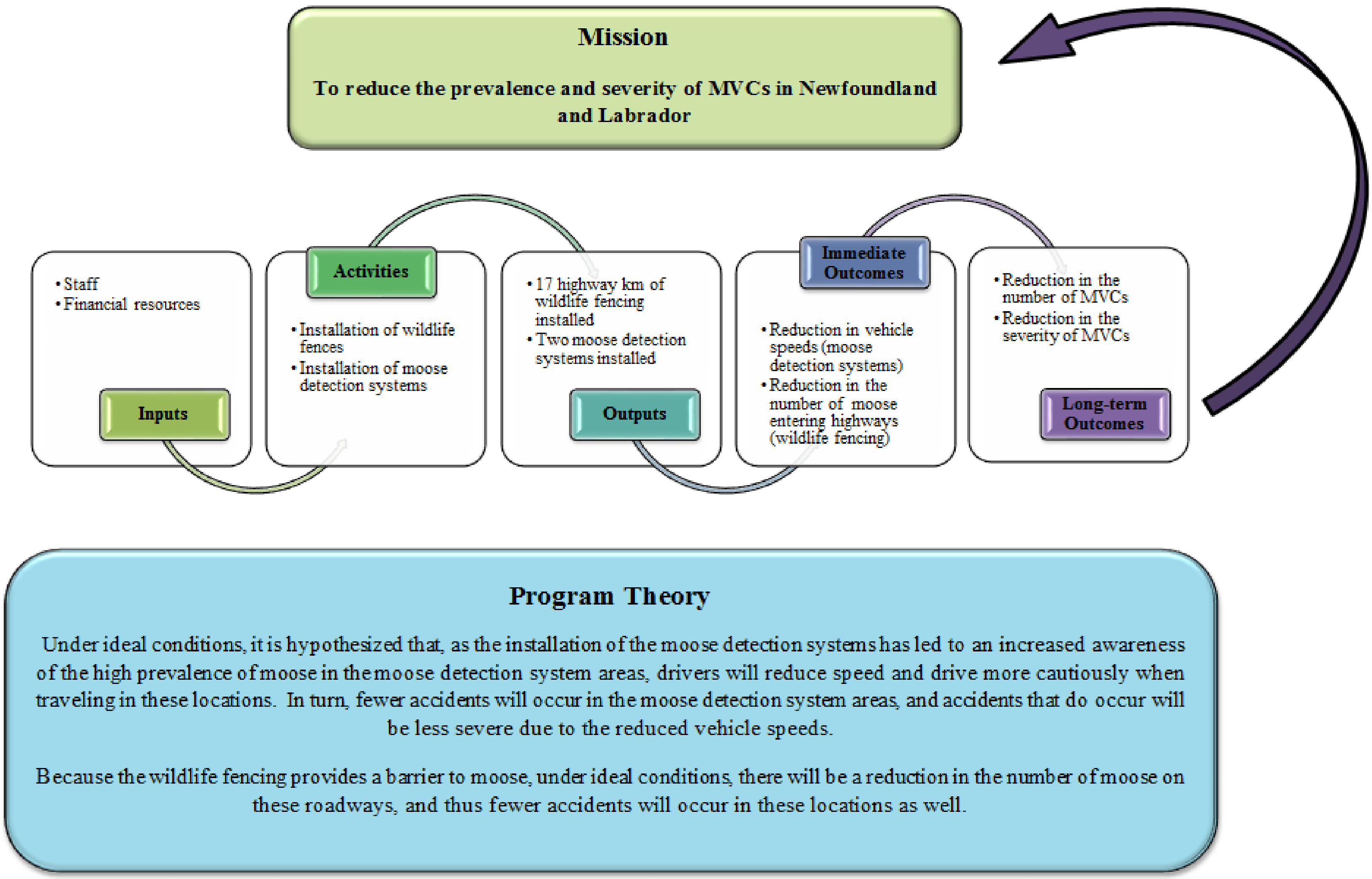

Figure 2. MVC Mitigation Pilot Project Logic Model.

Evaluation Approach

The purpose of the current evaluation was to assess the efficiency, necessity and sustainability of the two MVC pilot mitigation initiatives. This was accomplished by determining whether the pilot initiatives had been implemented successfully, if they were functioning as intended, and if the project goals had been met. The results of the evaluation will help TW to gauge the success of the pilot projects. A mixture of qualitative and quantitative methods was used to evaluate the pilot projects and obtain multiple perspectives for each evaluation question.

To determine the success of the implementation of the MVC mitigation initiatives a number of methods were used. A jurisdictional review of locations which have used similar wildlife-vehicle collision mitigation measures was conducted. This was used to determine whether there is evidence from other jurisdictions that these initiatives could potentially reduce the number of MVCs in Newfoundland and Labrador and to examine any barriers to implementation that other jurisdictions have faced. An academic literature review was also conducted to determine whether research supports the use of these wildlife-vehicle collision mitigation measures. The functionality of the detection systems was also analyzed to determine if these systems were working effectively throughout the duration of the pilot project initiative.

To examine if the desired outcomes of the project were achieved, several methods were employed. Comparative analyses of speeds before and after the implementation of the pilot projects, as well as at different points within the pilot areas were used to assess any potential change in vehicle speeds. An analysis of the number of MVCs before and after implementation was conducted to see if the pilot initiatives had met their goals as intended and led to a reduction in the number of MVCs in the pilot project areas. A financial analysis was also conducted to assess the cost-effectiveness of the pilot initiatives. A list of evaluation questions, along with the indicators and methods for exploring each, is presented in the evaluation matrix below.

Evaluation Questions	Performance Indicators	Methods
Relevance		
1. What evidence is there that the pilot study initiatives will reduce the number and severity of MVCs?	• Academic research results • Number of other jurisdictions using similar approaches • Number of jurisdictions who have had success with these approaches • Reduction in the number of MVCs in target areas	• Jurisdictional review • Academic literature review • Analysis of MVCs pre-implementation and post-implementation
Effectiveness		
2. Have the moose detection systems been operating efficiently since their installation?	• Number of days the systems were out of operation or having technical issues	• Analysis of detection systems' days out of service versus days in service

3. Have the MVC mitigation initiatives reduced speeds on the TCH in moose detections system areas, and increased speeds on the TCH in wildlife fencing areas?	• Changes in vehicle speeds in pilot project areas	• Analysis of speed studies
Cost-effectiveness		
4. What is the cost-effectiveness of the two pilot initiatives in reducing the number and severity of MVCs?	• Comparison to similar programs in other jurisdictions • Implementation and maintenance costs of the two pilot initiatives • Number of days the detection systems were out of operation or having technical issues • Reduction in the number of MVCs in target areas	• Jurisdictional review • Financial analysis of TW documents • Analysis of detection systems' days out of service versus days in service • Analysis of MVCs pre-implementation and post-implementation

Table 1. Evaluation Matrix.

