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ORIGINAL PAPER

Evaluating the potential of the Otto® Wildlife GPS device to record roadside moose and deer locations for use in wildlife vehicle collision mitigation planning

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Abstract
Wildlife vehicle collisions present a serious challenge to road safety. Although spatially accurate wildlife collision data are necessary to identify areas where wildlife vehicle collisions are recurrent, global positioning system technology has not been used extensively to mark either animal carcass locations or animal live sighting locations along roadsides. We modified an existing global positioning system device (Otto-Driving Companion®) to record live sightings and carcass locations of deer (*Odocoileus* spp.) and moose (*Alces alces*) in northern British Columbia, Canada and assess the operational feasibility of the device to collect data quickly and reliably. Ten modified Otto-Driving Companion® units were installed in commercial semi-trailer trucks and roadside points of interest were recorded between July 2006 and May 2007. The device was straightforward to install and operate, and functioned proficiently for data collection. Electronic data transfers from the units to the researchers were simple and easily completed. Maps showing live sighting and carcass locations were created from the data without difficulty. While methodologies remain to be developed to normalise the data and minimise temporal biases arising from non-systematic data collection, the modified Otto-Driving Companion® is well suited to the collection of specific roadside data point locations for a variety of operational and research purposes.

Introduction

Wild animals are reported to be the highest environmental factor, next to poor weather conditions, that contributes to police-attended collisions in British Columbia, Canada [1]. BC wildlife collision statistics from 2002 to 2006 indicate that on average, five people are killed and 431 people are injured each year due to collisions with wildlife [2]. In 2005, the Insurance Corporation of British Columbia (ICBC; universal provider of basic insurance coverage in BC) reported that over $33 million dollars were expended on 9,800 animal related vehicle collisions [3]. Wildlife collision records from 1998 to 2002 estimate that 19,600 mammals (ungulates, carnivores and small size mammals such as porcupine and fox) are killed annually on BC's major highways [4]. These high personal, economic, and environmental costs provide incentives to develop new methods to reduce the number of wildlife collisions.

Transportation agencies need to identify with confidence the locations where wildlife collisions take place in order to prioritise these areas for mitigation and develop site- and species-specific mitigation methods. Predictive modeling based on 1) expert opinion [5] 2) remotely sensed landscape data in combination with road traffic data [6] or high collision site characteristics [7] 3) collision records and landscape or fine-scale terrain features [8] and 4) road design characteristics and animal movements [9] have all been used in efforts to understand and predict wildlife vehicle collision hot spots. Importantly, predictive models that used high resolution global positioning system (GPS) carcass location data sets rather than the more commonly used km or mile marker reference data sets, had high predictive power to identify factors contributing to wildlife collisions [10], while recognizing that roadside live animal sighting locations are not necessarily high collision locations. In a survey to identify transportation and wildlife research and practice priorities, road ecology and wildlife collision reduction experts identified the second highest research priority and fourth highest practice priority in Canada as the need to "standardise spatially accurate roadkill carcass and animal-vehicle collision data collection" [11].

A recent survey of government transportation (DoTs) and natural resource (DNRs) departments in Canada and the United States found that most states and provinces collect either wildlife vehicle collision data or carcass location data or both [12]. This survey found that the accuracy of carcass and collision locations was generally ≥ than 0.1 km or mile and most DoTs used km or mile marking posts, road sections, or landmark features as references rather than GPS based locations.

In BC, road maintenance contractors are contractually obligated to remove and report roadkilled carcass locations by kilometer marker which are then recorded in the non GPS-derived Wildlife Accident Reporting System (WARS), managed by the BC Ministry of Transportation and Infrastructure. The WARS system records only carcass data and contains no information on live animal sightings along the road. The historical accuracy of the WARS collision location data has been variable, although it has improved due to consultation with road maintenance contractors and the introduction of a revised WARS form in 1999 [1].

