Federal Lands Wildlife-Vehicle Collision Data Coordination Project

Phase 2

by
Robert Ament, Road Ecology Program Manager
Kelley Hall, Research Associate
Matthew Bell, Research Associate

Western Transportation Institute
College of Engineering
Montana State University
P.O. Box 174250
Bozeman, MT 59717

And

Mike Wittie, Associate Professor
Gianforte School of Computing
Montana State University

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16. Abstract

The National Park Service (NPS) and US Fish and Wildlife Service (USFWS) have partnered on an effort to develop a federal lands wildlife-vehicle collision (WVC) database. The agencies seek to coordinate the use of a WVC Data Collection System with other federal land management agencies and with state and local agencies and other organizations. Phase 1 of this project developed a pilot WVC system using an existing commercial mobile device application and its data storage and serving capabilities; this commercial system is available to all Department of Interior (DOI) agencies and bureaus, but not to most other potential partners. It was customized for Phase I to collect WVC roadkill observations; the custom version is called ROaDS - Roadkill Observation and Data System. Phase 2 of the project developed three recommendations for preliminary national standards for WVC data collection systems – 1) A standardized national species list, 2) a spatial accuracy requirement for observation locations, and 3) a means for expert review of the species identified in each observation via a geo-synched photo. In phase 2, the research team also made recommendations to modify the ROaDS survey so it is shorter, easier to use and more efficient. In addition, the team also determined that the ROaDS survey can simultaneously capture the observer's survey route and link each individual observation to the route taken. Thus, for research or monitoring projects, ROaDS can provide a function that captures the observer's route, how long it took to complete the route and each individual observation made while on that route. Lastly, during Phase 2, the project began to engage other agencies and organizations to jointly develop national standards for WVC data collection systems via meetings, presentations and workshops at national conferences that will be continued in Phase 3.

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EXECUTIVE SUMMARY

The National Park Service (NPS) and US Fish and Wildlife Service (FWS) have partnered with the Western Transportation Institute – Montana State University (WTI) to develop a federal lands wildlife-vehicle collision (WVC) data collection system. This system is being designed to efficiently and effectively collect information on large animal-vehicle crashes, to address motorist safety concerns on federal land management agency (FLMA) roads, as well as to document carcass data of medium- and smaller-sized fauna relevant to FLMAs' conservation missions. This project offers user-friendly tools to collect and manage data that are key for conducting analyses that identify specific areas where mitigation measures may be used to reduce WVCs on roads in National Parks and National Wildlife Refuges. The system is basic and flexible enough to be used by any agency staff, on any FLMA system road, and can be adopted for wider use collecting WVC data on roads managed by state, tribal, county and metropolitan transportation agencies and other partners such as non-governmental organizations.

Phase 1 of this project developed a pilot WVC system using an existing commercial mobile device application and its data storage and serving capabilities; this commercial system is available to all Department of Interior (DOI) agencies and bureaus, but not to most other potential partners. It was customized for Phase I to collect WVC roadkill observations; the custom version is called ROaDS - Roadkill Observation and Data System.

This report summarizes Phase 2 of the project, which sought to develop recommendations for the next and final effort of Phase 3, when additional funding becomes available to complete the project. The primary objectives were **to develop preliminary WVC data collection standards** and **to recommend modifications for the data collection fields of the ROaDS survey**. The ROaDS project was able to develop several useful national standards for future discussion with partners to meet the first objective of Phase 2. They are:

1. Location Accuracy Standard: each wildlife observation shall be located in the field, at the time of the observation, using a reliable GPS system and have a location accuracy that does not exceed ±10 meters.

2. Expert Review Standard: The identification of the species present in each observation must be reviewable by an expert. To do so, a geo-synched photo must be linked with all observations by non-experts.

3. Standardized National Species List: A relatively short species list of the most frequently observed animals of interest from across the U.S., using their common names, will be provided by the WVC data collection system for the observer to choose from while making a data collection observation. In addition, the WVC data collection system shall provide the flexibility for the data collector to identify and record species not on the list.

The ROaDS survey on the pilot ESRI Survey123 application will be able to meet each of the above standards. In Phase 3, the ROaDS project will discuss these and additional standards.

The ROaDS project was able to meet the project's second objective by modifying the ROaDS survey so it is shorter, easier to use and more efficient. To accomplish this, the WTI Team members recommended that five data fields be removed from the Phase 1 ROaDS survey. They

recommended that two data fields be modified. Also, the team concluded that the complicated species list of both scientific and common names in Phase 1 should be shortened and only use common names. The ability to report successful wildlife crossings was added to the data field that had only allowed dead or dying animals to be captured in the Phase 1 survey. The only new data field that was recommended to be added determines whether the observer is an expert or not.

The WTI Team determined that the ESRI platform supporting the ROaDS survey can simultaneously capture the observer's survey route and link each individual observation to the route taken, as well as record the amount of time the observer spent on the route. Thus, for research or monitoring projects, it can document survey time and effort.

Lastly, the WTI Team and Technical Advisory Committee (TAC) have begun to engage other agencies and organizations to jointly develop national standards for WVC data collection systems. This will allow the different WVC data systems available in the U.S. to share information and allow researchers and practitioners to be confident in the quality of the data, regardless of the system. The WTI Team and TAC have engaged others via a poster presentation at the International Conference on Ecology and Transportation (ICOET) in Sacramento, CA, and a presentation at the summer meeting of the Transportation and Ecology Committee (ADC 30) of the National Academies' Transportation Research Board (TRB). The project has had its workshop on national WVC standards accepted for the TRB's Annual Conference in Washington, DC in January 2020. The effort to engage with partners to develop mutually acceptable national standards will continue and expand in Phase 3.

1. INTRODUCTION

Vehicle collisions with large animals can result in animal mortality, property damage, and human injuries or fatalities (Bissonette et al. 2008; Huijser et al. 2008). In the United States, it is estimated there are 1-2 million wildlife-vehicle collisions (WVCs) costing over $8 billion, annually (Huijser et al. 2008; Sullivan 2011).