Methodology

Jurisdictional Review

A jurisdictional review was conducted to determine if other areas with high wildlife activity have used the piloted strategies, and if the initiatives were successful in these regions. This analysis consisted of a review of documents, interviews, articles and news releases that examine similar programs in other areas as well as an assessment of the cost-effectiveness of these initiatives in those jurisdictions.

Academic Literature Review

An academic literature review was conducted to determine whether the methods selected for the pilot projects have been found to be effective by the academic community. In addition, the academic literature review was utilized to determine different ways to assess the effectiveness of these projects.

Speed Studies

An analysis of vehicle speeds was conducted at a number of locations, including at four points in the wildlife fencing area (in the center, at each end, and on Route 460) and at three points in each of the moose detection systems (in the center and at each end). Vehicle speeds at each of these locations were then compared pre-implementation and post-implementation and by position in the pilot project areas using repeated measured t-tests to determine if there was a change in vehicle speeds since the implementation of the pilot initiatives, specifically to determine whether speeds decreased in the moose detections system areas, and whether speeds increased in the wildlife fencing area.

Analysis of Traffic Volumes

Traffic volumes were assessed by location to facilitate the analysis of MVCs by traffic level and to estimate the number of motorists impacted by the pilot project initiatives.

Analysis of Detection Systems' Days In vs. Days Out of Service

To assess the functionality of the two moose detection systems, the days in which the systems were out of service were compared to the days that the systems were fully functional to determine if the systems were working effectively throughout the duration of the pilot initiative.

Number of MVCs

A comparison of the number of MVCs in the pilot project areas before and after the implementation of the two pilot projects was conducted.

Financial Analysis

Financial analyses were conducted to determine the costs associated with each pilot initiative, to examine the cost-effectiveness of these endeavors, and to assess the financial implications of potential future maintenance of these pilot projects should they be made permanent.

Results

Jurisdictional Review

<u>Moose detection systems</u>

When compared internationally, large animal detection systems (LADS) tend to receive mixed reviews on their effectiveness in mitigating animal-vehicle collisions. For instance, a study by Huijser and McGowen (2003) revealed that of the eight LADS in North America at the time, only four were still in operation, three were inoperable and one had been dismantled. However, of the 18 LADS across Europe at the time, 17 were in operation and only one had been dismantled. It is likely that this disparity between continents is due to differences in climate and terrain.

Likewise, this trend is also observed when North American LADS are compared. A break-beam LADS on Highway 19 in Yellowstone National Park demonstrated a reduction in vehicle speed by approximately 2.45 kilometres per hour. Although this reduction is small in scope, it is important to consider that small reductions in vehicle speeds cause a disproportionate decrease in the probability of severe accidents. Data from the system in Yellowstone National Park also showed a 58 to 67 per cent reduction in the number of animal-vehicle collisions in that area (US Department of Transportation Research and Innovative Technology Administration, 2009). Nonetheless, this system did experience multiple maintenance issues that led to its removal.

Studies in Wyoming and Ontario suggest that the positive results observed in other North American jurisdictions may fade over time. A LADS for mitigating collisions with pronghorns that was installed near Trapper's Point in Wyoming found that the system had a greater influence on reducing vehicle speeds in the earlier phases of data collection, suggesting that the effectiveness of this initiative may disappear over time. Researchers also found a downward trend in the number of collisions before and after the system was installed, but this result was not statistically significant (Dai, Young, and Vander Giessen, 2009). Thus, the observations in Wyoming insinuate that drivers may initially adjust their speeds and be more cautious of wildlife while in the LADS area, but over time return to their habitual driving speeds.

Similar effects were observed in Ontario, with promising results being observed initially but diminishing over time. The first break-beam system installed in Ontario was found to reduce animal-vehicle collisions, with no collisions reported in that area up to four years after the installation of the system in 2009 (Wood, 2013). Yet, when discussing the implementation of a new radar-based LADS in 2013, it was cited that the reason for installing the new system was to make up for the weaknesses noted with the break-beam LADS (Desjardins, 2013). Therefore it seems that, as witnessed with the Wyoming system, the break-beam LADS in Ontario became ineffective over time.

The majority of issues identified with LADS relate to false positive and false negative responses, as well as issues with maintenance and upkeep of the systems. A false positive response occurs when a LADS alarms and falsely detects another entity that is not the target animal, such as snow, rain, vegetation or another animal. When this occurs, the system's lights flash to warn motorists of a large animal's presence when it is in fact not there. A false negative response occurs when a LADS fails to detect a target animal that is within the LADS area. When this occurs, the animal that the system is meant to detect is not identified and the system fails to warn motorists of its presence.

Some LADS systems, despite numerous modifications, continue to have issues with false positive responses. For example, an area-cover system in Box, Finland suffers from false detections in the spring, when water from melting snow is mobilized by traveling vehicles and triggers the system (Huijser and McGowen, 2003). This occurs regardless of the multiple adaptations that have been made to the system to try and decrease the incidence of false positive responses. Modifications made to the Finland system include: addition of air pressure metal eaves to each sensor, addition of rain detectors to determine when rain was causing false detections, installation of additional passive infrared detectors, and modification of the vertical angle of the sensors (Huijser and McGowen, 2003). However, despite all of these updates the system still experiences false positive responses. Officials in Ontario also cited false positives as a reason that the radar-based system was better than the break-beam LADS, as the beams can easily be triggered by things other than the target animal (Ontario Ministry of Transportation, personal communication, April 16, 2012). Similarly, the system in Yellowstone National Park had been known to produce a high number of false detections before its removal in 2008 (US Department of Transportation Research and Innovative Technology Administration, 2009).

It has also been found that break-beam LADS sometimes fail to detect large animals. As stated by the Ministry of Transportation in Ontario, the break-beam systems only detect animals when they break-beams, making them incapable of tracking animals at other times or locations. That is, any animal that stays inside the beams for longer than three minutes will go undetected by this system. Thus, animals could graze on the right of way for long periods of time, or they could linger in the middle of the roadway and go undetected (Ontario Ministry of Transportation, personal communication, April 16, 2012). Likewise, an animal could run quickly through the detection system, but the warning lights would still flash for the entire three minutes (Ontario Ministry of Transportation, personal communication, April 16, 2012). This inevitably leads to periods in which the warning lights are flashing but no animals are present on or near the roadways, and/or to periods in which animals are near the roadways but the system is not alerting motorists to their presence.

The challenge posed by false positive and false negative responses seen by various LADS relates to the effect such errors have on drivers' perception of the technology. As stated by an official in the Ontario Ministry of Transportation, it is difficult to warn motorists of animals if they never get to see said animals (Desjardins, 2013). If travelers see the lights flashing on a LADS but never see an animal while driving through the system, they will begin to think the system is unreliable and start to ignore the systems warnings. Drivers will also consider the system to be unreliable if the warning lights do not flash when an animal is present. Therefore, if systems have high instances of false positive or false negative responses this could deter drivers from reducing speed and lead them to become complacent.

