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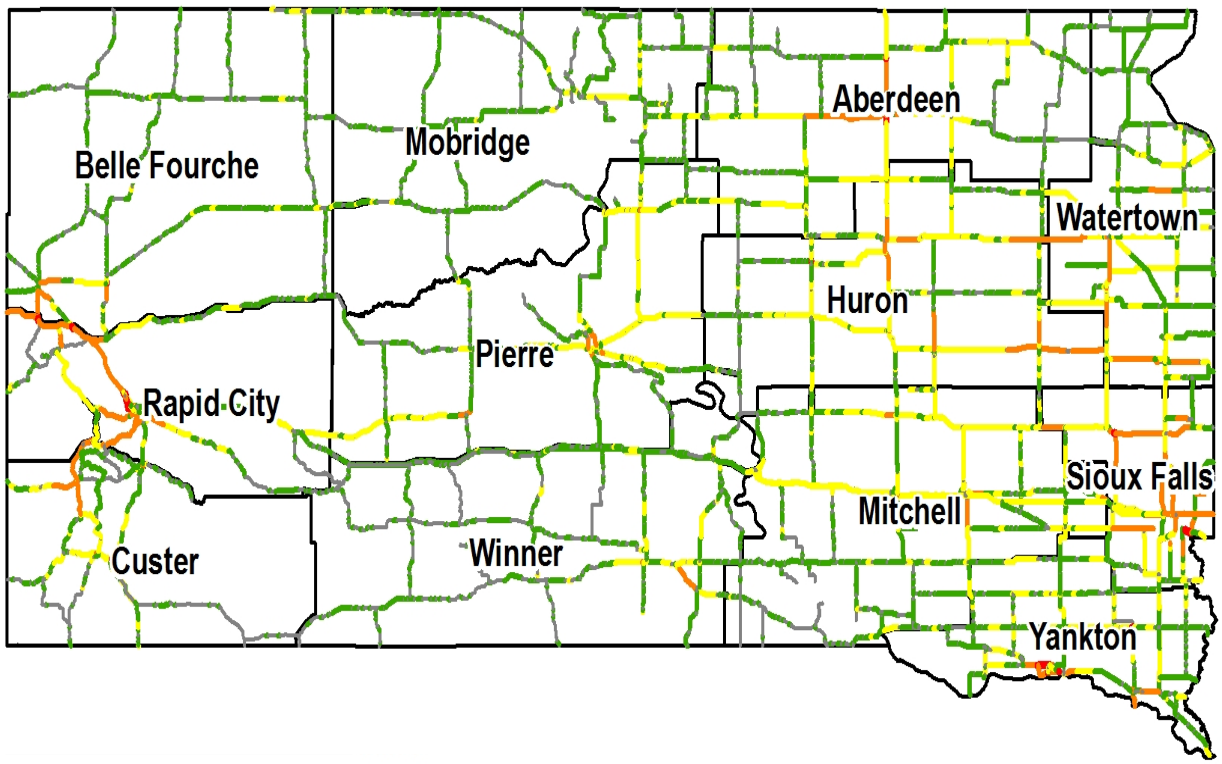

Reducing WVC in South Dakota

Study SD2014-03
Final Report

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DISCLAIMER

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16. Abstract

WVC (WVC) are a safety, ecological, and economic problem in South Dakota. This research examined the extent of the WVC challenge in South Dakota through: analyses of South Dakota Department of Public Safety (SDDPS) crash data, South Dakota DOT (SDDOT) and South Dakota Game Fish and Parks (SDGFP) wildlife carcass data, Tribal reservations' data, mapping, and a review of how data are collected and shared. There was an annual average of 4,696 WVC crashes reported to the SDDPS from 2004 through 2013. At an average value of $17,343 per property damage only crash, and greater costs for human injury and fatal crashes, the total cost to the South Dakota public exceeded $107.9 million annually. There are also ecological costs. Using research from Utah that found 5.26 more mule deer carcasses along roads than reported WVC crashes, it was estimated that 24,700 large wild animals are killed each year in South Dakota. To address these challenges, the research generated 15 recommendations for actions, including: Memoranda of Understanding and Agreement between SDDOT and other agencies to collect accurate, timely, and electronic data on WVC crashes, and WVC carcasses, that are placed in central electronic locations. Annually, SDDOT should map WVC crash data and work with SDGFP in developing State Transportation Improvement Programs and Long Range Plans, and other transportation actions.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