The National Park Service (NPS) and US Fish and Wildlife Service (FWS), and other Federal Land Management Agencies (FLMAs) lack sufficient information regarding the location, rate, and severity of WVCs along roadways within agency management units – such as parks and refuges - and on roads through adjacent public lands. Currently, there is no systematic collection and sharing of this information for what are primarily rural roads. Without this data, it is difficult for FLMAs to adequately analyze WVCs, develop priorities, fund programs, and implement the most effective mitigation solutions that resolve WVC issues and their adverse effects on both motorist safety and natural resource protection.

For rural areas such as national parks and wildlife refuges, the reduction of WVCs is a significant issue. Nearly 90% of all WVCs in the United States occur on two lane roads (Huijser et al. 2008). For example, in the largely rural state of Montana, nine out of the top ten WVC hotspots during the fall migrations of wildlife occur on rural two-lane highways (Creech 2016).

High quality, reliable and accurate WVC data will support NPS and FWS long range transportation plans (LRTPs). According to the NPS' National LRTP (2017), *"[f]rom 1990 to 2005, wildlife–vehicle collisions were the leading cause of single-vehicle crashes in the NPS system and accounted for 10 percent of total vehicle crashes, which was more than double the 4.6 percent national average (NPS 2009, Huijser et al. 2008). Wildlife–vehicle collisions were the most common crash type in the Intermountain, Northeast and Southeast regions.*" In the FWS's National LRTP (2016), one of the six strategic goals is safety. Under this goal, Objective 1 states: *"[i]dentify safety issue 'hot-spots' within the Service's transportation system…*." and Objective 3 states: "*[a]ddress wildlife-vehicle collisions with design solutions…*" Thus, both agency LRTPs have identified the need to address WVCs, and a high quality WVC data collection system will support these efforts.

Although the FWS and NPS each manage roads within their own jurisdiction, the surrounding transportation network is managed by other FLMAs, state Departments of Transportation (DOTs) or natural resource agencies, tribes, and county or metropolitan road departments. These entities may also have road segments with high rates of WVCs, with similar implications to human safety and natural resource protection. The lack of systematic WVC data collection and coordination on surrounding non-FLMA roads limits the ability of NPS, FWS and other FLMAs and their partners to fully recognize the negative impacts that WVCs are having on motorist safety and wildlife conservation.

The adverse effects of roads and traffic on FLMA visitors and natural resources are issues shared with other transportation and natural resource agencies across the nation, and in many other parts of the world. As a result, different technologies have been developed to gather more precise WVC data. The challenge is to sort through this variety of technologies to determine which systems are readily available with the least modification, and which best address the unique

circumstances of FWS, NPS, and other FLMAs, such as their data information systems, cultures, and environments.

Neither the NPS nor FWS systematically collect WVC information at this time. An NPS-wide survey, for which 106 national park management units responded, showed that managers perceived that roads were adversely affecting wildlife populations (Ament et al. 2008). More recently, a survey of national wildlife refuges in FWS Region 5 found that respondents felt road impacts on wildlife populations are a major concern as roads continue to fragment habitat and cause direct wildlife mortality (Clevenger et al. 2015). In addition, the survey found that a minority of the refuges quantify, moderate, and/or monitor these adverse impacts for threatened and endangered species (Clevenger et al. 2015).

Recently, in a state where collisions with deer are high, the lack of quality animal-vehicle collision data led to severe underreporting of deer-vehicle collisions (DVCs) - they were 8.5 times higher than reported and the costs of DVCs were 6 times costlier than documented in law enforcement crash reports (Donaldson 2017). Similarly, Department of Interior (DOI) agencies collect limited data on WVCs occurring on their roads through a department-wide law enforcement records management system known as the Incident Management and Reporting System (IMARS).

A high quality WVC data collection system could also be used to determine the effects of FLMA roads on animals that are not necessarily large enough to cause safety concerns for motorists but are threatened, endangered or of conservation concern. Huijser and others (2008) reviewed federally listed threatened and endangered species and identified 21 species for which direct road mortality is among the major threats to their survival. The NPS's National LRTP (2017) stated, "these species and other sensitive species are currently found within 32 parks units."

These reports and other related studies across the nation demonstrate the need for high quality, systematic WVC data collection to better evaluate safety issues, WVC impacts, true costs, problematic stretches of roads, and to support the investment in effective mitigation measures, such as wildlife crossings and animal detection systems with fencing. The data also will be used for outreach and education campaigns, communications and signage.

This project is developing a WVC data collection system for use by the FWS, NPS, other DOI agencies, and potentially other FLMAs. To support DOI efforts on adjacent or multi-jurisdictional roads, the project is seeking to determine if there are other willing partners that will collect the same or similar data on their own independent data collection systems. For example, state agencies in Arizona and Idaho currently use ESRI Survey123 to collect WVC data in their states. The project will determine if they collect the same information, so that national refuges, parks and other FLMA management units can share WVC data for the same highway that passes across multi-jurisdictional boundaries in these states.

Similarly, other state DOTs, tribes, non-government organizations (NGOs), and potentially citizen scientists may be willing to collect the same or similar WVC information as NPS and FWS, but on their own data collection and storage platforms. The project will assess the willingness and capabilities of partners to collect and share their data with the NPS, FWS, and

the FLMAs. The ability to share WVC data among partners strengthens the overall system and provides much more data at no cost. Each data collection system will be independent; yet, they can potentially collect the same information with common quality controls.

This project also aims to assess existing data collection systems, including commercial data collection systems already under contract to the federal government and the DOI to develop a WVC data system. To coordinate WVC data collection and sharing with partners across the country, the project will work with DOI agencies and other stakeholder to develop criteria, or national standards for WVC data collection. These guidelines will be co-developed with partners and stakeholders to garner broader use and to coordinate parallel development of data collection systems.

Also, the project seeks to explore the future implementation and sustainability of a WVC data system with recommendations for federal agencies to coordinate the WVC data system's collection, storage, analysis and reporting. It will facilitate the standardization of WVC data so NPS, FWS and their stakeholders are able to collect, store, retrieve and share, analyze and apply data as it is needed for their agencies or organizations.