Another difficulty cited by jurisdictions that have had a LADS deals with the maintenance and upkeep of the systems themselves. A break-beam system in Rosvik, Sweden had issues with maintaining power to its system due to issues with the electrical supply to the system (Huijser and McGowen, 2003). Similarly, the system in Yellowstone National Park had problems with power supply as one post was not getting enough energy from its solar panel due to darkness, snow cover and shady spots (US Department of Transportation Research and Innovative Technology Administration, 2009). Other maintenance issues with the Yellowstone National Park system include batteries having to be replaced more often than anticipated, the communication system not working properly in low temperatures, and vegetation between sensors having to be removed regularly, resulting in high maintenance costs. The culmination of these problems eventually led to the removal of the Yellowstone National Park LADS in 2008 (US Department of Transportation Research and Innovative Technology Administration, 2009).

Wildlife fencing

Wildlife fencing is a prevalent mitigation technique both internationally and nationally, and has generally been found to be effective in these locations. This animal-vehicle collision mitigation measure is used in France, Germany, Slovenia and the Netherlands, with France making it mandatory for all federal highways to be fenced (Transport Canada, 2003). Areas in the United States have also availed of wildlife fencing to prevent animal-vehicle collisions and have witnessed some success with this technique. For instance, since a wildlife fence was installed on Highway 82 in Colorado the number of wildlife-vehicle collisions has dropped from approximately 175 collisions in 2009 to under 50 in 2011 (Webb, 2013). However, representatives of the Arizona Game and Fish Department have stated they have not witnessed any changes in the number of animal-vehicle collisions that occurred in the target road section before and after the implementation of wildlife fencing and wildlife crossing structures, although more animals did appear to be using the wildlife crossing structures over time (Dodd, Gagnon, & Schweinsburg, 2003).

Locations in Canada have seen a reduction in the number of animal-vehicle collisions as a result of wildlife fencing. This effect is salient in the Banff and Kootenay National Parks, where researchers have found wildlife fencing to be among some of the most cost-effective measures for mitigating animal-vehicle collisions (Huijser, 2010). In a 15-year long-term research project on mitigation initiatives in Banff, it was found that there has been a 95 per cent reduction in the number of collisions with deer, elk and moose, on the TCH (Highway Wilding, 2013). Similar results were obtained in British Columbia, where it was determined that wildlife fencing was 97 to 99 per cent effective in preventing wildlife-vehicle collisions in all fenced areas across the province, with no collisions reported in the Coquihalia Highway between Dry Gulch Bridge and Kingsvale Bridge since the implementation of this measure (British Columbia Ministry of Transportation and Highways, 2013). Wildlife fencing was also proven effective in New Brunswick, with metal fencing determined to be the most cost-effective mitigation measure in a five-year pilot project (New Brunswick Department of Transportation and Infrastructure, 2009).

Thus, it seems as though most areas have either had success with this technique and reduced the number of collisions in their area, or have not experienced any changes in the incidence of animal-vehicle collisions from this measure. It is important to consider that some areas have installed more fencing than others and as a result have fewer areas in which large animals could gain access to the roadways. For instance, Banff National Park has 166 kilometres of wildlife fencing along a single 83 kilometre stretch of the TCH, with just 1.7 kilometres between wildlife crossing structures (Huijser, 2010). This does not leave much space for large animals to cross other than at the wildlife crossing structures. Jurisdictions with shorter lengths of wildlife fencing have more gaps between fencing, and as a result have more areas in which large animals can cross the road besides underpasses or overpasses. This influences the effectiveness of wildlife fencing as it is potentially more likely that animal-vehicle collisions will occur in areas with shorter lengths of fence, as animals have more access to roadways. Therefore, fence length is an important factor in evaluating the success of such measures.

Representatives of the Department of Transportation in Colorado also note the influence that the length of fencing could have on the effectiveness of the technique. They point out that fencing longer stretches of road may be more beneficial than fencing shorter stretches, as large mammals may learn to go somewhere else to cross when longer sections are fenced, whereas they may learn to walk to the end of the fence and cross there if the fenced area is shorter (Webb, 2013). When animals cross at the fence ends it can potentially lead to an increased risk for animal-vehicle collisions at fence ends, a trend which was observed in New Brunswick at distances as great as one kilometre from the end of the fencing. Officials in New Brunswick also noted maintenance issues associated with the wildlife fence in the winter months including: gate hinges sticking, fence poles rising in the frost and snowmobile and all-terrain vehicle (ATV) operators cutting the fence to access trails (New Brunswick Department of Transportation and Infrastructure, 2013).

Thus, it is important to note that although other jurisdictions have found success with wildlife fencing, there are a number of factors to consider when judging its effectiveness. Wildlife fencing is a very site-specific measure which has high costs and associated maintenance with it. Officials need to consider the species' behaviours, including migratory and grazing behaviours, and ensure that there are alternative crossing measures in place for these animals (Transport Canada, 2003). One also needs to consider the length of fence that has been installed when comparing other jurisdictions and their successes or failures. Locations with entire highways fenced will possibly observe a significantly higher reduction in animal-vehicle collisions than those with shorter sections of fencing as there are fewer gaps where animals can access roads. This makes it difficult to compare jurisdictions as fence length varies between locations, making effectiveness ratings vary as well. Even though other jurisdictions have found this measure effective, many factors that vary from jurisdiction to jurisdiction need to be considered locally before making judgments about the feasibility of this animal-vehicle collision mitigation initiative in Newfoundland and Labrador.

Academic Literature Review

<u>Moose detection systems</u>

Through examining the literature currently available it is apparent that academics have conducted little research on the efficacy of LADS. Of the research that has been conducted, mixed results have been obtained. It is important to note that most of the studies focus on large animals other than moose, for instance deer, elk, bears, or wolves, due to the fact that these are some of the animals most frequently associated with wildlife-vehicle collisions in other jurisdictions. It should also be noted that the results of species-specific studies may not hold true for other species due to behavioural differences between animals (Huijster, Duffield, Clevenger, Ament, and McGowen, 2009). Therefore, some of the results obtained in these studies may not directly translate to the moose detection systems installed in Newfoundland and Labrador.