TABLE OF ACRONYMS

Acronym	Definition
AADT	Average Annual Daily Traffic
AVC	Animal-vehicle collision, can include domestic animals as well as wildlife
AZDOT	Arizona DOT
AZGF	Arizona Game and Fish
CDOT	Colorado DOT
CDFW	California Department of Fish and Wildlife
CROS	California Roadkill Observation System
DOT	Department of Transportation
ESA	Endangered Species Act
FHWA	Federal Highway Administration
FTP	File Transfer Protocol
GIS	Geographic Information Systems
GPS	Global Positioning System
HWY	Highway
ILT	Incident Location Tool
IPLAN	A web-based portal for Idaho agency personnel to access GIS data
ITD	Idaho Transportation Department
IDFG	Idaho Fish & Game
LAT/LONG	Latitude and Longitude bearings for a geo-referenced location
LHRS	Linear Highway Referencing System
MDT	Montana DOT
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MRM	Mile Reference Marker
MTFWP	Montana Fish Wildlife and Parks
NEPA	National Environmental Policy Act
NESCA	Nebraska's Non-Game Endangered Species Conservation Act
NDOT	Nevada DOT, and Nebraska DOT
NDOW	Nebraska Department of Wildlife
NMGF	New Mexico Game and Fish
NMDOT	New Mexico DOT
OMTO	Ontario Ministry of Transportation
ODOT	Oregon DOT
ODFW	Oregon Department of Fish and Wildlife

PAS	Passage Assessment System
PI	Primary Investigator
PDO	Property Damage Only Crashes
QA/QC	Quality Assurance/Quality Control
SDARS	South Dakota Accident Reporting System
SDDOT	South Dakota Department of Transportation
SDGFP	South Dakota Game Fish and Parks
SDDPS	South Dakota Department of Public Safety
STIP	Statewide Transportation Improvement Program
TAMS	Transportation Asset Management System
T&E	Threatened & Endangered
TEG	Technology Enterprises Group, Inc.
TraCS	Traffic and Criminal Software
TXDOT	Texas DOT
UC	University of California
UPLAN	An interactive GIS mapping platform on the Internet for Utah agency personnel
USDA	United States Department of Agriculture
USDOT	United State Department of Transportation
UDOT	Utah Department of Transportation
UDWR	Utah Department of Wildlife Resources
VMS	Variable Message Signs
WGA CHAT	Western Governors Association Crucial Habitats Assessment Tool
WISDOM	Wyoming Interagency Spatial Database and Online Management System
WSDOT	Washington DOT
WYDOT	Wyoming DOT
WYGFD	Wyoming Game and Fish Department
WVC	WVC

1 EXECUTIVE SUMMARY

South Dakota Department of Transportation (SDDOT) recognizes that wildlife-vehicle collisions (WVC) are a safety problem for motorists and an ecological problem for wildlife populations across the state. This research project was initiated to help identify solutions for reducing these collisions. Research results are reported that address the problem of WVC and the work being conducted and needed in order to help reduce these collisions.

1.1 Problem Description

South Dakota averages close to 5,000 reported WVC on its roads and highways each year. From 2004 through 2013 there were 46,961 accurately reported crashes due to collisions with wildlife in South Dakota for an annual average of 4,696 reported WVC (data from South Dakota Department of Public Safety, (SDDPS)). This average can be translated into annual costs incurred to society in 2015 dollars by taking the average number of reported collisions of different severity types and multiplying the monetary value SDDOT places on those collisions. SDDOT estimates the crash costs of reported accidents using two values: a $378,800 average for every crash with fatalities or injuries to humans, and a $17,343 average for every property damage only (PDO) crash. Between 2004 and 2013 there was an annual average of 1.5 human fatalities, and 735 reported crashes with human injuries that were incurred by WVC reported on South Dakota roads. The cost of reported crashes with wildlife in South Dakota is valued at over one hundred million dollars annually.