The advantages of a national standardized animal-vehicle collision (AVC) data collection program were described over a decade ago in a National Cooperative Highway Research Program report (Huijser et al. 2007):

- The occurrence of road incidents that cause human fatalities, injuries and property damage as well as those adversely affecting natural resource conservation, and property damage are documented;
- Locations that may require mitigation can be identified and prioritized, allowing for an effective use of resources; and
- The effectiveness of mitigation measures in reducing collisions can be evaluated. This allows for modifications (if needed) and the application of lessons learned at other locations, again allowing for an effective use of resources.

2. PROJECT BACKGROUND

The WVC Data Collection System for use by the NPS, FWS and their partners will be designed to collect information on large animal-vehicle crashes, which are the focus of the safety requirements for FLMA roads. It will also be capable of collecting carcass information of medium-sized and smaller taxa which are the focus of the FLMAs' conservation mission and to meet LRTP goals. This is analogous to meeting the joint needs of state DOTs and state Departments of Wildlife (DOWs) or tribal transportation and wildlife agencies.

The development of WVC data systems has evolved over the past decade. Originally, personal data assistants (PDAs) were coupled with Geographic Position Systems (GPS) back in the mid-2000s (i.e., Huijser et al. 2006, Ament at al. 2007, Donaldson and Lafon 2010). More recently, as cell phone use has escalated and smart phones with excellent GPS capabilities have become common, web-based and mobile device applications have superseded the use of PDA-GPS systems. Mobile devices using web-based systems have greatly improved data collection capabilities and efficiencies (Olson et al. 2014) and enable citizen scientists or the general public to add to a transportation agency's efforts (Shilling and Waetien 2015). Some systems combine web-based with mobile device applications (Bil et al. 2017) and smart phone systems with citizen science capabilities to increase robustness of the data (Vercayie and Herremans 2015).

The WVC Data Collection System will:

- Allow for all DOI agencies and other stakeholders to collect the same information – nationally standardized WVC data.
- Collect spatially precise WVC data by user-friendly data entry via mobile devices.
- Facilitate the collection of all types of WVCs from large animals, the focus of motorist safety, to smaller mammals, reptiles, birds and amphibians for conservation purposes.
- Provide for improved coordination of the FLMAs and surrounding stakeholders for collecting, reporting and assessing WVC data at various scales – management unit, regional and national.
- Create central data storage that simplifies data management across federal land management units and across individual units within the same agency. This will allow agencies to have controlled access and provide security for sensitive data, such as for federally listed threatened and endangered species.
- Allow for greater public engagement in natural resource conservation by encouraging citizens to collect and report similar WVC data on their own data collection platforms.
- Enhance the understanding of WVC incidence, species, and contributing factors to improve transportation safety decisions, mitigation investments and natural resource protection.

2.1. Phase 1

This phase completed initial steps to facilitate the coordination of WVC data collection by the NPS, FWS and other FLMAs such as the USDA Forest Service and Bureau of Land Management. It identified the data collection, storage, and retrieval needs for the NPS, FWS, and their stakeholders. The project also assessed existing data collection systems – both for WVCs

(e.g., i-naturalist) and those that could be adapted for WVC purposes (e.g., Incident Management Analysis and Reporting System [IMARS]). The project also explored the use of the commercial data collection system already under contract to the DOI. One of the important factors that was evaluated for these systems was the capability for the FWS, NPS, and other FLMAs to manage, support and sustain users. Recommendations were provided for coordinating the WVC data system's collection, storage, analysis and reporting methods.

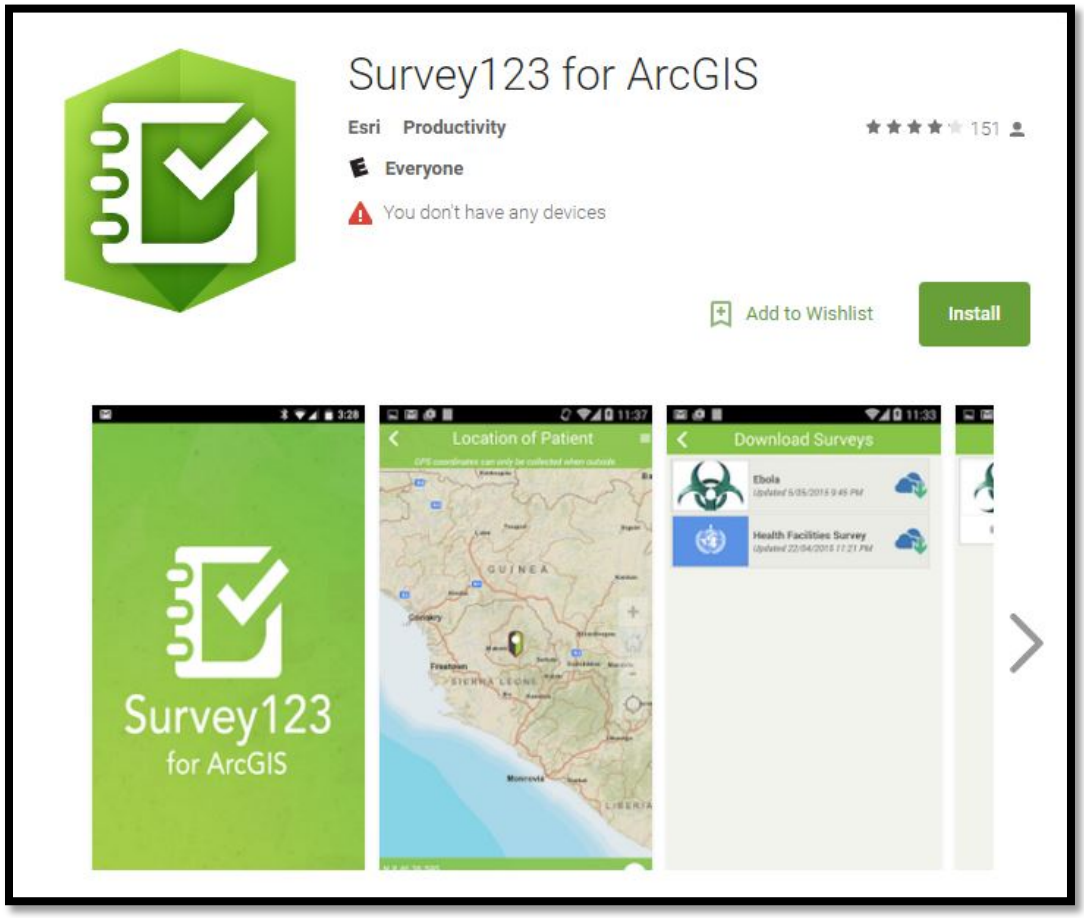

Figure 1. Screenshot of the e-store where Environmental Systems Research Institute (ESRI) Survey123 can be installed on a user's mobile device.

