Wildlife Accident Reporting: A fundamental element in B.C.'s mitigation efforts

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ABSTRACT

Wildlife-related motor vehicle accidents are becoming an increasingly significant environmental and public relations problem for transportation agencies. Nationally, growing public expectations for motorist safety and the protection of endangered species, as well as the increasing political influence of wildlife advocacy organizations, are forcing transportation officials to address the wildlife accident situation.

Without fundamental, long-term information on wildlife accident types, locations and trends, transportation officials can not avoid the risk of marginal, ad hoc decisions regarding accident mitigation efforts. At present, only British Columbia has a comprehensive, province-wide system for reporting and analyzing highway-related wildlife accidents.

Since 1978, the British Columbia Ministry of Transportation (BCMoT) has used its Wildlife Accident Reporting System (WARS) to systematically record the location, number and type of wildlife accidents reported by its Maintenance Contractors. The WARS database contains long-term wildlife-related accident records that cannot be assembled or extrapolated from any other information sources.

With the WARS system, BCMoT has the unique ability to comprehensively:

1. identify wildlife accident-prone locations and wildlife accident trends;
2. focus wildlife accident mitigation efforts;
3. evaluate the effectiveness of wildlife accident mitigation techniques;
4. provide wildlife data for highway planning purposes;
5. model and forecast wildlife accidents; and
6. establish policies and strategies for wildlife accident issues.

To meet conventional operational Ministry needs, WARS data is used to rationalize the placement of wildlife warning signs and wildlife exclusion fencing as well as determine the effectiveness of wildlife warning reflector installations. As part of the BCMoT's continuing efforts to foster new wildlife accident mitigation techniques, WARS data is being used to identify suitable locations for highway tests of an infrared camera detection system currently under development by the Insurance Corporation of British Columbia.

Both motorists and wildlife have benefited greatly from BCMoT's systematic approach to collecting and analyzing wildlife accident data on a province-wide basis. Given its ease of implementation and administration, and low cost, the WARS system provides a framework suitable for wildlife accident data collection and accident mitigation analysis by other transportation agencies.

1. INTRODUCTION

The British Columbia Ministry of Transportation and Highways (BCMoT) administers the Wildlife Accident Reporting System (WARS), a database designed to collect and analyze information on wildlife killed on provincial highways. Over 70,000 wild animal accidents have been recorded in the WARS database since 1978. More than 90% of the accidents involve large ungulates, primarily deer, elk and moose.

In 2002, 4,889 wildlife-related accidents were reported in British Columbia. After weather, wildlife rates as the next highest environmental contributing factor for police-attended accidents. In 2002, it is estimated wildlife accidents cost British Columbia over $26 million in motor vehicle accident claims and approximately $600,000 in highway accident clean-up costs. It is estimated these accidents also cost British Columbia over $300,000 in lost provincial hunting license revenues; and over $30 million in lost value to residents and non-residents who view or hunt wildlife.

Between 1997 and 2002, the Insurance Corporation of British Columbia (ICBC), the Provincial Crown corporation insuring all motor vehicles in British Columbia, spent approximately $118 million on wildlife-related motor vehicle accident claims (2). Between 1991 and 2002, it is estimated BCMoT Maintenance Contractors spent over $6 million on wildlife-related accident clean-up and carcass disposal. From 1987 to 2001, on average, approximately 2.5 people were reported killed annually in wildlife-related collisions in British Columbia.

As part of its commitment to protect the safety of the motoring public; stem the rising societal cost of human fatalities and injuries, motor vehicle damage, and highway maintenance; and reduce the loss of wildlife on provincial highways, BCMoT uses the WARS system to:

1. identify wildlife accident-prone locations and wildlife accident trends;
2. direct wildlife accident mitigation efforts;
3. evaluate the effectiveness of wildlife accident mitigation techniques;
4. provide wildlife data for highway planning purposes;
5. model and forecast wildlife accidents; and
6. establish policies and strategies for wildlife accident issues.

Since the mid-1980's, BCMoT has used WARS data to direct its investments in wildlife accident mitigation, primarily exclusion fencing and reflectors. BCMoT is using WARS data to assess the performance of accident mitigation efforts. Research is in progress to determine how effective wildlife accident mitigation efforts are at influencing ungulate roadside behavior and reducing ungulate-related motor vehicle accidents; and which designs and installation configurations may be best suited for highway applications.

2. WILDLIFE ACCIDENT REPORTING SYSTEM (WARS) OVERVIEW

a) Software and Hardware

The WARS system was designed to be used on an IBM-compatible PC platform. The system has been upgraded over time and currently uses Microsoft Access as the operating platform. The WARS system has a custom designed user interface which allows data to be entered directly into the database and information to be extracted using a range of database query functions. WARS is a relatively flexible system designed to meet a broad range of requirements, from producing site specific reports over a few hundred metres of highway to creating general reports for BCMoT Districts and Regions, as well as the entire province.

b) Data Collection and Assembly

Wildlife accidents are recorded by Ministry Maintenance Contractors located throughout British Columbia. Data regarding wildlife-vehicle accidents, such as species, location, date, etc., are recorded on the WARS H0107 accident forms (Figure 1). The completed H0107 forms are sent to BCMoT District Offices where they are screened, and then forwarded to BCMoT Headquarters for entry into the WARS database. Presently, WARS forms are not completed for highways maintained by the Federal Government or the Yukon Government under agreements with the British Columbia Government.

c) Assumptions and Constraints

BCMoT estimates the number of wild animals recorded by the WARS system represents only about 25% to 35% of the actual number of wild animals killed. The low number of reports can be attributed to a number of factors, including the species involved. In high traffic areas, the remains of small animals, like rabbits, badgers and raccoons, often become unrecognizable after being run over by a large number of vehicles. Other animals, primarily deer and moose, are removed from the roadside by passing motorists before they are recorded by BCMoT Maintenance Contractors.