Although GPS radiotelemetry technology is widely used in wildlife and habitat monitoring [13] and used to track animal movements relative to highways and identify potential and actual collision and crossing hot spots [14,15,16], data interpretation must address any position, orientation, and habitat induced error and bias [17,18,19]. Most DoTs (89%) and DNRs (60%) rarely or never use GPS in carcass location reporting [12]. However, staff in most in those agencies believe that animal carcass data collection could be improved by increased consistency of data collection and improvement in spatial accuracy of carcass locations primarily with the use of field computers integrated with GPS units that allow for digital data entry in the field [12]. Roadside GPS waypoints marked by people are less subject to orientation and habitat induced errors than GPS fixes acquired on a pre-defined schedule where the GPS unit is subject to varying degrees of vegetative cover and antenna orientation due to collared animal activity. Consequently, GPS units have begun to be used to record wildlife collision location data for research purposes [20,21,22].

The need for a U.S. national standard for wildlife collision data initiated the development of software allowing for standardised and spatially precise data collection [23,12]. Further software development and field testing resulted in the RoadKill Observation Collection System which integrates a personal digital assistant with a GPS unit, and, through the use of custom developed software, can be used to collect spatially accurate wildlife collision data [23]. With further refinement and development, this system may become operationally available in the future.

Responding to the need for consistent, standardised and spatially accurate wildlife collision location data in Canada, we partnered with PerSen Technologies Inc., (PERSENTECH) of Winnipeg, Manitoba, Canada to develop a new application for a portable GPS road safety device already being marketed under the trade name Otto-Driving Companion® model OM0405. We had the device modified to overcome the two shortcomings of most existing data collection systems: improving the accuracy of carcass location reporting by using global positioning technology instead of using mile or kilometer marker reference markers and including live animal sightings in addition to carcass locations.

Here, we report on a pilot study we conducted with the following broad objectives in mind: 1) work with PERSENTECH to modify the Otto-Driving Companion® according to the desired project specifications 2) trial its use with community partners and 3) assess the potential of Otto® Wildlife to assist wildlife collision mitigation researchers, planners, managers, and other transportation and road safety agencies in increasing road safety by providing standardised and accurately recorded animal location data for site-specific mitigation.

Methods

In collaboration with PERSENTECH, we modified the Otto-Driving Companion® model OM0405, and called it the Otto® Wildlife University of Northern British Columbia (UNBC) Location Application Device (herein; the Otto® Wildlife or Otto; Fig. 1). Otto units were attached to the vehicle dashboard with removable Velcro™ strips. They could be battery powered, but preferentially were plugged into the vehicle accessory socket. The existing volume, speed, and power buttons were modified to create 2 buttons for live species sightings (deer; *Odocoileus* spp. and moose; *Alces alces*) and 1 button for carcass locations (a ‘dead’ button). When any of the three buttons were pressed, the latitude and longitude, time of day, and day of year were recorded. To record a live animal sighting point of interest (POI), the appropriate species button was pressed, a species-specific colour coded light emitting diode was activated and voice playback of “moose” or “deer” was annunciated to confirm the operator’s selection. To record a carcass location, the appropriate species and ‘dead’ buttons were pressed sequentially. We also modified the Otto to allow direct uploading and email transfer of memory log files to end user computers.

Fig. 1. Photograph of the Otto® Wildlife unit used to record live sightings and carcass locations of moose and deer and the Version 2 Otto® Wildlife developed to record POI for multiple species. Photo by Roy V. Rea.

We verified the accuracy of the Otto units by comparing the collected locations of live animal sightings and carcass locations, as recorded by the Otto device, to an existing GIS road layer, called the provincial Digital Road Atlas (DRA) <http://ilmbwww.gov.bc.ca/crgb/products/mapdata/digital_road_atlas_products.htm>, supplied by the government of B.C. The DRA, compiled through the use of high quality base station corrected GPS devices, ensures that the spatial information for road locations in B.C. is accurate within 2 metres. We performed a nearest feature analysis to compare the Otto location data POI to the DRA. We calculated the distance from each Otto POI to the closest segment of the DRA layer (finding the nearest road segment from the Otto points). Once these differences were calculated, we reviewed the results to determine what percentage of the total Otto location data POI were 10 metres or greater from the DRA layer. Only 1.5% of the Otto location data POI were outside of the 10 metre threshold.