Phase 1 developed a data collection system based on the Environmental Systems Research Institute's (ESRI) software platform, a commercial smart phone/tablet application called ESRI Survey123 (Figure 1). The ESRI Survey123 application is available to all DOI agencies and bureaus. Importantly, it meets the internet technology security needs of DOI. Survey123 has DOI certification for authority to operate. Further, other organizations have licenses to use this commercial application and may be potential cooperators for WVC data collection. A key factor is that each licensee, including the DOI, collect, store, and have access to retrieve their data independently. This provides data security while at the same time may encourage closer cooperation among agencies to share data.

The survey, named Roadkill Observation and Data System (ROaDS), collects roadside wildlife mortality observations and related information, and includes a geo-synched photograph capability. The logo created for the ROaDS survey can be seen in Figure 2. In Phase 1, 28 beta-testers from Oregon to Florida were registered from the NPS and FWS to test ROaDS's functionality. The data was stored on ESRI's cloud-based data server. A function was added so selected experts could be given access to review species identification data and photos. As part of its license, ESRI also provides post-collection analysis capabilities to visualize the data, such as providing heat maps for roadkill locations.

Figure 2. ROaDS icon developed for the project's wildlife vehicle collision data collection system.

During Phase 1, if the mobile device had connectivity, either via the internet (wifi) or through cellular phone coverage, the data from each roadkill observation was uploaded directly to the cloud-based data storage provided by ESRI. If a smart phone or tablet was disconnected, it stored the information in the mobile device's memory until connectivity was restored. For safety, the data collector simply pushed a button to lock in the location, i.e. UTM coordinates, of the

roadkill observation on the mobile device's map. This allowed the observer to move to a safe location, if needed, to enter the rest of the information attached to those coordinates.

Once the observation data was in ESRI's cloud-based server, each observation's data and geo-synched photo could be exported and reviewed by NPS or FWS experts for quality assurance and control. This was not available on the ESRI data storage cloud but was developed by the WTI Research Team and was located on Montana State University's (MSU's) data server under its license with ESRI. Once reviewed, data can then be returned from the MSU data server to the ESRI database. The ESRI database can be queried and retrieved by FLMA personnel using ArcGIS online. Agency personnel can then retrieve the collected data for map-based viewing or further analyses of the WVC information by exporting the data into electronic spreadsheets or other software used for analyses.

2.2. Phase 1 Beta-Test of ROaDS

A beta-test was conducted of the WVC data collection, storage and retrieval system. There were 28 volunteers from the federal agencies and the WTI Team who were registered for the test and provided feedback on ROaDS. A sampling of comments on the system include:

- It was possible to skip many of the data fields, if they didn't appear to be necessary or applicable. Users "liked" that they were not required to be filled out.
- The geo-synched photo feature was very easy to use.
- The safety feature of allowing the collector to mark the site and then move to somewhere away from traffic to fill out the data fields was poorly understood.
- Minimize and simplify the survey; there are too many data fields.

Other issues identified during the beta-test included the need for quality control or an expert review of species identification in ROaDS observations. This function was developed for Phase 1 on Montana State University servers, but in the future, it will be transferred to a function within DOI agencies so their staff can conduct the expert reviews to maintain the quality of the data. For future reviews of ROaDS data and species identification, this functionality and data will stay within the confines of the DOI's own IT security and firewalls.

3. PHASE 2 OBJECTIVES

This report focuses on Phase 2, which was a simple and truncated project lasting four months. It sought to develop recommendations for the next and final effort of Phase 3, when additional funding becomes available to complete the project. It aimed to simplify the data collection survey that what was beta-tested in Phase 1 and to explore the development of national standards for WVC data collection systems to be adopted with other stakeholders. Phase 2 had two tasks that are described below.

3.1. Task 1: Development of Preliminary WVC Data Collection Standards

Phase 2 sought to develop recommendations for the DOI's data standards that will be incorporated into ROaDS during Phase 3. The WTI research team (WTI Team) worked with the project's Technical Advisory Committee (TAC) to explore several options for NPS and FWS standards for ROaDS data collection. These could also be used by other DOI agencies with access to the ESRI Survey123 platform. These data requirements and other specifications will serve to initiate a discussion with other stakeholders who use WVC data collection systems on common national standards.

3.2. Task 2: Recommend Modifications for the ROaDS Survey

The second objective was to review and make recommendations to modify the ROaDS survey's data collection fields. The WTI Team used the information collected in Task 1 of Phase 2, as well responses and suggestions from beta-test volunteers in Phase 1, to develop recommendations for modifying the ROaDS survey on the ESRI Survey123 mobile device application for the NPS, FWS and other DOI bureaus and agencies. These will require the modification of data fields and the information they collect in the ROaDS survey before it is deployed across parks, refuges and other DOI land management systems in Phase 3. It is envisioned that this will be a simpler ROaDS survey than what was created in Phase 1.

In the beta-test of the Phase 1 ROaDS survey, many of the beta-test volunteers commented that there was too much information being collected at each roadkill site. For example, they stated that the species list was too complex – in addition to common names, the pulldown list on the ROaDS survey had the scientific names, or Latin binomials of all North America mammals, birds, reptiles and amphibians; literally thousands of scientific names.