Data is believed to be lost due to the following factors:

1. animals die outside the highway right-of-way and are not found;
2. animal remains are removed by natural predators or scavengers;
3. animal remains are obscured by snow, ice, vegetation, or roadside debris;
4. animal species or accident locations are incorrectly identified; and
5. random and systematic errors and omissions in reporting and data processing.

d) Data Quality

The quality of the data contained in the WARS system is very dependent on the reporting diligence of the Ministry's Maintenance Contractors. Since wildlife accidents

tend to occur at very untimely hours, under less than ideal weather conditions, comprehensive reporting at the accident scene is difficult, if not impossible, at times.

Accurate reporting of wildlife accident locations is essential for effectively identifying and evaluating accident patterns. Given the limited amount of training provided for reporting wildlife accidents, accurate differentiation between various species of bears, deer, elk and sheep has been sporadic. Correct species identification is completely dependent on those completing the WARS H0107 accident forms. Consequently, some species are misreported, based on species and normal range.

While reporting has been relatively good in areas where wildlife accident awareness and interest by the Ministry's Maintenance Contractors is greatest, the accuracy of accident locations in some reports has been problematic. In 1999, new WARS H0107 forms were developed, in conjunction with the Ministry's Maintenance Contractors, to address the issue of data completeness and accuracy. In 2000, of the 4,768 report forms received for the year, 20% lacked valid segment numbers, and 31% lacked valid kilometre references (5). These reports did not contain enough information to determine the valid segment numbers and km references. This was a dramatic improvement over 1995, when 28% lacked valid segment numbers and 44% lacked valid km references. To date, the data provided on the new WARS H0107 forms is increasingly more complete and accurate.

e) Wildlife Accident Location Reporting

In British Columbia a number of different highway locating reference systems are used. Some confusion exists between the use of the Road Features Inventory (RFI) and the Landmark Kilometre Inventory (LKI) systems for identifying wildlife accident locations. Ministry Contractors largely use the RFI system for locating highway features and structures such as bridges, signs, etc. The WARS system uses the LKI system for locating wildlife accidents. Wildlife accidents reported with RFI references are often converted to LKI references by Ministry Maintenance Contractors staff or Ministry staff. Errors can occur during data conversion.

It is anticipated the problems associated with wildlife accident location reporting will diminish dramatically when the Ministry implements a new referencing system, currently under development and nearing completion.

f) Improving Wildlife Accident Reporting

While the WARS database is an invaluable resource for wildlife accident research and mitigation, the quality of the data and its usefulness for BCMoT and wildlife researchers could be improved. Wildlife accident location could be improved by having those who complete the WARS H0107 reporting forms provide GPS coordinates for each accident reported. GPS coordinates would help ensure more consistent and accurate reporting of accident locations. GPS coordinates would also make transferring the WARS data

into a GIS system for mapping and analysis purposes considerably easier and more precise.

While, the WARS system was primarily designed to provide BCMoT with general information about the types of wild animals killed on Provincial highways and the locations of the accidents, WARS is increasing becoming a valuable tool for wildlife researchers. The value of the WARS data could be significantly improved for wildlife research by increasing the detail regarding species identification. If those who complete the WARS H0107 reporting forms were better able to distinguish between the various species, WARS data could be used for more advanced wildlife management. In particular, if detailed information about rare or endangered species, such as badgers, and bighorn sheep could be collected and provided to wildlife researchers, it is possible the chances of survival of such wild animals could be improved.

Both improvements would require increased training for BCMoT Maintenance Contractors and increased the demands on their time. GPS devices and training required to use them would have to be provided to the crews responsible for attending wildlife accidents. The collection of more specific species identification details would require training by wildlife biologists.

3. WILDLIFE SPECIES ACCIDENT SUMMARIES

In order to understand the wildlife accident problem and develop effective mitigation strategies, it is essential to establish the magnitude and temporal characteristics of the problem.

In 2002, over 77% of the wildlife-vehicle accidents recorded on British Columbia numbered highways involved deer. Of the remaining reported accidents; moose were involved in over 7%, elk were involved in over 3%, and all other wild animals, ranging from badgers to wolves, made up the remaining 12%. These accident trends appear to have remained relatively consistent over the last twelve years (Table 1). When the accident patterns for ungulates, specifically deer, moose, elk and sheep are examined, it is apparent the monthly accident distributions vary by species (Table 2).

When deer accidents are evaluated by season and sex, female deer are involved in most accidents, occurring between March and May, and occurring between October and November. The majority of bucks are killed between May and July and in November.

The fall peak for both does and bucks appears most likely related to the rutting season. When deer accidents are evaluated by age, adult deer are involved in most accidents. Young deer are mostly killed between May and November. This may be related to natural reproduction and cohort survival rates, and the fact adult deer vastly outnumber young deer at all times.

The majority of moose are killed between October and March. This coincides with times of high snowfall when moose are often found alongside highways actively cleared of snow. An accident peak is also observed in June, this may be due to pregnant cows moving to calving grounds in the early summer or licking salt on or along the highway.

The pattern for elk-related motor vehicle accidents is less established because fewer numbers of elk are reported. However a small peak in elk-related accidents occurs between October and March. Elk appear to be influenced by the same snow conditions which affect moose.

Sheep accidents exhibit peaks in February, June and September, with the largest peak occurring in February. In late winter, as snow levels at higher elevations increase, sheep migrate to valley bottoms where highways are typically located. In early summer, sheep begin moving out of the valleys, feeding near highways, on their way to higher elevations for lambing. In late summer, they begin moving back in preparation for the rutting season, which usually occurs in October or November.