Mixed results were obtained in the academic studies conducted on the effectiveness of LADS as a wildlife-vehicle collision mitigation initiative. In a study by the Western Transportation Institute, nine LADS created by five different manufacturers were assessed in the Roadside Animal Detection System (RADS) test-bed in Montana where they detected horses and llamas roaming free range. On average, it was found that of all the detections, less than one per cent were false positive detections, with an average of 0.10 false positives per hour. The rate of false negative responses varied between machines, with some machines having no false negatives and others failing to detect target animals 31 per cent of the time. Thus, the proportion of animals detected by the machines ranged from 100 per cent to as low as 73 per cent (Huijser, Holland, Blank, Greenwood, McGowen, Hubbard and Wang, 2009). Of the nine systems that were evaluated, five met the requirements for reliability whereas four did not. This led researchers to conclude that more robust results would need to be obtained before launching this wildlife-vehicle collision mitigation measure on a larger scale (Huijser et al., 2009).

In another study by the Western Transportation Institute, which examined the cost-effectiveness of 13 different mitigation measures, it was determined that the effectiveness of LADS was approximately 87 per cent. Note that this figure was based on the results from previous research which was limited compared to other mitigation measures. This study also calculated threshold values by animal species and mitigation measure. Threshold values assess the minimum number of wildlife-vehicle collisions that need to be avoided so that the costs of installing a LADS equal the benefits gained from its installation. It was found that for the costs of a LADS to equal the benefits, 1.3 to 1.6 MVCs would need to be avoided. Thus, this number would need to be reached or exceeded for a LADS to be considered effective (Huijser et al., 2009).

Despite these seemingly positive results, the Western Transportation Institute has also noted multiple issues with LADS systems. During the RADS test-bed it was found that break-beam systems may generate false positives in certain types of weather (Huijser et al., 2009). High winds may cause false positive responses in break-beam systems as they may cause the sensors to sway in and out of alignment. In particular, winds that blow perpendicular to LADS could potentially cause vegetation and air pockets to trigger systems more often than winds that blow parallel to the system (Huijser et al., 2009). It was also found that excellent visibility is essential for break-beam systems, as reduced visibility due to atmospheric conditions such as fog may block or reduce the signal path of beams and lead to higher instances of false positives. Although there was little precipitation during the test period, researchers did note that high humidity also tended to increase the number of errors made by break-beam systems (Huijser et al., 2009). Gallagher also noted that high visibility levels are a necessity for break-beam systems and that these systems are only suitable when the line of site is clear (M. Gallagher, public presentation, August 30, 2011). Thus, academic research supports the finding of the jurisdictional review that a number of weather patterns can influence the efficacy of LADS.

In evaluating the effectiveness of the Marshall LADS in Minnesota, Gallagher noted several issues with the upkeep and performance of this wildlife-vehicle collision mitigation measure (M. Gallagher, public presentation, August 30, 2011). These issues include: detector mounts were unstable and led to alignment issues and increased power consumption, local weather conditions led to less solar power than anticipated, communications and control devices failed in a shorter amount of time than anticipated, and it took longer than expected to acquire replacement devices. Thus, in addition to experiencing difficulties performing in certain weather conditions, LADS tend to have technical issues associated with the equipment itself. Therefore, it should be noted that despite the fact that some academic studies have shown LADS to be effective, these results were obtained in optimal and controlled research conditions, and as such these results cannot be generalized to LADS installed in jurisdictions where the systems are in more uncontrolled and unpredictable environments.

Wildlife fencing

As seen in the jurisdictional review, mixed results have been obtained in academic research with regards to the effectiveness of wildlife fencing. Again, it is important to note that some of these studies were targeted toward other species besides moose and, due to behavioural differences between species, some of the results from these studies may not generalize to the moose fencing implemented in Newfoundland and Labrador.

In a study by Clevenger, Chruszez and Gunson (2001) it was found that collisions with moose, deer, and elk were reduced by 80 per cent post-fencing installation. In addition, wildlife-vehicle collisions were not found to be associated with gates or access points within the fence. When examining the cost-effectiveness of 13 wildlife-vehicle mitigation measures, the Western Transportation Institute also found that the threshold value of wildlife fencing for MVCs was between 0.2 to 0.3 collisions avoided, meaning that at least this number of MVCs would need to be prevented for the costs of installing wildlife fencing to equal the benefits gained from its installation and for it to be considered an effective mitigation measure (Huijser et al., 2009).

With regards to the optimal length of animal fencing, a study using hypothetical lengths of fence ranging from two kilometres to 25 kilometres suggested that the optimal fence length was approximately 10 kilometres (Ford, Clevenger, Huijser, and Dibb, 2011). This length provided a compromise between the cost-effectiveness of shorter fences and the mitigation-effectiveness of longer fences. Wildlife fencing is an expensive initiative, making it more cost-effective to have less fencing. However, allowing for fewer gaps within fencing, achieved by fencing long sections of road, results in a greater reduction in wildlife-vehicle collisions. Therefore, it is important to achieve a balance between these two concepts when installing wildlife fencing. It should be noted however, that in the same study Ford et al. (2011) stated that although longer fences were more effective, all fence lengths, irrespective of length, rarely prevents more than 50 per cent of wildlife-vehicle collisions. That is, despite being 25 kilometres in length, even the longest hypothetical fence could not capture a large portion of wildlife-vehicle collisions.

The number of collisions at the ends of fencing is also a concern noted by researchers. For example, Clevenger et al. (2001) noted that on three sections of the TCH in Banff National Park, three of four areas with high rates of wildlife-vehicle collisions were within 735 metres of fence ends. McCollister and Van Manen (2010) also noted this phenomenon, as four out of seven deer mortalities in their North Carolina study occurred at fence ends. The researchers hypothesized that this may be due to deer following the fencing away from underpasses or overpasses and then getting struck by vehicles when they cross at the fence ends. McCollister and Van Manen (2010) also found that there were more wildlife mortalities recorded inside or near fenced areas than in unfenced areas, and suggested that this could be due to the clustering of accidents at fence ends.

Another element of wildlife fencing discussed in academic literature is the importance of wildlife crossing structures. McGower and Huijser (2009) included wildlife fencing in a list of mitigation measures that have been proven successful, in particular when used in conjunction with wildlife underpasses or overpasses. Another study suggested that wildlife mortalities from wildlife-vehicle collisions were lowest near wildlife underpasses and overpasses and increased with distance from these structures (McCollister and Van Manen, 2010). Thus, if wildlife fencing is utilized as a wildlife-vehicle collision mitigation measure wildlife crossing structures are essential to its effectiveness, as they allow for wildlife to continue migrating across roadways, resulting in fewer wildlife-vehicle collisions.

In terms of fencing that does not use wildlife crossing structures, Clevenger et al. (2001) cites that research in Pennsylvania did not find any reduction in deer-vehicle collisions along an interstate highway. The Western Transportation Institute also shares this opinion of wildlife fences without wildlife crossing structures, and do not recommend implementing a fence without some type of natural or man-made crossing structure as it increases the barrier effect of roads, cutting animals off from other habitats or trapping animals within fenced corridors (Huijser et al., 2009).