In addition, the WTI Team was asked to determine whether a new function could be added to the ROaDs survey, specifically one that records the path of the monitoring route the observer traveled, and the amount of time spent on the route (time and effort). Each individual observation, its geo-synched photo and other data would be linked to a map of the route taken by the observer. This helps differentiate whether an observation was made during a planned data collection survey or was simply an opportunistic observation. This new functionality would be very useful for monitoring programs and research efforts.

A ROaDS User's Manual based on the recommended changes to the survey’s data fields is planned to explain the ESRI Survey123 application, the updated ROaDS survey, and its use for

collecting data for Phase 3. In addition, the User's Manual will explain how DOI employees register to use the ROaDS survey as well as how to access the ESRI cloud-based data that has been collected.

In Phase 3, further development of a comprehensive User's Manual will describe the different ways to generate, display and interpret the stored data on the ESRI cloud for reports and how to incorporate the information into NPS/FWS planning processes. Phase 3 will expand the Manual to incorporate descriptions of the different methods available to analyze and interpret WVC clusters and explain basic predictive models that could be used to identify the risk of WVCs for driver safety and mitigation efforts.

4. PHASE 2 RESULTS

4.1. Task 1: Development of Preliminary WVC Data Collection Standards

The WTI Team, with advice from the TAC, developed the following recommendations for the DOI's data standards that are to be incorporated into the ROaDS survey in Phase 3.

1. Location Accuracy Standard: each wildlife observation shall be located in the field, at the time of the observation, using a reliable GPS system and have a location accuracy that does not exceed ±10 meters (m).

The WTI Team reviewed the various WVC data collection systems currently in use to determine the relative spatial accuracy that exists. Many WVC data collection systems are web-based. This type of system allows observers to collect field data but some of these systems do not require them to mark the GPS location while at the site. If they are not connected to the internet, the observation's location can be identified later when the observer is in their office and gets online, often after a significant amount of time has elapsed. These systems often have web-based maps using satellite imagery, topographic contours or similar base layers to help observers pinpoint the observation location via their computer screen. Other WVC systems use paper and require the location of the observation to be estimated as a distance from mile posts or other physical roadside markers. Both of these types of systems, as well as other similar systems, lead to observations with very low spatial accuracy.

Location accuracy based on current mobile device GPS technology is quite accurate. For a Utah WVC Data collection project, researchers using a commercially available GPS handheld location device had a median location error of ±2.5 m, while smart phones had a median location error of ±4.6 m to ±5.2 m, depending on the model (Olson et al. 2014). Thus, setting location accuracy standards of ±10 m or less using existing readily available commercial technologies and products seems to be a reasonable national standard.

ROaDS, which is based on the GPS incorporated into commercial mobile devices – smart phones or tablets – will meet this location accuracy standard of ±10 m.

2. Expert Review Standard: The identification of the species present in each observation must be reviewable by an expert. To do so, a geo-synched photo must be linked with all observations by non-experts.

Often WVC data collectors, particularly non-biologists, may inadvertently mis-identify the species in the observation. Proper identification can often be complicated by the poor condition of the carcass which may be partially destroyed or defaced by the collision, poorly preserved due to the amount of time elapsed after the collision, or partially scavenged by other animals. For quality control purposes, a post-field collection review must be available in the WVC data collection system.

Such a methodology should allow a wildlife expert to review the accuracy of each observation's determination of the species. To maintain quality control of the species identification accuracy of

a WVC data collection system database, the system must have data gathered so that observations can either be sampled to determine species identification accuracy of the entire database, a sub-component of the database (e.g., year, geographical area, highway segment, species), or to evaluate individual observations of interest.

The ROaDS system has a geo-synched photo capability, so that a photo of the animal/carcass can be collected along with the other information at an observation site. The ROaDS survey has another data field that helps identify potentially misidentified species to complement the geo-synched photo. There is a data field that asks observers to list their confidence in proper identification – either high or medium-low. Thus, NPS, FWS or other DOI agency experts can query the ESRI data base to locate, review and correct all observations with medium-low identification confidence, using the geo-synched photos. This allows quality control for the identification of species via the ROaDS expert review process.

3. Standardized National Species List: A relatively short species list of the most frequently observed animals of interest from across the U.S., using their common names, will be provided to the observer to choose from while making a data collection observation. In addition, the WVC data collection system shall provide the flexibility for the data collector to identify and record species not on the list.

There are thousands of species of animals in the United States. For observers, choosing from such a high number of species on an electronic list on their mobile device can be onerous. To make WVC data collection systems efficient, a short list of the most frequently occurring, and broadly distributed, species should be named on the list. For example, the vast majority of WVCs, up to 90 percent, reported in North America involve deer, *Odocoileus spp.* (Huijser et al. 2007).

An abbreviated electronic list of the 10, 20 or 30 most common species still will not capture all the different species that might be needed for any particular observation or monitoring program by the NPS, FWS and their stakeholders. Thus, the WVC data system must allow for other species names to be added, including domestic animals, so the full diversity of species can be captured by the system.

The recommended national list of animals for the ROaDS survey has 16 of the most common species in North America on its pull-down list for observers to choose (Table 1). Fourteen are native species and two are very common domestic animals, cats and dogs. The ROaDS survey also allows data collectors to write in a species not on the list, and has provided four categories: Domestic livestock, mammal, reptile/amphibian or bird (Table 1). The truncated species list and the optional boxes will allow the ROaDS system to collect the name of any dead or live animal on or along a road in the United States.