We collaborated with three trucking companies based in Prince George, BC, Canada (53º 53' N 122º 40' W) to test ten Otto® Wildlife devices. Excel Transportation Inc. and Grandview Transport Ltd. ran two 12-hour shifts per day, spending 24 hours per day on the road and Lomak Bulk Carriers Corp. ran two ten-hour shifts, spending 20 hours per day on the road. POI entries were recorded by drivers while driving their regular routes. Because operators were driving at the same time that they were observing and recording the POI, they were instructed that safety was paramount and that recording of POI was secondary to safe operation of the vehicle. If both a deer and a moose carcass were present at the same location, operators were instructed to record both POI. If multiple species were observed at the same location, operators were instructed to record both species of interest. We did not conduct detection efficiency validation checks, such as seeding carcasses at known locations and subsequently vetting the data for the known carcass locations. Data were collected on weekdays only. Trucking companies collected data between July 10, 2006 and May 11, 2007. All truck routes originated in Prince George, BC, and traveled north, south, east and west along the four major highways (Yellowhead Highway 16 east and west; Highway 97 north and south) leading out of Prince

George. We conducted exit interviews with the trucking companies after data collection was complete to assess the ease of use and functionality of the Otto device and to determine the successes and challenges of the pilot project.

Trucking company staff periodically uploaded memory logs from the Otto® Wildlife to company computers, and then emailed the data to us for analysis. Using the downloading application developed specifically for Otto® Wildlife, we exported a log file to an American Standard Code for Information Interchange (ASCII) file in a comma separated value (CSV) format. We imported the data into Excel (Microsoft Office Professional Edition, Microsoft Corporation, Redman, WA) (Table 1) for further sorting and to detect any data recording abnormalities.

We vetted the data to classify all POI as either live sightings or carcass locations,

Table 1. Example of Otto® Wildlife CSV file data following transfer to an Excel spreadsheet
Note: time difference of <60 seconds, combined with latitudinal and longitudinal references within 200 m, define a dead moose carcass POI.

Date	Time	Latitude (°N)	Longitude (°W)	Deer	Dead	Moose
9/11/2006	9:11:23	53.864548	-123.340836	1	0	0
9/11/2006	9:25:34[1]	53.821110[2]	-123.092026[2]	0	0	1
9/11/2006	9:25:36[1]	53.820942[2]	-123.091393[2]	0	1[3]	0
9/11/2006	9:25:39	53.820705	-123.090454	0	0	1

[1] Time difference of 2 seconds
[2] Latitudinal reference and longitudinal references within 200 m
[3] Dead moose carcass POI

and then further classified the carcass POI as double-counted carcass POI, falsely recorded carcass POI, or actual true dead carcass POI. We defined a POI as a carcass location when there was both less than a 60 second interval and less than 200 meters between the species record and the dead record (Table 1). The time interval was generally less than 20 seconds. A 60 second interval allowed for the driver to deal with any circumstances related to vehicle operation requiring full driver attention, such as oncoming traffic or corners, prior to pressing any other buttons.

We eliminated double counted carcass POI by establishing an initial POI at the earliest time of day and removing any subsequent POI records of the same species within 200 m that occurred in the same 24-hour period. We assumed that carcasses would be removed within a 24-hour period because the contractual requirements for maintenance contractors in this area is removal of carcasses within 60 to 180 minutes of detection or notification and the highway is generally patrolled at 24-hour minimum intervals [24].

We defined a falsely recorded carcass POI as: 1) a dead record with no corresponding species record occurring within 200 m or 2) a dead record logged at the very beginning or end of a truck run. After checking with the drivers, we noted that because the power button also functioned as the 'dead' button, the Otto unit was powered down when the button was pressed and held, but when the button was pressed and released more quickly, it inadvertently recorded a carcass POI instead of powering down. Therefore, carcass POI that were recorded at the start or end of a truck run with no corresponding species record were the result of not pressing the power button long enough to correctly shut off the device, and were the result of operator error, not device error.