4. WILDLIFE VEHICLE ACCIDENT MITIGATION METHODS

Methods utilized by BCMoT to reduce wildlife vehicle accidents are pursued with multi-faceted objectives. The Ministry strives to reduce, and ultimately eliminate human and wildlife deaths and injuries, and motor vehicle and property damage; as well as increase public awareness and ensure mitigation techniques are cost effective. The mitigation methods currently used by BCMoT include:

a) Habitat Modification
b) Warning Signs
c) Reflectors
d) Wildlife Exclusion Systems
e) Integrated Wildlife Management

a) Habitat Modification

The habitat of rural and semi-rural highways and rights-of-way is intrinsically attractive to wildlife. Given the topography in British Columbia, highways are often located in areas where wildlife naturally congregate, especially during winter, such as valley bottoms and riversides. Also many ungulates, in particular deer, prefer to travel along open areas close to cover, which represents the typical highway and right-of-way situation.

Traditionally, the Ministry used a variety of agricultural type seed blends to reseed right-of-way areas, after road construction, to prevent soil erosion. Although effective for their intended purpose, some seed blends, particularly those containing legumes such as clovers and alfalfa, appear to attract animals to the roadside.

In order to deter this, the Ministry has been adjusting its seed mixes in problem areas to remove the plant types which are known to attract animals. The Ministry is also examining the potential of non-toxic, biodegradable systemic fertilizers and repellents which make roadside plants taste and smell less desirable to ungulates.

Currently, BCMoT is working closely with ICBC on a vegetation-related moose accident reduction project near Prince George. The Ministry is reviewing the potential of timed brushing and mowing in an effort to reduce the attractiveness of roadside vegetation for moose foraging.

b) Warning Signs

Wildlife warning signs are the Ministry's most commonly used wildlife-vehicle accident mitigation measure because they are the least expensive and easiest to install and maintain (Figure 2). Standard sized signs (75 cm x 75 cm) cost approximately $150 while oversized signs (244 cm x 122 cm) cost approximately $550.

The Ministry understands wildlife warning signs have the potential to lose their effectiveness over time if motorists do not perceive a hazard. To ensure its signage is as effective as possible, the Ministry's Traffic Engineering Section continually evaluates warning sign designs developed by transportation agencies in other jurisdictions.

To increase the long-term effectiveness of its wildlife warning signs and motorist awareness of wildlife hazards, the Ministry recently developed a high level warning sign to indicate when a wildlife hazard is imminent or when the historic wildlife collision rate is extreme. These signs are particularly useful for addressing short-term and seasonal use for migration events, and other unique wildlife activities, such as salt licking on roads by mountain sheep.

The Ministry is currently examining the potential use of WARS data for establishing seasonal, species-specific warning messages on its changeable message signs located throughout the Province (Figure 3).

c) Reflectors

The Ministry has been installing wildlife warning reflectors since the late 1980's as part of its continued effort to reduce wildlife-related accidents. The reflectors are prisms mounted on posts and installed along the sides of the highway as a means of deterring animals from entering the highway when vehicles are present. At night, as the headlights of an approaching vehicle strike the reflectors they reflect beams of light at ninety-degree angles to the roadway. The concept behind reflectors is that reflected light apparently catches the attention of animals and distracts them long enough to delay their movement onto the road until the vehicle has passed (Figure 4).

Reflectors cost approximately $10,000/km to install along both sides of a highway. Maintenance costs range in the order of $500 to $1,000 annually. Reflectors require

regular cleaning and alignment. In British Columbia, reflectors have been the targets of theft and vandalism. Locating reflectors in suitable locations along highways is essential to avoid creating new problems for regular highway maintenance.

To date, reflectors have been installed at over 95 locations throughout the Province. The reflectors have been installed on either one side or both sides on over 160 km of highway. Reflectors have been extensively used in the Interior of British Columbia along highways prone to high numbers of deer-related accidents.

d) Wildlife Exclusion Systems

The greatest investment in wildlife accident mitigation by BCMoT has been its wildlife exclusion fencing. Approximately 470 km of fencing have been installed on the Coquihalla Highway (Highway 5), the Okanagan Connector Freeway, Highway 97 and the Vancouver Island Highway Project. The fencing is typically installed as a part of new highway construction or on existing highways where problematic wildlife accident locations have been identified.

Fencing can be installed as a primary deterrent or with crossing structures such as overpasses, underpasses and one way gates. This type of mitigation is expensive. It can cost between $40,000 to $80,000 per km to fence both sides of a highway. Construction costs vary greatly due to differences in terrain and locations.

As part of its growing commitment to increase protection for other species of wildlife, BCMoT installed amphibian exclusion fencing as part of the wildlife exclusion fencing construction at select locations on the Vancouver Island Highway Project.

e) Integrated Wildlife Management

It is becoming evident that approaching the issue of wild accident mitigation from a single species perspective does not provide the maximum benefit for motorists or wildlife. In British Columbia, integrated wildlife accident management is becoming a greater component of new construction and rehabilitation projects. While, for over 20 years, BCMoT projects have focused on the accident issues associated with larger ungulates, primarily deer, elk and moose, new projects are increasingly becoming more responsive to the needs of smaller mammals and amphibians.

Wildlife exclusion systems are being designed and integrated with larger scale structures and alignment drainage schemes to provide protect an increasing number of animal species. The construction of larger underpasses, such as bridges and culverts, and the retention of natural watercourses, vegetation and landforms under these structures, increases their effectiveness for wildlife and fish passage. High quality wildlife habitat ponds are developed along highway alignments to lessen the impact of highways on wildlife habitat.