Table 1. Recommended ROaDS Survey's Standard Species List

Species or Taxonomic Category

1. Whitetail deer
2. Mule deer
3. Unknown deer species
4. Moose
5. Elk
6. Pronghorn antelope
7. Raccoon
8. Striped skunk
9. Opossum
10. Armadillo
11. Black bear
12. Mountain lion/ panther/ cougar
13. Coyote
14. Red fox
15. DOMESTIC: Cat
16. DOMESTIC: Dog
17. DOMESTIC: Livestock (TEXT BOX)
18. OTHER: Mammal (TEXT BOX)
19. OTHER: Reptile/amphibian (TEXT BOX)
20. OTHER: Bird (TEXT BOX)

4.2. Task 2: Recommend Modifications for the ROaDS Survey

The WTI Research Team worked with the TAC to review the data fields that were utilized in the beta-test of the ROaDS survey in Phase 1 (Figure 3) and determined ways to streamline and simplify the data to be collected across all NPS and FWS management units. In Phase 1 there were eleven different data fields, but after the beta-test some of these were deemed unnecessary or unnecessarily complicated. The revised data fields recommended to be used in Phase 3 include just seven fields (Figure 4).

Data Field No.	Data Field	Type of Data Field	Comments
1	Name of animal observed		Different wildlife groupings
1a	Common Name (single line text)	Text	Allow 100 characters
1b	Scientific Name (single line text)	Pull-down auto-	Official latin binomials for mammals, birds, reptiles and amphibians of the U.S.
2	More than one animal observed?	2 Buttons	No and yes, if yes, type number in blank field
3	Animal(s) observed is dead or dying?	2 Buttons	Dead, dying
4	Observer witnessed crash or found carcass	3 Buttons	Witnessed crash, found carcass, other
5	Is there an accident report?	3 Buttons	Yes, no, I don't know
6	Observer's proximity to animal when recording data	3 Buttons	< 10 feet, 10 feet to 100 yards, > 100 yds (type distance in blank field)
7	Observer's confidence in their species ID	3 Buttons	High, medium, low
8	Observer's mode of travel	Pull-down	Commercial vehicle, personal vehicle, agency vehicle, bicycle, pedestrian, other
9	Observation is part of a survey or random occurrence	2 Buttons	Random or if survey, blank field allows observer to describe survey
10	Take a photo (geo-referenced)	Button	1 photo - it is optional
11	Comments	Text	Allow 140 characters

Figure 3. Standard data fields used in Phase 1 of ROaDS as part of beta-test of data collection system.

Data Field No.	Data Field	Type of Data Field	Type of Data Field		Comments
			Button (Y/N/other	Pull Down	
1	Location of observed animal	Map with locator flag	x map pin		Compass button or map pin
2	Species observed	Pull-down menu	X?	X	Most common WVC species list using common names or text box
3	Take a photo*	1 button			Geosynched photo(s)
4	Confidence in spp. identification	2 buttons	X		High; Medium/Low
5	Animal status	3 buttons	X		Dead; Alive Crossing Road; Alive Near Road (< 100 yards from road)
6	Number of animals observed	2 buttons	X		1; More than 1 --> drop-down scroll with numbers
7	Comments*	Text box		X	Allow 140 characters

Figure 4. Recommended national standard data fields for DOI agencies for use in the ROaDS survey. * Optional data field

4.2.1. Phase 1 Data Fields That are Recommended to be Removed

The WTI Team recommended that data fields 4 and 5 (Figure 3) be removed from the Phase 1 ROaDS survey since they were duplicative of law enforcement data collection. Most crashes with large animals that cause human injuries, human fatalities and significant vehicle damage are captured by national park and wildlife refuge law enforcement officers attending the crash. Thus, WVC data for these events will be stored and accessible in agency databases.

Upon further review after the beta-test, data fields 6 and 8 were deemed non-essential information. Knowing the proximity of the observer to the animal when recording observation data provided information that could not be used for either safety analysis purposes or to determine conservation values. Lastly, data field 9 which asked if the observation was random and opportunistic or part of a planned monitoring route was removed. A new function that records the monitoring route taken by the data collector has been recommended to be added to the ROaDS survey.

To summarize, the following five data fields have been recommended to be removed from the ROaDS survey (Figure 3):

Data Field 4. Observer witnessed crash or found carcass
Data Field 5. Is there an accident to report?
Data Field 6. Observer's proximity to animal when recording data
Data Field 8. Observer's mode of travel
Data Field 9. Observation is part of a survey or random occurrence

4.2.2. Phase 1 Data Fields That are Recommended to be Modified

There were several data fields that were modified as a result of Phase 1 user feedback after the beta-test of the ROaDS survey and further exploration of the most useful and efficient information that should be collected for the DOI land management agencies. The names of the species – common and/or scientific - and the recording of whether the animal observed is dead or injured have been addressed with new recommendations.

The WTI Team recommended that the names of the species available in the pulldown list should be modified, simplified and shortened from the Phase 1 ROaDS survey. The Phase 1 ROaDS survey had both common and scientific name options in their species lists, depending on the observer's expertise.

The species name lists were very extensive in Phase 1. The pull-down list for experts in the Phase 1 ROaDS survey included the scientific name (Latin binomial) of every North American species of mammal, bird, reptile and amphibian. The list included thousands of species known to be present in North America, and their official scientific names, as listed by their professional associations (i.e. American Ornithologists' Union for birds). The scientific names were automatically filled as they were typed out to reduce the input time.

The Phase 1 ROaDS survey also allowed for common names to be recorded for observation of dead or injured species (see Figure 3; data fields 1, 1a, 1b). It is now recommended that the naming of species be shortened to a list of 16 species using their common names, with an option to type in additional names of species not on the list, using either their common or scientific names (Table 1). This same species list in the ROaDS survey is recommended to be the national standard (see this report's Results, Task 1, National Standard 3).