We counted and summarised live deer sightings, live moose sightings, and deer and moose carcass locations. We then imported the data (CSV format) into the geographic information system software program ArcMap (ArcMap 9.2, Environmental Systems Research Institute, Redlands, California, USA), which was used for spatial data analysis, verifying POI accuracy, and to produce maps showing the locations of live animal sightings and carcass locations (Fig. 2).

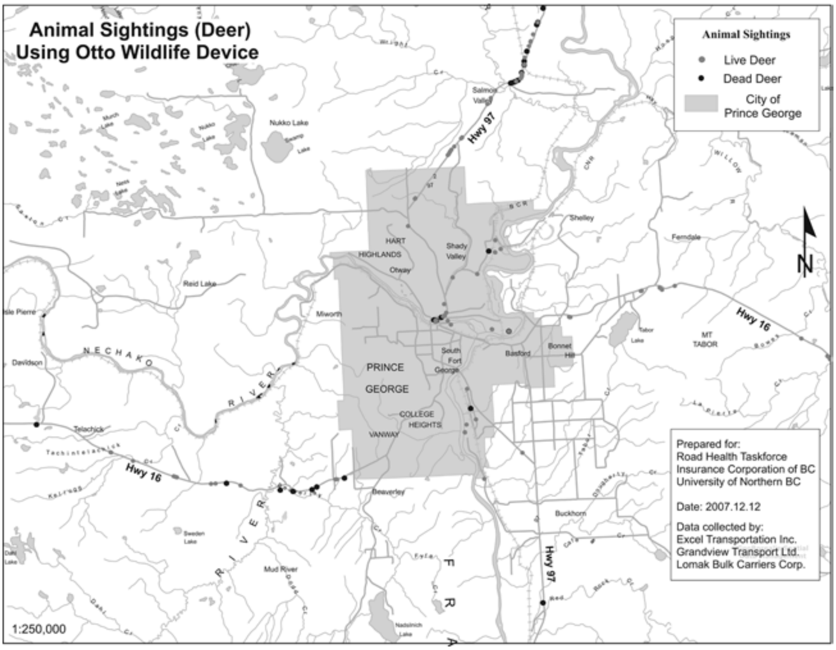

Fig. 2. Points of interest (POI) locations recorded by Otto® Wildlife for live and dead deer located around Prince George, British Columbia, Canada.

Results

Otto® Wildlife data collection

The trucking companies used the Otto devices to collect data for a minimum of 289 days during the study period. We could not determine the actual number of days each Otto was used, because drivers did not keep records of the number of days when the unit was in operation, but no carcasses or live animals were encountered.

Live sighting data

During the study, 1380 deer and moose live sighting POI were recorded on all routes. Of these, 65% (n=901) of the POI were deer and 35% (n=479) were moose. Live deer were sighted more frequently than live moose from July to October 2006, and live moose were sighted more frequently than live deer from November 2006 to January 2007.

Carcass sighting data

During the study, 165 carcass POI were recorded for all routes. Of these, 22.4% (*n*=37), matched the false dead POI criteria, and were excluded from the final carcass count and analysis. The remaining 77.5% (*n*=128) were entered correctly by the drivers, but included 7.2% (*n*=12) which were determined to be double-counted carcasses, leaving 70.3% (*n*=116) true dead carcasses. Of the 116 actual dead carcasses, 56% (*n*=65) were deer, and 44% (*n*=51) were moose. Similar to the frequency of the live sightings, deer carcasses were sighted more frequently than moose carcasses from July to October 2006 and moose carcasses were sighted more frequently than deer carcasses from November 2006 to January 2007.

Assessment of Otto® Wildlife functionality

Exit interviews with the community partners assessed the functionality and ease of use of the Otto. The partners were in agreement that the Otto unit was easy to install and operate, straightforward to use and generally, no operating difficulties were encountered. The drivers reported that operating the unit while driving did not pose a safety hazard or impede their ability to operate the vehicle. The units were subjected to reasonable wear and tear during operations and few operational difficulties were encountered. No difficulties in unit functionality were encountered due to extreme cold weather conditions (approximately -35° C). Uploading the data was quick and easy, and no problems were encountered. There were no known instances of lost data due to Otto malfunction. The software was simple, self explanatory, and intuitive. Data retrieval and transfer into secondary spatial and non spatial programs for analysis were easily conducted. Analysis of wildlife collision locations using Otto data indicated that the data can be used to produce maps of carcass locations and animal sightings quickly, reliably and accurately. At a corporate level, interest in our study was maintained throughout the project, however, for the volunteer drivers, the novelty of participating in the project decreased over time, and when data collection decreased, the project was terminated.