Most recently, on the Vancouver Island Highway Project, wildlife crossing structures and wildlife habitat ponds were carefully integrated with natural topography and drainage systems, to reduce the potential for wildlife-related motor vehicle accidents and limit the wildlife habitat fragmenting effects of highways.

5. DESIGNING WILDLIFE ACCIDENT MITIGATION APPLICATIONS

BCMoT uses WARS data to design wildlife accident mitigation applications based on recorded accident data. The development of seasonal, species-specific warning signs for mountain sheep resulted from the use of WARS data to justify both the locations of the signs and the periods when the signs would be made visible to the motoring public. This enabled the Ministry to target the signs when they would be most effective and most timely. Recently, WARS data was used to support the construction of wildlife exclusion fencing on Highway 97 between Bentley Road and Deep Creek for deer and near Vaseux Lake for sheep.

Whenever new technology suitable for reducing wildlife accidents becomes available, WARS data is used to support decisions for locating the technology for test purposes. BCMoT has been working closely with ICBC identifying locations suitable for an infrared camera detection system being developed to detect wildlife on highway to warn motorists. WARS data has enabled BCMoT and ICBC to identify problematic accident locations based on animal species to ensure the infrared camera detection system can be tested in an environment where specific types of wildlife accidents are known to occur over a long period of time.

BCMoT is providing WARS data to ICBC for the vegetation-related moose accident reduction project ICBC is sponsoring near Prince George. The data is being used to identify problematic moose accident locations in order to focus the project's vegetation management activities.

6. EVALUATING WILDLIFE ACCIDENT MITIGATION METHODS

The highway environment in British Columbia is a very complex and varied one, ranging from multi-lane freeways located in urban centres to two-lane highways transecting the undeveloped hinterland. British Columbia has a diverse number of wild animal species, ranging from ubiquitous deer to elusive wolves, each with their own highway interaction characteristics. There are many related and unrelated, man-made and natural factors which may influence drivers and wildlife interactions, and affect highway conditions. Some of the factors identified, many difficult to measure and evaluate, are listed in Table 3 (5). ICBC has found approximately 45% of the animal collisions which occur in the Southern Interior of British Columbia occur between 7:00 p.m. and 12:00 p.m. (2). Preliminary investigation has shown there appears to be a relationship between snow depths and deer accidents (Figure 5). With any system of evaluating a wildlife accident mitigation initiative, it is important to ensure potential factors influencing the occurrence of wildlife accidents are taken into consideration.

a) Reflectors

The success of wildlife warning reflectors for reducing wildlife accidents has been the subject of much discussion and speculation. Research by BCMoT and other transportation agencies continue to provide inconsistent evaluations of the devices.

Most BCMoT installations are less than 2 km long, with 17% being 0.5 km or less in length. Given the relatively short distances of the majority of the reflector installations, the relatively low number of wildlife accidents recorded before and after the reflectors were installed, and the lack of measurable controls, determining if the reflectors produce statistically significant reductions in the numbers of deer-related motor vehicle accidents is very difficult. Short installations make evaluation difficult because it is easier for wild animals to travel to the end of the reflectors and cross the highway. Short installations also make the accuracy of reporting accident locations difficult because the remains of wild animals may be found outside the reflectorized areas, thereby undermining any measurement of reflector effectiveness.

The "before and after" method typically used to evaluate reflectors does not give a true picture of effectiveness because there is no control of those factors which can change during the course of the evaluation period, such as weather, traffic flow, and deer population densities (1). However, even if accidents are reduced following the implementation of a safety project, it does not necessarily follow that the decrease was caused by the project (3).

Reflector Case Studies

Highway 3, located near the Canada/US border in British Columbia, north of the U.S. states of Washington, Idaho, and Montana, has one of the worst records for ungulate related motor vehicle accidents in British Columbia. In an attempt to reduce the number of deer related motor vehicle accidents, BCMoT installed wildlife warning reflectors on a 9.37 km section of Highway 3 (LKI Segment 1325), east of Grand Forks, and on a 7.45 km section of Highway 3 (LKI Segment 1375), east of Creston. The installations were completed in March 1995. These are the longest continuous reflector installations in British Columbia.

i) Highway 3 (Segment 1325)

When comparing the deer accident rate for the 9.37 km reflectorized section of the highway with the deer accident rate for immediately adjacent 9.37 km non-reflectorized sections of the highway, it appears the installation of reflectors did not alter the overall local accident trends (Figure 6).

ii) Highway 3 (Segment 1375*)*

When comparing the deer accident rate for the 7.45 km reflectorized section of the highway with the deer accident rate for immediately adjacent 7.45 km non-

reflectorized sections of the highway, it appears the installation of reflectors did not alter the overall local accident trends (Figure 7).

Although these trends were not observed as part of a controlled scientific experiment, they raise questions about the effectiveness of wildlife warning reflectors. When comparing the deer accident rates before and after a reflector installation, there appears to be no consistent accident rate drop after the reflector installation that can be specifically attributed to the reflectors.

In 1999, BCMoT and ICBC initiated a controlled study to determine the effectiveness of wildlife warning reflectors on a 3.4 km stretch of Highway 5 between Clearwater and Vavenby, in central British Columbia. It is anticipated data will be collected for at least 5 years before any conclusive results can be expected.