Therefore, even though some academic studies have presented positive views on the effectiveness of wildlife fencing as a wildlife-vehicle collision mitigation measure, each of these studies have noted several issues with this technique and caveats that need to be considered when judging its effectiveness overall.

Speed Studies

To determine whether the moose detection systems were successful in reducing drivers' speed in pilot project areas, an analysis of speeds was conducted. Specifically, for the moose detection systems to be deemed effective, drivers' speeds would need to be lower after the implementation of the initiative than prior to their implementation, and drivers' speeds would have to be lower inside of the detection system areas compared to outside of them. With regards to the fence, these results would not be expected, as the purpose of the fence is to alter animal behaviour as opposed to driver's behaviour. In fact, in other jurisdictions it has been found that vehicle speeds actually increase in fenced areas due to the increased comfort and false sense of security felt by motorists. Therefore, it is anticipated that speeds in the fenced areas may actually be higher post-implementation of the wildlife fence than before its installation.

In order to determine whether vehicle speeds changed as a function of the pilot projects, speeds from before and after the implementation of the pilot projects, and speeds at different locations inside and outside of the pilot area, were compared. Drivers' speeds were measured at three points along the sections of road for the detection systems and fence; measurements were taken at each end of the initiatives as well as in the center of the road sections. An average of the speeds at either end of the pilot location was taken to represent "outside" speeds, whereas the center speed measurement represents "inside" speeds. Additionally, vehicle speed was measured inside of the wildlife fencing on Route 460 separately, as this road section has a different speed limit than the other sections, with a speed limit of 80 kilometres per hour as opposed to 100 kilometres per hour. All speeds were measured both before and after the installation of the pilot initiatives.

Descriptive statistics for each of the pilot projects, including the number of vehicles observed, the average speed for the target road segment, and the standard deviation, by pilot project type, location, and posted speed limit are presented in Table 2. As can be seen in Table 2, average vehicle speeds on all road segments seem to be either near or greater than the posted speed limit, with the majority of average vehicle speeds falling within approximately five kilometres per hour of the posted speed limit. The greatest difference between average vehicle speed and posted speed limit was observed near the Black Duck Siding (Route 460) fencing, with speeds being approximately eight kilometres per hour above the posted speed limit. Notably, despite all pilot project locations being in areas of high wildlife population, no average vehicle speeds were below the posted speed limit.

Location	Posted Speed Limit	# of Observations	Average Speed	Standard Deviation
Wildlife Fencing* (Gallants - All)	100 km/h	4,579	100.2	11.2
Wildlife Fencing* (Gallants - Outside)	100 km/h	2,320	102.6	9.6
Wildlife Fencing* (Gallants - Inside)	100 km/h	1,542	102.3	9.7
***Wildlife Fencing* (Black Duck Siding)**	80 km/h	717	87.9	11.4
***GFW Detection System* (All)**	100 km/h	8,507	101.0	9.4
***GFW Detection System* (Outside)**	100 km/h	5,547	100.4	9.7
***GFW Detection System* (Inside)**	100 km/h	2,960	102.0	8.8
***Salmonier Line Detection System* (All)**	100 km/h	6,546	104.9	9.5
***Salmonier Line Detection System* (Outside)**	100 km/h	4,120	104.4	9.6
***Salmonier Line Detection System* (Inside)**	100 km/h	2,426	105.7	9.3

**Note*. Wildlife Fencing (Gallants - All) , Wildlife Fencing (Gallants - Outside) and Wildlife Fencing (Gallants - Inside) excludes the 500 highway metres of fencing near Black Duck Siding, as it has a different posted speed limit (80 kilometres per hour.).

Table 2. Descriptive Statistics.

The comparison of speeds from before and after the activation of the pilot projects is presented in Table 3. It was found that there was no significant difference in speeds before (M = 102.3, SD = 9.6) and after (M = 102.7, SD = 9.6) the installation of the wildlife fencing near Gallants (p = .162). However, all other pre and post speeds were significantly different. Specifically, motorists in the Black Duck Siding wildlife fencing drove significantly faster before (M = 90.0, SD = 9.9) than after (M = 84.1, SD = 12.9) the fence was installed (p < .000). However, it should be noted that although a reduction in speed was observed, the average vehicle speed in this area was still above the posted speed limit of 80 kilometres per hour after the fence was installed.

Similarly, a statistically significant reduction in speeds was observed in the Grand Falls-Windsor (Grand Falls-Windsor) detection system area; motorists drove significantly faster before (M = 102.4, SD = 9.1) rather than after (M = 99.1, SD = 9.5) the system was in operation ($p < .000$). Thus, the Grand Falls-Windsor detection system seems to be showing the predicted trend, with an observed reduction in speed after the detection system was installed. However, speeds in the Salmonier Line detection system area had the opposite effect, with motorists driving significantly slower before (M = 104.5, SD = 9.7) than after (M = 105.7, SD = 8.9) the moose detection system was in operation ($p < .000$). Some possible explanations for this observation include that drivers gain a false sense of security when inside the detection system area, or that drivers have learned to ignore the system due to it being out of service for long periods of time (see the Analysis of Detection Systems' Days In versus Out of Service). Thus, based on the results of the speed studies, it seems as though the Grand Falls-Windsor moose detection system were successful in reducing vehicle speeds, whereas the Salmonier Line moose detection system was unsuccessful in achieving its desired outcome of reducing speeds, as speeds increased from pre-implementation to post-implementation of the detection system. In addition, no changes in vehicle speeds pre and post-implementation were observed in the wildlife fencing area, with the exception of the 500 highway metres of fencing near Route 460 which counterintuitively had a decrease in vehicle speeds after wildlife fencing was installed.

Location	Posted Speed Limit	Time	# of Observations	Average Speed	Standard Deviation	Significance (*p* value)[1]
Wildlife Fencing* (Gallants)	100 km/h	Pre	2,037	102.3	9.6	0.162
		Post	1,825	102.7	9.6	
***Wildlife Fencing* (Black Duck Siding)**	80 km/h	Pre	459	90.0	9.9	0.000*
		Post	258	84.1	12.9	
GFW Detection System	100 km/h	Pre	4,736	102.4	9.1	0.000*
		Post	3,771	99.1	9.5	
Salmonier Line Detection System	100 km/h	Pre	4,149	104.5	9.7	0.000*
		Post	2,127	105.7	8.9	

**Note*. The Wildlife Fencing (Gallants) statistic excludes the 500 highway metres of fencing near Black Duck Siding, as it has a different posted speed limit (80 kilometres per hour) than the other pilot areas (100 kilometres per hour).

Table 3. Pre vs. Post Speeds

[1] A number labeled with an * means it is a statistically significant result. The critical *p* value is set at .050

The similarity of speeds before and after fence installation is also seen when comparing speeds inside (M = 102.8, SD = 9.5) and outside (M = 102.7, SD = 9.5) the wildlife fencing; motorists maintained a steady speed throughout the fenced areas, indicating that the wildlife fencing is not associated with an increase in drivers' speeds (*p* = .847). This can be seen in Table 4.