Discussion

Our trucking partners reported positively on the merits of Otto units for collecting animal activity data and the ease of unit operation. All partners shared our enthusiasm for collecting these data and had a vested interest in the project outcomes because their business operations had been negatively impacted by the costs and time loss associated with wildlife collisions. However, consistency in data collection between partners over the long term eventually decreased. Due to data recording inconsistencies at the end of the project and the evolving operational schedules of our partners, we considered our data to be collected opportunistically rather than systematically, and as such, we did not seek to ascribe any form of collision risk to the highway sections for which we identified frequent live sightings or carcass locations. Rather, data collected during our project represented an opportunity to test and report on the utility of Otto® Wildlife as a tool for wildlife collision mitigation planning.

Data analysis and constraints

We collected data for 11 months and recorded a total of 116 carcass locations. Despite the fact that some routes changed over time and data collection incurred some biases because POI: 1) were not recorded on weekends 2) recorded infrequently from January to May 2007 and 3) could only be recorded if the carcass was detected prior to removal by maintenance contractors, we believe our data underscore the utility of the Otto device for recording animal locations.

Most carcasses recorded on our devices between July and October 2006 were deer, but shifted to moose from November 2006 through to January 2007. These trends support similar findings from the regions of northern BC where we were collecting data which showed deer vehicle collisions peaking in October and November, and moose vehicle collisions peaking in December and January [4,25]. Similar seasonal collision trends have been reported for moose [26] and deer in other regions [27,28,29]. Furthermore, out of the total number of deer and moose carcasses observed in our study, the percentage of moose carcasses (44.0%) and deer carcasses (56.0%) differed only slightly from those previously determined in northern BC [4] where moose comprised 47.8% and deer comprised 52.1% of the roadkill species profile.

Discussions with our partners helped us to identify an observation bias in collecting wildlife data that must be considered whether using a GPS device or other recording methods. When data were collected during hours of dusk or dark, the drivers' ability to see live animals or carcasses was generally limited to the area illuminated by the vehicle headlights. This likely resulted in the data over-representing animal sightings in the daylight hours relative to when animals were actually active [30], when in fact the presumed increased counts would likely have been a consequence of improved visibility.

Considerations for use

Where Otto units are going to be used to analyze collision risk and live animal movements along roadsides, we recommend the implementation of a systematic sampling methodology to standardize the number of trips taken per month, season and route. We also recommend users randomize the trip start times over a 24-hour period, and systematically track hours of unit use or distance traveled to normalise the data and reduce driving schedule-induced bias. Route traverses in which no carcass or live sightings are recorded must be documented in order to incorporate the absence of animal activity into the data set.

To minimise data concentrations of sightings during the daylight hours, the physical area in which the driver sees a live animal or carcass needs to be carefully defined. Only POI on the roadbed or shoulder, within a distance approximating the area illuminated by headlights at night should be recorded. Animals or carcasses outside this headlight illuminated zone (ditch, right of way or too far down the road) should not be recorded. This also reduces the possibility of the POI marking the location of the vehicle at the time the sighting is made, rather than the location of the actual sighting. Adherence to these protocols would result in a more accurate representation of temporal patterns of animal behaviour near roads and avoid data gaps on weekends or at certain times of the day. This would enable researchers to draw site- and time-specific conclusions about the location of carcasses and about the movement patterns of live animals and would help facilitate the analysis of animal populations and frequency of wildlife use within the road corridor.

To increase operational efficiency, we recommended some physical modifications to the Otto unit such as: 1) bigger buttons which are easier to locate and use while driving 2) the addition of a button with an erase last keystroke function in order to correct field data entry errors 3) the addition of a button to record animal sex class and 4) the addition of two or three buttons to record simple animal behaviours such as crossing the road, standing on the road, or standing adjacent to the road.