B: AUTOMATIC / POST-COLLECTION PROCESSED FIELDS - derived from core data fields or the mobile devices' GPS					
	Data Field	**Type of Data Field**			**Comments**
1	Name of Data Collector/Collector ID	Auto-filled	Required		Auto-filled: Information included in registration
2	Data Collector's Email Address	Auto-filled	Required		Auto-filled: Information included in registration
3	Type/Expertise of Data Collector	Auto-filled	Required		Auto-filled: Information included in registration
4	Date Data is Collected	Auto-filled	Required		Automatically collected from mobile device
5	Time of Day Data is Collected	Auto-filled	Required		Automatically collected from mobile device
6	Incident Location	Auto-filled	Required		Automatically collected from mobile device
7	FLMA Region	Auto-filled			Processed after data collected, based on lat-long
8	Agency Management Unit	Auto-filled			Processed after data collected, based on lat-long
9	State	Auto-filled			Processed after data collected, based on lat-long
10	County	Auto-filled			Processed after data collected, based on lat-long
11	City or Township	Auto-filled			Processed after data collected, based on lat-long
12	Road/Highway Identification	Auto-filled			Processed after data collected, based on lat-long
13	Number of Lanes	Auto-filled			Processed after data collected, based on lat-long
14	Posted Speed Limit	Auto-filled			Processed after data collected, based on lat-long
15	Type of Staff (resource management, law enforcement, admin, etc.)	Auto-filled			Auto filled information included in registration

Figure 5. Automatically collected ROaDS data, or data that can be filled after field collection. Red data field 15 is additional auto-filled information that was not available in Phase 1.

The ROaDS survey in Phase 1 only recorded dead or dying animals (Figure 3, data field 3). After further reflection, the WTI Team and TAC agreed to add the option of recording live animal crossings and live animal sightings adjacent to the road that are within 100 yards of the road's surface (Figure 4, data field 5). It was deemed important to capture the locations where habitat connectivity and traffic levels currently allow wildlife to safely cross highway segments. This type of information, and the road segments they identify, would identify important areas that will need to be protected in future highway expansion projects, transportation plans, or when increases to traffic volumes or infrastructure expansion are envisioned.

4.2.3. Data Fields that are Recommended to be Added for Phase 3

To allow for quality control of the ROaDS database, particularly for species identification, it is recommended that the relevant qualification of the observer be attached to the observation records in the ROaDS survey (See Figure 5, data field 15). Thus, as part of registration process to use the ROaDS survey, DOI employees will disclose whether they are employed by the DOI agency as a biologist, natural resource specialist, or other type of expert.

4.2.4. Development of an Updated ROaDS User's Manual

A ROaDS User's Manual based on the recommended changes to the survey's data fields was developed to explain the ESRI Survey123 application, the updated ROaDS survey and its use for collecting data. In addition, the ROaDS User's Manual explains how to access stored data on the ESRI cloud and the types of visual reports that can be generated from the data stored there. As a result, the User's Manual can be utilized to support a beta-test of the revised ROaDS survey in Phase 3.

4.2.5. Development of a Route Tracking Capability in the ROaDS Survey

The WTI Team also sought to determine if ESRI Survey123 had the capability to simultaneously track the survey route of observers while they collect observations, as well as record the amount of time spent on the route collecting ROaDS information. This helps differentiate whether an observation was made during a planned data collection survey (monitoring or research) or was simply an opportunistic observation.

The WTI Team explored the development of a route tracking function within the ROaDS survey that can be used in Phase 3. ESRI Survey123 does not allow the route of the observer to be automatically recorded. Instead observers must manually enter location data points (way points) beginning at the start of their planned survey, periodically as they travel along their route, and at the end of their planned survey. Observers will be encouraged to manually add way points to their route more frequently if their route becomes complex since way points are connected with straight lines when displayed (e.g., curvy road, turns at intersections, a route with many turns on to different roads). When collecting each waypoint, the ROaDS survey would save the current location of the mobile device/observer, as well as the GPS time stamp for that waypoint in local time. The WTI Team acknowledges that this is not an ideal route tracking system, but ESRI's Survey123 tool does not allow observers to track their route automatically. Thus, it is not recommended that this inefficient and cumbersome route and time recording function be integrated into the Phase 3 ROaDS survey. Instead, it is suggested that it be used by researchers and in monitoring programs for particular management units or roads segment of interest. Additional methods to record survey routes will be explored in Phase 3.

4.2.6. Seeking Partners to Cooperatively Develop National Standards

The ROaDS project aims to determine if there is broad agreement on the standard data to be collected, its spatial accuracy, and reliability. If so, this consensus would allow for recommending a multi-agency standard. This would facilitate WVC data collection and sharing among various agencies, citizen science projects, and a variety of different WVC data collection systems, including ROaDS. Thus, data collected by Department of Interior agencies via ROaDS

could be shared more easily with other federal and state agencies and non-profit organizations. Conversely their data could be incorporated into ROaDS data for use by DOI FLMAs.

The WTI Team and the TAC have scheduled meetings and a workshop for Phase 3. The International Conference on Ecology and Transportation (ICOET) held its biennial meeting in Sacramento, CA in late September 2019. The WTI Team submitted an abstract on the ROaDS project that was accepted by the conference as a poster, so the WTI Team and TAC members in attendance at ICOET had the opportunity to discuss the project with many different agencies and NGO representatives. In particular, it allowed the ROaDS project's proponents to start the process of seeking partners for Phase 3 efforts to establish national WVC data collection standards.

At ICOET, a side meeting was also held by the Transportation Research Board's Committee on Ecology and Transportation (ADC 30). Working with the ADC 30 chairman, the side meeting included a 30-minute session to discuss the development of national standards for WVC data collection systems. This served as another opportunity for the ROaDS members in attendance to recruit, encourage and begin development of common sense standards among federal, state, local and tribal authorities. This effort to seek broad approval will increase the potential for future adoption of standards by FWS, NPS and their stakeholders.

There is also a plan to continue the activities developed at the side-meeting in California in September. The WTI Team and TAC with ADC 30's support, submitted a proposal for a 2-hour workshop to develop national standards for WVC data collection systems at the TRB's Annual Conference in Washington, DC in January 2020. The workshop proposal has been accepted, and this workshop championed by the ROaDS project will be included in the work plan for Phase 3.

5. CONCLUSIONS

During Phase 2, the ROaDS project made substantial progress toward its two objectives.

With regard to the first objective, the WTI Team developed several useful national standards for future discussion with partners. They are:

- Location Accuracy Standard: each wildlife observation shall be located in the field, at the time of the observation, using a reliable GPS system and have a location accuracy that does not exceed ±10 meters.

- Expert Review Standard: The identification of the species present in each observation must be reviewable by an expert. To do so, a geo-synched photo must be linked with all observations by non-experts.