With regards to the detection systems, speeds tended to be faster inside (M = 100.2, SD = 8.8) than outside (M = 98.6, SD = 9.8) for both the Grand Falls-Windsor detection system and the Salmonier Line detection system, where speeds inside the system (M = 106.2, SD = 9.3) exceeded those outside (M = 105.1, SD = 8.5) of it (*p* < .000). Thus, while people seem to be driving a consistent speed when entering, exiting and driving through the wildlife, they tend to increase speed after passing the warning lights and inside the detection system areas, and then slow their speed when exiting the detection system areas. Again, the observed increased speed inside the detection systems could be due to drivers developing a false sense of security when inside of the detection system areas. Drivers also could have become complacent to the moose detection systems as they were often out of service for long periods of time (see Analysis of Detection Systems' Days In versus Out of Service).

Location	Posted Speed Limit	Section	# of Observations	Average Speed	Standard Deviation	Significance (*p* value)
Wildlife Fencing (Gallants)*	100 km/h	Inside	802	102.8	9.5	0.847
		Outside	1,023	102.7	9.7	
GFW Detection System	100 km/h	Inside	1,276	100.2	8.8	0.000*
		Outside	2,495	98.6	9.8	
Salmonier Line Detection System	100 km/h	Inside	1,101	106.2	9.3	0.006*
		Outside	1,026	105.1	8.5	

**Note*. The Wildlife Fencing (Gallants) statistic excludes the 500 highway metres of fencing near Black Duck Siding, as it has a different posted speed limit (80 kilometres per hour) than the other pilot areas (100 kilometres per hour).

Table 4. Post Inside Speeds vs. Post Outside Speeds

Due to the mixed results obtained via the speed studies, it cannot be confirmed that the pilot projects were successful in changing vehicle speeds. The Salmonier Line system had the opposite effect from what would be expected, with speeds increasing after its installation, and with motorists increasing their speed when driving through the detection system. Mixed results were obtained for the Grand Falls-Windsor detection system, with it demonstrating the predicted decrease in speed after its introduction, however with motorists still driving faster through the detection system than outside of it. Similarly, the wildlife fencing did not show any differences in speeds, with the exception of the 500 highway metres of fencing on Route 460 that showed a counterintuitive decrease in speed after the fenced was installed. However, it should be noted that this section represents only a small segment of the total wildlife fencing (approximately three per cent) and has a different posted speed limit than the rest of the fence areas, so these results cannot be generalized to the entire fence.

These results suggest that the moose detection systems did not have the desired effect of reducing drivers’ speeds, and that the installation of wildlife fencing did not lead to an increase in drivers’ speeds.

Analysis of Traffic Volumes

Electronic traffic counts of eastbound and westbound travelling vehicles were conducted for each of the three pilot project areas during a 24-hour period to determine the volume of traffic travelling through the pilot project areas that are being impacted by the MVC mitigation initiatives. These counts were converted to Annual Average Daily Traffic (AADT) counts to provide an estimate of the level of traffic on these road sections on any day of the year. To do this, electronic traffic counts were adjusted to better represent different days of the week, and different months of the year. For the Route 90 Interchange near the Salmonier Line moose detection system an AADT of 18,935 was obtained. Similarly, near the Grand Falls-Windsor moose detection system data there was an AADT of 10,056. For the moose fencing an AADT of 3,384 was obtained.

Analysis of Days In vs. Days Out of Service

To examine the functionality of the two moose detection systems, the number of days the systems were in service were compared to the days that the systems were out of service. A depiction of the number of days in and out of service can be seen in Figures 3 and 4 for each of the moose detection systems. Note that the assessment period runs from the first day of implementation for each system until December 31, 2013, and that to be considered “out of service,” the detection system could have been non-functional for any period of time ranging from minutes, to hours, to full 24-hour periods.

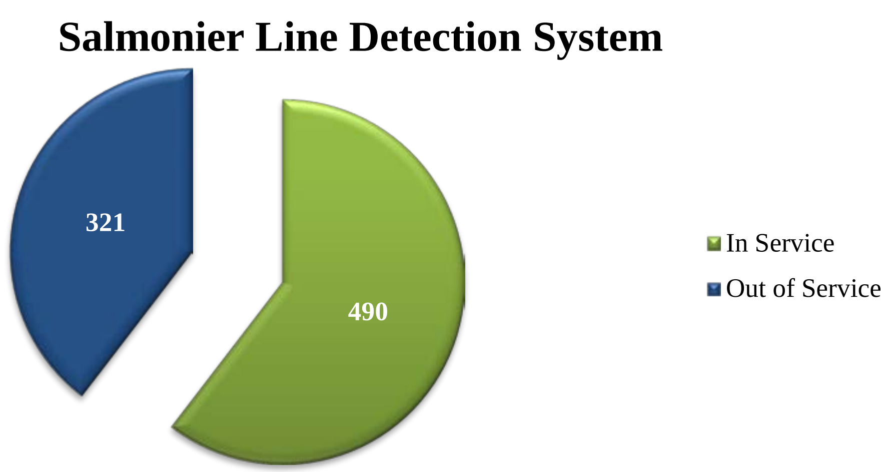

Figure 3. Number of Days the Salmonier Line Detection System was In and Out of Service.

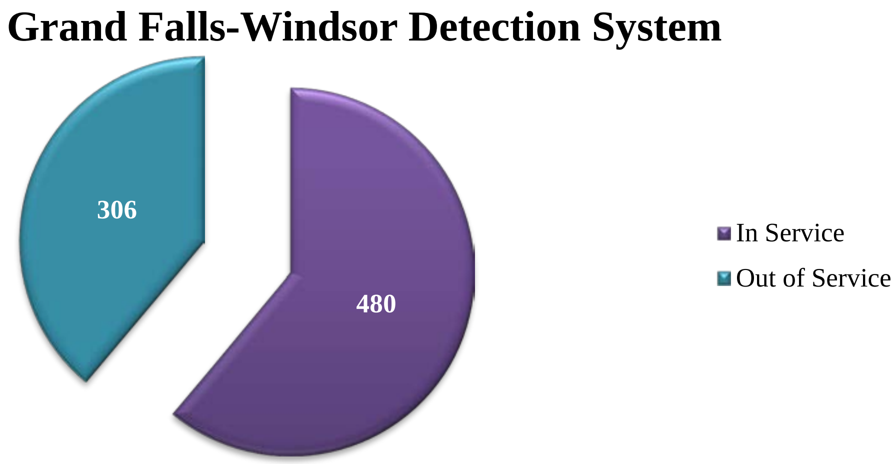

Figure 4. Number of Days the Grand Falls-Windsor Detection System was In and Out of Service.