In collaboration with PERSENTECH and ICBC, we spearheaded the development of a second version of Otto® Wildlife (Fig. 1) with the ability to record multiple species because most jurisdictions have more than two large species that are involved in wildlife vehicle collisions and ungulate species such as deer, elk, caribou and bison are social animals which are frequently encountered in herds.

Version 2 Otto® Wildlife devices provide for an external 19 button key pad programmed to record POI for 16 different types of animals, plus carcass location as well as a herd button for animal groups more than a user-determined number. One button has no function. Version 2 Otto® Wildlife devices are formatted with sufficient memory to capture 21,900 animal sightings without requiring data downloads. In 2007, based on a production run of 100 units, PERSENTECH estimated a cost of $100.00 CAD per multi species unit.

In addition, we recommend exploring the possibilities of developing additional applications to allow remote uploading links between Otto and the end user’s computer, or Otto and the receiving agency’s web browser and web-based mapping program. This would enable quicker access to the data and subsequent map production without having to manually retrieve the unit from the vehicle.

Otto® Wildlife operational potential for live sighting locations

Little is known about the relationship between roadside live sighting location data and collision occurrence. Wildlife may successfully cross roads in areas that are not identified by standard carcass location data. In New Hampshire, locations where moose frequently cross roads were not identified as areas with high moose collision rates [31]. Road segments with frequent live animal sightings and low collision rates should be compared with road segments that have high collision rates to determine site characteristics such as visibility, road profile, number of traffic lanes and right of way characteristics that influence successful wildlife crossings [32].

Live sighting POI data collected with the Otto® Wildlife can be used to produce maps of recurrent sightings so that the motoring public, trucking companies, courier companies and other frequent road user groups can be aware of high risk areas. These maps, locations and wildlife warnings can be made available on websites (<www.drivebc.ca>, <www.rockies.ca/roadwatch>, <www.roadkilltas.org>, and <www.wildlifecollisions.ca>), in tourist information centres, on radio stations, in adjacent local communities and in other locations where motorist warnings and road hazards are posted.

Live sighting data collected by Otto® Wildlife could also become an important source of information about animal behavior in transportation corridors, particularly if future versions of the device can be developed which allow for the recording of simple animal behaviors. Deer behaviors along roadsides and at crossings have been analyzed by temporal class (day, evening, morning, night) and behavior [33] showing that the number of deer and the duration of stay by deer in the right of way was highest at night, but that the highest risk vehicle collision behaviours were exhibited during the day.

Otto® Wildlife operational potential for carcass locations

Otto® Wildlife is well suited as a data collection device for carcass locations because data recording and subsequent analysis and mapping of collision hot spots is not dependent upon a systematic or time-sensitive sampling methodology. Road maintenance contractors and other agencies or jurisdictions that currently collect roadkilled carcass location data using pen and paper methods, such as many park, public works and police departments, can use the Otto unit as a quick and accurate method of recording roadkilled carcass locations to supplement or replace existing methods.

The spatially accurate data collected with the device can be useful to road safety planners, engineers, managers and biologists in complementing, cross referencing or auditing the information collected by road maintenance contractors and other agencies. Such data can be used to conduct wildlife collision prevention research, identify and assist in prioritization of stretches of highway with high collision rates at multiple scales, and can contribute to localized mitigation decisions regarding the placement of wildlife crossing structures and the alteration of roadside habitat and design [10].

Conclusions

Whether employed as part of a community-based approach for collecting roadside wildlife information [32] or as a alternative method for agencies currently using km or mile markers to record carcass locations, the Otto® Wildlife demonstrates promise as an effective mitigation tool. Using the Otto® Wildlife to record carcass locations and live animal sightings for subsequent analysis and mapping of collision hot spots and frequent sighting locations is an improvement over most currently published methods that use mile or kilometer markers as location reference points. In summary, the Otto® Wildlife GPS unit is well suited as a user friendly, convenient and inexpensive data collection device for carcass and live sighting locations with a wide variety of potential operational uses by agencies involved in road safety and roadside wildlife management.

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