Given the low amount of light reflected by these reflectors, any dust or other material generated by traffic or nature deposited on a reflector has the potential to significantly reduce the reflector's effectiveness for reflecting light (6). In winter, deer related motor vehicle accidents appear to be closely correlated with snow falls, a time when maintaining wildlife reflectors is very difficult (Figure 8). Reflectors with higher light reflection intensities may be more effective for reducing wildlife accidents. Low light intensity was considered a factor in the reduction in effectiveness of WEGU wildlife warning reflectors (7).

Historically, BCMoT has used red-coloured reflectors for its installations. Questions have arisen suggesting that red may not be the most effective colour for reflectors if they are used for ungulates, such as deer, which may not see the colour red well (4,8).

b) Wildlife Exclusion Fencing

Exclusion fencing has been found to be the most effective means of keeping wildlife off highway rights-of-way when installed in conjunction with wildlife crossing structures. The Ministry's experience with 2.4 m high fencing on both sides of rights-of-way shows it is 97-99% effective in preventing wildlife-vehicle accidents.

BCMoT has also found wildlife exclusion fencing appears to be effective when installed on only one side of a highway, if the unfenced side of the highway has pre-existing barriers to animal movement, such as a cliff face. On Highway 97, between Bentley Road and Deep Creek Bridge, fencing was installed on the west side of the highway right-of-way. On the east side of the highway right-of-way there is a steep cliff dropping down to Okanagan Lake. It is anticipated the wildlife exclusion fence on the west side of the highway will prevent a repeat of earlier recorded accident peaks (Figure 9).

It should be noted, regular maintenance and monitoring are key factors to ensuring wildlife exclusion fencing remain effective. During fence audits, BCMoT has found that the integrity of fencing can be compromised by poor fence designs, faulty construction

and materials, snow accumulation and tree falls, as well as poachers and ATV riders seeking passage through the fence.

7. SUMMARY

Both motorists and wildlife have benefited greatly from BCMoT's systematic approach to collecting and analyzing wildlife accident data on a province-wide basis. Given its ease of implementation and administration, and low cost, the WARS system provides a framework suitable for wildlife accident data collection and accident mitigation analysis by other transportation agencies.

8. REFERENCES

(1) Damas and Smith Ltd., 1983, Wildlife Mortality in Transportation Corridors in Canada's National Parks, Impact and Mitigation, Volume 1, Main Report, Submitted to Parks Canada, Ottawa, Ontario, Canada

(2) Gilfillan, G., 2003, Personal Communication, Project Manager, Winter Road Research and Development, Insurance Corporation of British Columbia, B.C., Canada

(3) Griffin, L., 1997, A Preface to a Discussion of Six Procedures for Evaluating Highway Safety Projects, Report No. FHWA-RD-08-033, Federal Highway Administration, Washington, D.C.

(4) Jacob, G.H., J.F. Deegan II, J. Neitz, B.P. Murphy, K.V. Miller, and R.L Marchinton, 1994, Electrophysiological measurements of spectral mechanisms in the retinas of two cervids: white-tailed deer (Odocoileus virginianus) and fallow deer (Dama dama), Journal of Comparative Physiology A, 174: 551-557.

(5) Sielecki, L., 2001, WARS 2000 Wildlife Accident Reporting System (2000 Annual Report), British Columbia of Transportation, ISBN 1203-5521.

(6) Sivic, A. and L. Sielecki, 2001, Wildlife Warning Reflectors Spectrometric Evaluation, British Columbia Ministry of Transportation and Highways, Engineering Branch, Environmental Management Section, B.C., Canada

(7) Ujvari, M., H.J. Gaagoe, and A.D. Madsen, 1998, Effectiveness of Wildlife Warning Reflectors in Reducing Deer-Vehicle Collisions: A Behavioral Study, Journal of Wildlife Management, 62(3), 1094-1099

(8) Zacks, J.L., 1986, Do White-Tailed Deer Avoid Red? An Evaluation of the Premise Underlying the Design of Swarflex Wildlife Reflectors, Transportation Research Record 1075, 35-43

9. TABLES

Table 1: Total Annual Number of Ungulates Killed (1991 to 2002)