The Salmonier Line detection system was installed on October 13, 2011. Based on the assessment period of October 13, 2011 to December 31, 2013, the system was installed for 811 days. The system was out of service during this period at some point in the day for 321 days (39.6 per cent), thus, was functional 60.4 per cent of the 811 days.

The Grand Falls-Windsor system was installed on November 7, 2011. Based on the assessment period of November 7, 2011 to December 31, 2013, the system was installed for 786 days. During this period, the system was out of service at some point during the day for 306 days (38.9 per cent), thus, was functional 61.1 per cent of the 786 days.

Reasons cited by the contractor, Safeguards of Canada Incorporated, for why the systems were out of service for these significant amounts of time relate to the climate and terrain in Newfoundland and Labrador, as well as to unforeseen damage to the systems. For instance, the systems were non-functional during periods of heavy snow, heavy rain and fog, all of which are common weather patterns in Newfoundland and Labrador. The ability to function in these conditions was a requirement of this system when the project was tendered, and the Ontario break-beam system, after which the two moose detection systems were modelled, had not reported any issues with performance in certain weather conditions at the time that the moose detection systems were installed. Similarly, long grass, which can obscure the sensors and result in false positive detections, was an issue, as highway mowing is not a component of current highway maintenance activities. This is due to the fact that although herbicide treatment prevents the regrowth of brush in treated areas for approximately 10 years, it actually promotes grass growth which is a deterrent to moose, as they do not feed on it (Shochat, Robbins, Parish, Young, Stephenson, and Tamayo, 1997). Sabotage was also a potential reason cited by the contractor for why the detection systems were out of service for significant periods, and this claim has since been referred to the Royal Canadian Mounted Police (RCMP). In addition, a vehicle caused damage to the Grand Falls-Windsor system, causing it to be out of service for an extended period of time.

Due to the fact that the results of speed studies conducted in the detection systems locations did not support the project goals, and given the evidence that both detection systems were inoperable for a significant portion of the time, it is evident that the moose detection systems were not effective in mitigating MVCs in Newfoundland and Labrador. It is apparent that this initiative was not the right technology for the province, as it had many issues functioning in weather patterns commonly experienced in Newfoundland and Labrador.

Number of MVCs

Due to the implementation of the new CDMS database in 2012, limited data is available on the number of MVCs near the pilot project areas. The data analyzed in this evaluation ranges from January 1, 2012 to March 31, 2013. From the available data, the number of accidents within each of each of the pilot project areas as well as within three kilometres of their endpoints was examined. It should be noted that the accidents in the CDMS database are only those which have been reported to local authorities. Accidents which have incurred $1,000 or more in property damage must be reported to local authorities, whereas anything less than that may go unreported. Therefore, there could potentially be other unreported accidents that could have occurred in the pilot project areas that are not included in this analysis.

Between January 1, 2012 and the installation of wildlife fencing on July 15, 2012, two MVCs occurred within the area selected for the fencing pilot project. The first accident occurred on January 7, 2012 and the second accident occurred on May 14, 2012. Both accidents occurred during the night when lighting conditions were poor. In addition, the vehicles involved in both accidents collided with a moose that was travelling across the highway. There were no injuries or fatalities associated with these accidents, with moderate vehicle damage reported in the first accident and severe vehicle damaged reported in the second. No MVCs were reported within or near the wildlife fencing post-implementation. Thus, although there was a reduction in the number of MVCs before and after the installation of the wildlife fencing, there is not sufficient data to draw causal conclusions about the effectiveness of the wildlife fencing to reduce MVCs as data was only obtained from approximately seven months prior to the installation of fencing and approximately eight months after its installation.

As both of the moose detection systems pre-date CDMS there is no data recorded in this system from before the installation of the moose detection systems. Any data prior to the installation of the moose detection systems would have been recorded in the SAS Accident System. As these databases collect different levels of details associated with accidents, the data from them are not comparable. In addition, from other analyses it has been determined that the moose detection systems were non-functional for approximately 40 per cent of the time, and thus could not reliably warn motorists of moose on the highways. As such, the moose detection systems cannot be expected to reduce the number of MVCs in their respective areas. However, for informational purposes, a description of the accidents that did occur in the moose detection system areas, post-implementation, is provided.

Between January 1, 2012 and March 31, 2013, no MVCs were reported inside of the Grand Falls-Windsor moose detection system area. However, two MVCs were reported outside of the detection system area. The first accident, which was reported on April 6, 2012, occurred 0.5

kilometres west of the moose detection system in the late evening when lighting conditions were poor, and on a day in which the moose detection system had been down for some period of time. The vehicle involved in the accident had collided with a moose that was travelling across the highway and did sustain moderate damage. Two injuries were also associated with this accident, however no fatalities were reported. The other accident occurred on May 1, 2012, 2.5 kilometres east of the detection system during late evening when lighting conditions were poor. Similarly, the vehicle involved in this accident collided with a moose that was moving across the highway and the vehicle sustained moderate damage. There were no injuries or fatalities associated with this accident and the detection system was functional.

Between January 1, 2012 and March 31, 2013, no MVCs were reported inside of the Salmonier Line moose detection system area. However, similar to the Grand Falls-Windsor detection system, two accidents were also reported within three kilometres outside of the pilot project area. The first accident occurred on March 6, 2012, 1.5 kilometres east of the Salmonier Line detection system. The accident occurred in the evening in poor lighting conditions. In contrast, the second accident occurred on June 19, 2013, 0.5 kilometres west of the pilot project area in the evening while there was still good lighting conditions. In the case of both accidents, the vehicles involved collided with a moose while it was travelling across the highway. Moderate vehicle damage was associated with both accidents, while no injuries or fatalities were reported. On both of these days the Salmonier Line moose detection system was functional.

As there is no pre-implementation data available for either of the detection systems, no causal conclusions can be drawn as to whether there was a reduction in the number of MVCs in each of the moose detection system areas. Despite the installation of these systems, MVCs did still occur within three kilometres of the pilot project areas after they had been implemented. However, as it was determined that the systems were non-functional for significant periods of time, they were unable to consistently warn motorists of the presence of moose on or near highways. Thus, it is plausible that MVCs could potentially occur within or near the pilot project areas.

Financial Analysis

The total cost of installing the two moose detection systems was $1.5 million. Any repairs or maintenance completed on the detection systems since their implementation was by the contractor, Safeguards of Canada Incorporated. Thus, any repairs to the moose detection systems to date have been of no cost to Government.

The installation of the wildlife fencing cost a total of approximately $2 million. Repairs were made to the fence following a vehicle collision with the fence at a total cost of approximately $1,700. Other minor maintenance has been done to the fence to remove a fallen tree and to close access gates that were left open by pedestrians.