- Standardized National Species List: A relatively short species list of the most frequently observed animals of interest from across the U.S., using their common names, will be provided by the WVC data collection system for the observer to choose from while making a data collection observation. In addition, the WVC data collection system shall provide the flexibility for the data collector to identify and record other less common species not on the list.

The ROaDS survey on the ESRI Survey123 application will be able to meet each of the above standards. Its national list of species using their common names totals sixteen. In Phase 3, the ROaDS project will discuss an effort to reach consensus on these and other national standards.

For the ROaDS project's second objective, the WTI Team modified the ROaDS survey so it is shorter, easier to use and more efficient. To accomplish this, the WTI Team removed five data fields from the Phase 1 survey and modified two additional data fields. The team also recommended that the complicated species list of both scientific and common names should be shortened and only use common names. Another recommendation included adding the ability to report successful wildlife crossings to the data field that previously only allowed dead or dying animals to be captured in the Phase 1 survey.

The only data field that was recommended to be added will be an automatically filled data field that determines whether the observer is an expert or not. This information is already gathered during the registration process. When observers register to receive the ROaDS survey, one of the fields they fill out is their professional title, so if they are a biologist or natural resource specialist, this will be attached to each of their data observations.

The WTI Team determined that the ESRI platform supporting the ROaDS survey can also simultaneously capture the observer's survey route and link each individual observation to the route taken. However, this function cannot be automatically recorded using ESRI Survey123. The ROaDS observers must manually enter the beginning and ending location of their route as well as multiple locations along their path. Thus, due to the inefficiency of the function, it is recommended not to include it in the Phase 3 ROaDS survey. Instead, for research or monitoring projects, it can be added to specific individuals or management unit teams to provide a function

that captures the observers' route, how long they took to complete the route and each individual observation they made while on that route.

Lastly the WTI Team and TAC have begun to engage other agencies and organizations to jointly develop national standards for WVC data collection systems. They have already engaged others via a poster presentation at an international conference, and they have plans to engage more at an upcoming national meeting and a potential national workshop. The effort to engage with partners to develop national WVC data collection system standards will be more robustly developed in Phase 3.

6 REFERENCES

Ament, R, Clevenger, AP, Yu, O, Hardy, A. 2008. An assessment of road impacts on wildlife populations in U.S. national parks. Environmental Management, 42(3):480-96.

Bil, M, Hubecek, J, Sedonnik, J, Andrasik, R. 2017. Srazenazver.cz: A system for evidence of animal-vehicle collisions along transportation networks. Biological Conservation, 213, 167-174.

Bissonette, J., Kassar, C., & Cook, J. (2008). Assessment of costs associated with deer–vehicle collisions: human death and injury, vehicle damage, and deer loss. Human-Wildlife Conflicts 2:17–27.

Clevenger, AP, Kociolek, AV, Allen, TDH. 2015. Assessment of road impacts on wildlife populations in National Wildlife Refuges and National Fish Hatcheries in Region 5. A report to US Fish and Wildlife Service, Region 5. 55 pp.

Creech, T, McClure, M, Callahan, R. 2016. High-Risk Zones for Ungulate-Vehicle Collisions during Montana's Fall Migration Season. Policy report, Center for Large Landscape Conservaton, Bozeman, MT. Online: https://largelandscapes.org/wp-content/uploads/2019/03/High-Risk-Zones-Ungulate-Vehicle-Collisions-Montana-Fall-Migration.pdf

Donaldson, BM, Lafon, NW. 2010. Personal digital assistants to collect data on animal carcass removal. Transportation Research Record, 2147: 18-24.

Donaldson, B. 2017. Improving animal-vehicle collision data for the strategic application of mitigation. Final report, VTRC 18-R16. Virginia Transportation Research Council, Charlottesville, VA, USA.

Huijser, MP, Galarus, DE, Hardy, AR. 2006. Software for Pocket PC to collect road-kill data. Poster presentation. Page 640 in *Proceedings of the 2005 International Conference on Ecology and Transportation*, eds. C.L. Irwin, P. Garrett, and K.P. McDermott. Raleigh, North Carolina: CTE-NCSU, 2005.

Huijser, M.P., P. McGowen, J. Fuller, A. Hardy, A. Kociolek, A.P. Clevenger, D. Smith & R. Ament. 2007. National wildlife-vehicle collision reduction study. Report to Congress. U.S. Department of Transportation, Federal Highway Administration, Washington D.C., USA.

Huijser, MP, Fuller, J, Wagner, ME, Hardy, A, Clevenger, AP. 2007. *National Cooperative Highway Research Program Synthesis 370: Animal-Vehicle Collision Data Collection.* Transportation Research Board of the National Academies, Washington, D.C.

Huijser, MP, McGowen P, Clevenger AP, Ament R. 2008. Best practices manual, wildlife-vehicle collision reduction study, Report to U.S. Congress. Federal Highway Administration, McLean, VA.

Olson DD, Bissonette JA, Cramer PC, Green AD, Davis ST, et al. (2014) Monitoring wildlife-vehicle collisions in the information age: How smartphones can improve data collection. PLoS ONE 9(6): e98613. doi:10.1371/journal.pone.0098613

Shilling FM, Waetjen DP. 2015. Wildlife-vehicle collision hotspots at US highway extents: scale and data source effects. In: Seiler A, Helldin J-O (Eds) Proceedings of IENE 2014 International Conference on Ecology and Transportation, Malmö, Sweden. Nature Conservation 11: 41–60. doi: 10.3897/natureconservation.11.4438

Sullivan JM. 2011. Trends and characteristics of animal-vehicle collisions in the United States. J Safety Res 42, 9–16.

Vercayie D, Herremans, M. 2015. Citizen science and smartphones take roadkill monitoring to the next level. In: Seiler A, Helldin J-O (Eds) Proceedings of IENE 2014 International Conference on Ecology and Transportation, Malmö, Sweden. IENE 2014. Nature Conservation 11: 29–40. doi: 10.3897/natureconservation.11.4439