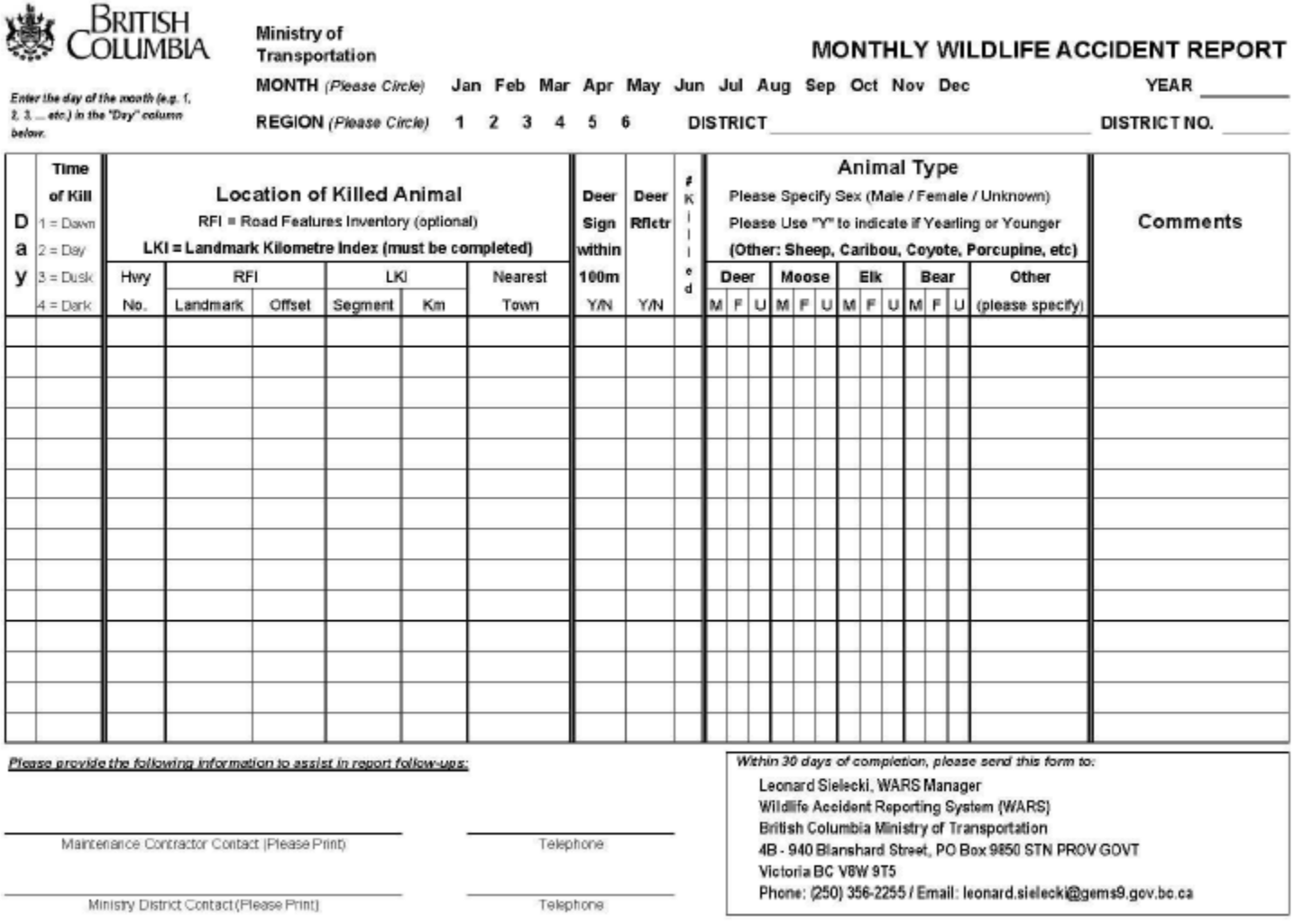
Species	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Totals
All species	3,306	3,176	4,798	5,339	4,764	3,902	3,661	4,611	4,889	4,785	5,172	4,889	53,292
All ungulates	2,998	2,860	4,352	4,929	4,396	3,576	3,347	4,196	4,448	4,348	4,590	4,320	48,360
Specific Ungulates													
Caribou	6	8	0	7	9	4	2	3	0	3	3	4	49
Deer	2,745	2,585	3,992	4,375	3,917	3,174	3,006	3,713	3,899	3,840	4,028	3,788	43,062
Elk	59	63	75	120	93	104	78	103	129	167	159	179	1,329
Moose	183	196	271	405	367	284	255	364	411	323	392	343	3,794
Sheep	5	8	14	22	10	10	6	13	9	15	8	6	126

Table 2: Total Monthly Distribution of Ungulate Accidents (1991 to 2002)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
All ungulates	3,988	3,396	3,686	3,790	4,133	3,768	4,081	3,627	3,589	4,668	5,559	4,078	48,363
Specific Ungulates													
Caribou	8	1	4	1	5	2	1	1	6	7	11	5	52
Deer	3,073	2,936	3,415	3,542	3,870	3,352	3,681	3,300	3,316	4,332	5,033	3,212	4,3062
Elk	182	89	106	94	103	107	73	66	57	103	149	200	1329
Moose	710	354	151	143	151	298	320	251	201	220	353	642	3794
Sheep	15	16	10	10	4	9	6	9	9	6	13	19	126

Table 3. Potential Wildlife-Related Motor Vehicle Accident Factors

1. Wildlife Characteristics	Species, population, age, sex, stage of reproduction, nutritional needs, movement behavior, population cycles
2. Wildlife Activities	Feeding, breeding, sleeping, migrating, evading predators, chasing prey
3. Natural Water Sources	Intermittent and permanent streams, rivers, slews, lakes, ponds, springs, waterfalls
4. Man-made Water Sources	Settling ponds, surface drainage systems, wells, dugouts
5. Natural Food Sources	Natural vegetation, salt licks, fish-bearing waters, prey
6. Man-made Food Sources	Orchards, gardens, fields, pets, livestock, garbage
7. Wildlife Shelter	Caves, cliffs, forests, culverts, bridges
8. Habitat Conditions	Seasonal vegetation changes, snow depth, drought, flooding, fire, overgrazing
9. Traffic	Volume, speed, composition, time-of-day, time-of-year
10. Vehicles	size, design, operating condition, brakes, lights, horns
11. Drivers	Wildlife hazard awareness, highway familiarity, general alertness, driving skill, response time, response actions
12. Highway Design	road width, number of lanes, curvilinearity of alignment, right-of-way width, shoulder width, ditch depth, pavement surface, lighting
13. Roadside Management and Maintenance	Native and non-native right-of-way vegetation, weed control, mowing, brushing, ditching, snow removal, de-icing, sign and reflector repairs
14. Roadside Development	Natural, urban, suburban, rural
15. Accident Mitigation Devices	Wildlife signs, fencing, under/overpasses, reflectors
16. Topography	Elevation, cliffs, slopes, plains, undulating terrain
17. Weather	rain, snow, sleet, fog, haze, smoke, wind, cloud cover
18. Time of Day	dawn, day, dusk, night, length of day/night
19. Lunar Cycle	Phases of the Moon, intensity of Moonlight
20. Human Activities Outside Right-of-Way	Construction, forestry, farming, mining, hunting, off-road recreation