If the wildlife fence was to be maintained, it is expected that approximately 25 per cent of the fence will need to be replaced each year. Adjusting for two per cent inflation per year, this maintenance would cost approximately $490,000 to $510,000 per year. Although not recommended based on the results of the present evaluation, if wildlife fencing was expanded to other areas of the province, installing additional fencing would cost approximately $50,000 per kilometre of fence. Although there was a natural wildlife passing system at the Trout River Culvert for the pilot fencing, if this initiative was continued elsewhere wildlife crossing structures in the form of underpasses or overpasses would also need to be built. The cost of these structures can range from $800,000 to $3 million each.

To date, the pilot projects have been of insignificant extra cost to Government outside of what was first spent to install the wildlife fencing and two moose detection systems, however consideration needs to be given to the ongoing maintenance of the wildlife fencing and detection systems, especially since it has been shown that the moose detection systems were unsuccessful overall in achieving their desired outcome of reducing drivers' speeds, and it cannot be definitively concluded that either of the pilot mitigation initiatives resulted a reduction in the number of MVCs in their respective areas.

Challenges

As mentioned above, there are several issues related to the moose detection systems which make them an ineffective mitigation technique in Newfoundland and Labrador. The system could not function consistently during snow, rain and fog conditions. Fog and precipitation are common weather patterns throughout all seasons in Newfoundland and Labrador, and a successful MVC mitigation technique would need to operate effectively in such a climate. Similarly, vegetation growth can obscure the sensors for the infrared beams and cause them to make a false detection. Although the brush is cut on the highways and major trunk roads in Newfoundland and Labrador, as well as treated with herbicide, this does not completely prevent vegetation growth in the interim. These challenges were noted by other jurisdictions however, some challenges noted by systems in other jurisdictions were not an issue with either the Salmonier Line or Grand Falls-Windsor detection systems, such as maintaining power.

The weather and vegetation growth also poses a problem for the wildlife fencing. Snow buildup can provide a step to assist moose in jumping the fence and becoming trapped in the corridor. Although this has not happened yet to date in Newfoundland and Labrador, snow has caused damage to the wildlife fence since its installation. Additionally, a moose damaged the fence after becoming trapped inside. This leads to another issue with the fencing - the possibility that access gates may be left open by pedestrians and allow moose to access the roadways. Moose could then attempt to knock down the fence to try and get out of the fenced corridor, leading to potential damages to the fence. Although this has not been an issue with the existing fence as a natural wildlife crossing exists at the Trout River Culvert, if fencing was to be extended to other areas of the province there would be a need for wildlife underpasses or overpasses to be constructed, which would cost an additional $800,000 to $3 million per structure. Without such passing mechanisms to avoid this issue occurring elsewhere, wildlife populations would become isolated from their habitats as their natural migration is disrupted, or moose would learn to cross at fence ends, potentially leading to an increased number of collisions at the end of the fences, which would not support the goals of the fencing, to reduce the number and severity of MVCs in Newfoundland and Labrador.

Conclusions and Recommendations

Moose detection systems

From the results of the present evaluation it is apparent that the break-beam infrared moose detection systems are not an appropriate MVC mitigation measure for Newfoundland and Labrador's climate and terrain. Mixed results were obtained from other jurisdictions that had used the technology, as well as in academic research. Despite positive results being observed in some instances, most studies found issues with the wildlife-vehicle collision mitigation measure in terms of reliability of performance in certain weather patterns and maintenance of the system itself.

Mixed results were also obtained in the speed study analyses undertaken in the pilot project areas. Although the moose detection system near Grand Falls-Windsor demonstrated a decline in speed from pre-implementation to post-implementation of the system, the opposite effect was observed with the Salmonier Line moose detection system, with speeds increasing from pre-implementation to post-implementation. Therefore, the desired decrease in vehicle speeds was not consistently observed by the two moose detection systems. In addition, the results of the speed study analysis demonstrated that motorists were driving faster inside both of the moose detection system areas than outside of them. This increase in speeds could potentially augment the incidence and severity of MVCs at the end of the detection systems, which would be an unintended negative outcome of this mitigation strategy.

Further analyses of the systems' performance also demonstrated that both systems were non-functional approximately 40 per cent of the time. As the systems were out of service for a significant portion of time since their installation, they could not consistently warn drivers of the presence of moose on the TCH. As such, two accidents, including one in which injuries were sustained, and which occurred on a day the system was non-functional, were reported just outside of the Grand-Falls Windsor detection system, and two accidents were reported just outside of the Salmonier Line detection system. The culmination of these negative results warrants the conclusion that the break-beam moose detection systems were largely ineffective in Newfoundland and Labrador.

Given the results of the evaluation of the moose detection systems, it is recommended that the pilot project initiative not be expanded to other areas of the province. Furthermore, due to their ineffectiveness, the removal of the existing systems should be considered.

Wildlife fencing

The mixed results found in the present evaluation of the moose fencing pilot initiative demonstrate that wildlife fencing could potentially be effective in mitigating MVCs as it provides a barrier to moose, but several factors have an influence on its effectiveness. In reviewing other jurisdictions and academic research, most seem to find fencing an effective mitigation tool. However, a number of caveats need to be considered when examining these results and attempting to generalize them to Newfoundland and Labrador, such as the length of the wildlife fencing, the target species for the fence, and the expenses associated with fencing.

Research has also shown an increase in the number of accidents clustered near fence ends. Thus, although moose fencing provides a barrier to moose, there are a number of factors that call into question the true effectiveness of this MVC mitigation measure.

The moose fencing did not have the predicted outcomes of increased speeds post-implementation of the fencing in the speed study analyses. There was no difference between vehicle speeds pre-implementation and post-implementation of the moose fencing, with the exception of the 500 highway metres on Route 460 (which has a lower speed limit than the TCH) where motorists counterintuitively drove slower after the fence was installed. Similarly, there was no significant difference between vehicle speeds inside and outside of the moose fencing. Thus, the installation of wildlife fencing did not lead to any increases in vehicle speeds as was seen in other jurisdictions.

In terms of MVCs, it was found that although a reduction in the number of MVCs reported prior to and after the installation of the wildlife fencing was observed, no direct relationship can be inferred due to the low number of accidents that occurred in the pilot project areas during the identified time range and the limited data available. As a new accident management system was implemented in 2012, coinciding with the installation of the wildlife fencing, only seven months of pre-implementation data and eight months of post-implementation data are available, despite the fact that the fence has been operational for approximately 19 months. More data, including the monitoring of potential confounds or artifacts which could construe the success of this MVC mitigation initiative would need to be collected before it could be definitively concluded that wildlife fencing was effective at reducing the number of MVCs in the pilot project area.

It is therefore recommended that the above factors be considered and data collection and performance monitoring be continued before concluding that this MVC mitigation measure is effective in reducing the number of MVCs in Newfoundland and Labrador.

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