BRITISH COLUMBIA

Ministry of Transportation

MONTHLY WILDLIFE ACCIDENT REPORT

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

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

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

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

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

_____ Maintenance Contractor Contact (Please Print) _____ Telephone

_____ Ministry District Contact (Please Print) _____ Telephone

Within 30 days of completion, please send this form to:

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

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

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Figure 1. WARS H0107 monthly wildlife accident report form

Figure 2. Wildlife warning signs

Figure 3. Changeable message signs

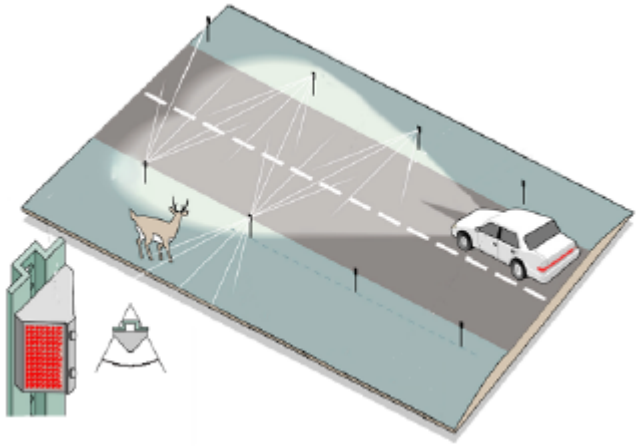

Figure 4. Light reflection concept of wildlife warning reflectors
(Source: Brian Shellito, The Detroit News (copyright) (adapted) (used with permission))

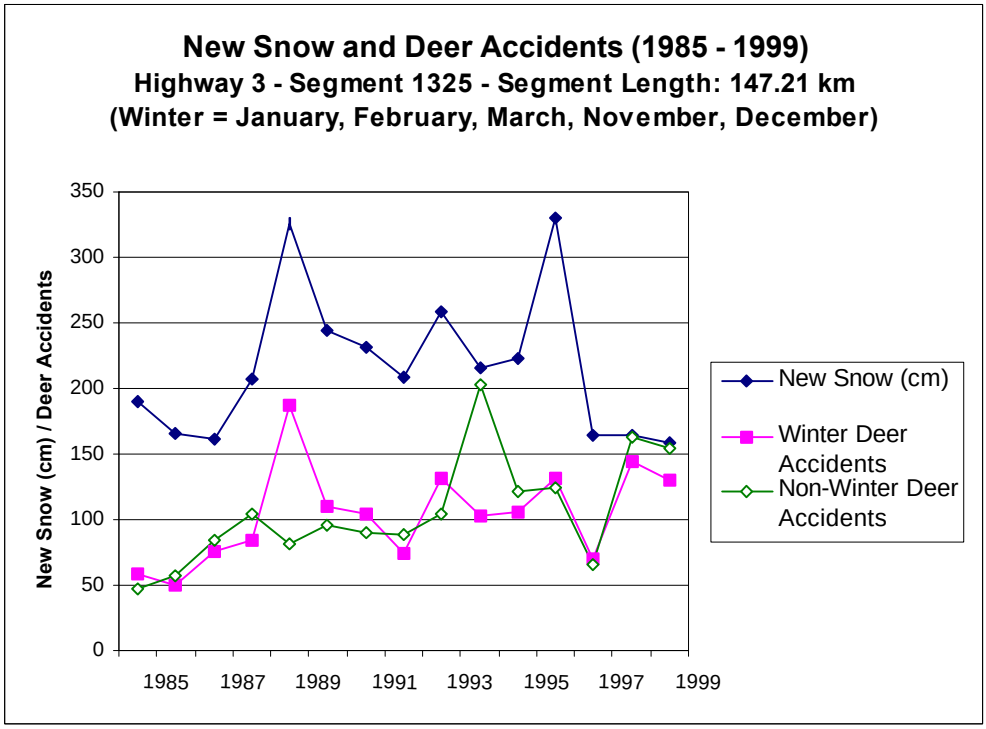

Figure 5. Relationship between deer accidents and new snow accumulations

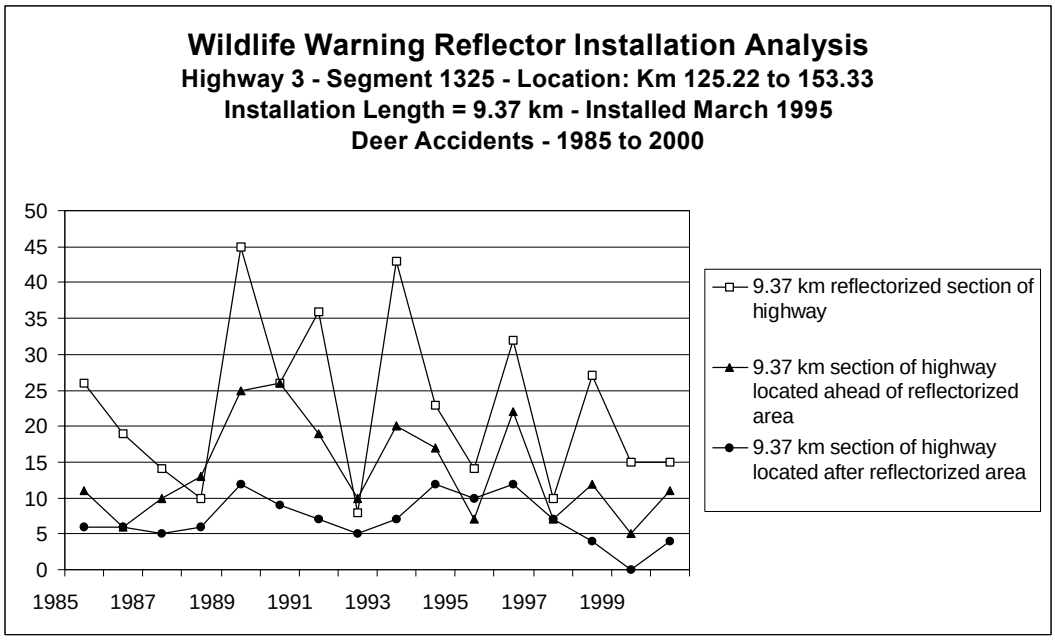

Figure 6. Wildlife warning reflector installation analysis (Highway 3, Segment 1325)

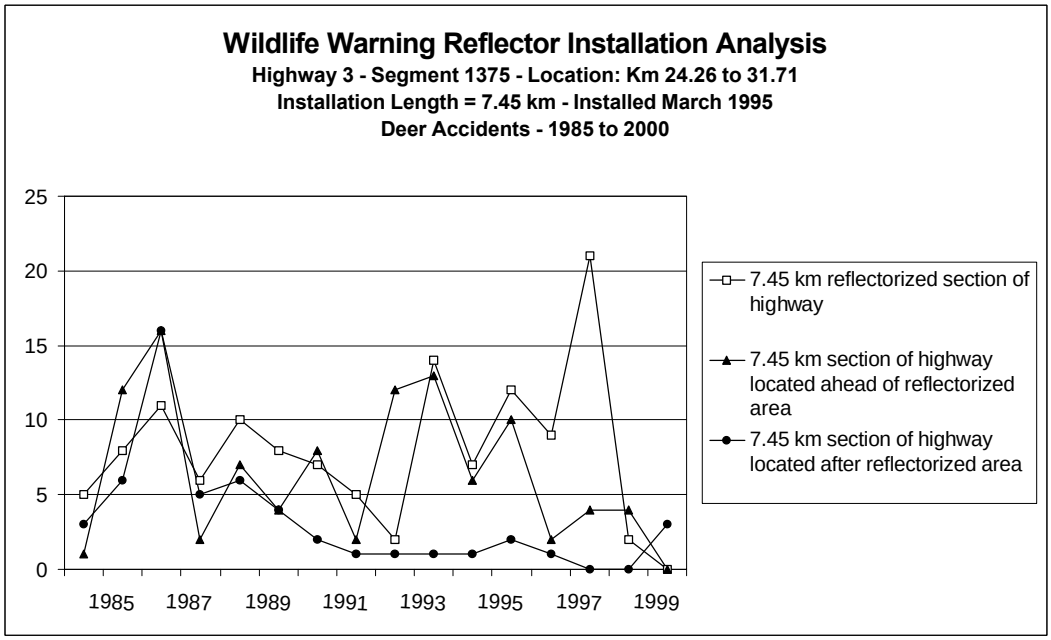

Figure 7. Wildlife warning reflector installation analysis (Highway 3, Segment 1375)

Figure 8. Wildlife warning reflectors subjected to winter roadside conditions

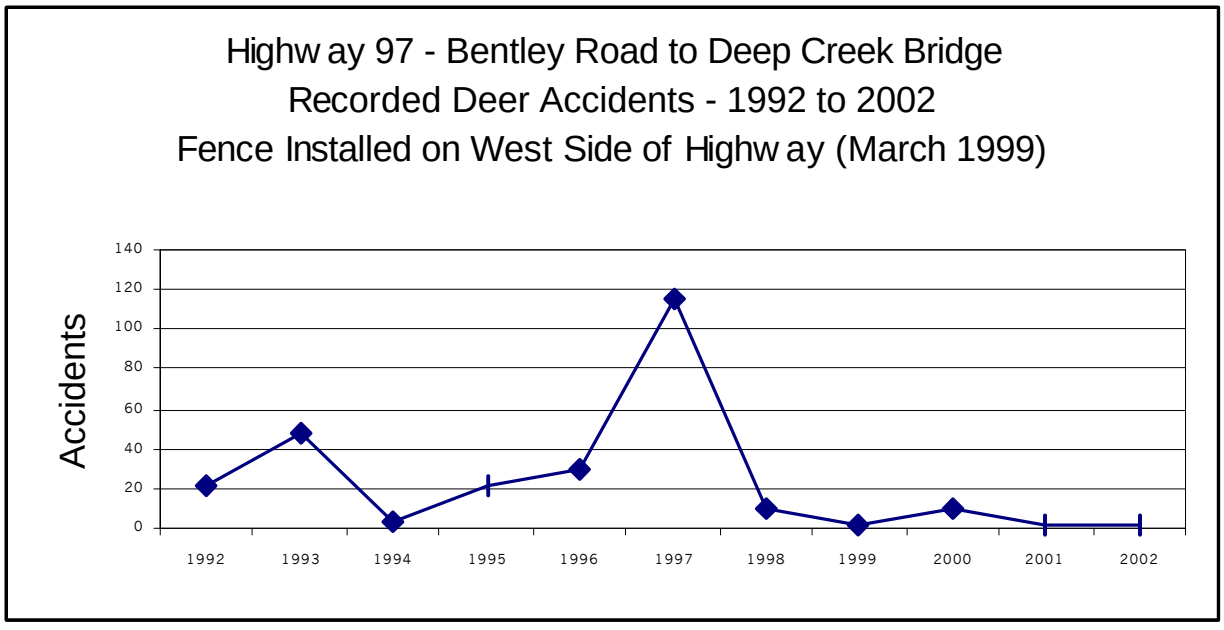

Figure 9. Highway 97 recorded deer accidents – Bentley Road to Deep Creek Bridge