Reported WVC crashes on all South Dakota roads cost the public an average of $107.9 million every year.

Collisions with wildlife that result in reported crashes are typically with hooved wild animals, (ungulates), whose value lost to South Dakota can also be estimated. These monetary values are difficult but not impossible to estimate. To estimate the numbers of ungulates killed in WVC, an estimate of the collisions not reported can be generalized through multiplying values from western state studies. In Utah, the ratio of roadside mule deer and other large wildlife carcasses to reported crashes was found to be 5.26 carcasses for every one reported crash (Olson et al. 2014a). If the 5.26 correction value from Utah is used, South Dakota's 4,696 reported crashes with ungulates may equate to as many as 24,700 large ungulates lost to WVC in South Dakota annually.

The majority of collisions with wild animals across the U.S. is with deer (Insurance Information Institure 2012), hence calculations for the value of wild animals lost are focused on deer. In 2015 South Dakota Game Fish and Parks (SDGFP) placed a value of $1,000 for a single mule or white-tailed deer and upwards of $5,000 for a trophy buck of either species (South Dakota State Legislature 2015) when used in valuing animals killed by poachers. These values were used in this valuation. If it is assumed that 95 percent of the collisions involved typical deer (at $1,000 each), and 5 percent of collisions were with trophy deer (at $5,000 each), then the equivalent value equals (.95 x 24,700 x $1,000) + (.05 x 24,700 x $5,000) = $29.6 million.

It is estimated that each year South Dakota loses an average of over 24,700 large ungulates due to collisions with vehicles, at a cost of over $29.6 million to the South Dakota public.

With such large monetary consequences from crashes with wildlife, and other impacts to both the motoring public and the survival of wildlife populations, it is recommended that South Dakota create standardized protocols for evaluating and addressing WVC These protocols include a systematic, reliable system of reporting WVC crashes and carcasses; coordinated data collection and sharing among agencies; the incorporation of WVC data and maps of wildlife habitat into transportation planning; and processes for using this information to implement, conserve, and enhance wildlife crossing structures and other mitigation. This SDDOT study is a stepping stone on the road to South Dakota becoming more proactive in identifying problem areas where roads may be barriers to wildlife movements and where there are increased risks of WVC. Ultimately these efforts will assist the state in developing the necessary mitigation to help preserve wildlife populations and protect the driving public.

1.2 Objectives of the Study

Objective One: Evaluate existing WVC tracking and data collection systems and coordination among stakeholder agencies and identify needed improvements.

Objective Two: Develop a plan to improve collaboration among multiple South Dakota organizations and agencies with common goal of reducing WVC.

Objective Three: Develop guidance premised on best practices for reducing WVC in South Dakota.

1.3 Study Findings

1.3.1 The State of the Practice of WVC Reporting, Analyses, Modelling, and Mitigation

The researchers contacted colleagues in departments of transportation and wildlife agencies in eight western U.S. states and one Canadian province to learn of the state of current practices for defining WVC hotspots and creating solutions. Overall the researchers found these states share the following characteristics for this practice:

1. All states and the one Canadian province (Ontario) surveyed have WVC crash data from law enforcement and safety departments, and this is the source of most state WVC hotspot maps.

2. Carcass data collection is often mandated, but loosely enforced, and without the necessary resources for data management, thereby creating databases that are unreliable in evaluating the problem of WVC at the state scale.

3. Several states created wildlife linkage maps which represent models depicting large ungulate habitats and hypothesized connections among habitat patches. These wildlife linkage maps are combined with WVC hotspot maps to better inform agencies of the potential areas for wildlife mitigation.

4. Several states and Ontario have begun creating, and Idaho has completed, a standardized WVC prioritization process that sets protocols for how information on ecological resources and traffic safety are brought together to identify priority areas to mitigate for wildlife movement.

1.3.2 The State of the Practice: Evaluation of South Dakota Systems to Identify WVC

The research identified three steps where the current systems work to identify high priority areas for WVC problems, and how these processes could be further improved. These steps are: WVC crash and carcass data collection, mapping of crash data, and agency collaboration and cooperation.

Collection of WVC Crash Data

The first task of identifying WVC hotspots on South Dakota roads is to use the WVC crash database. The crash data are collected by safety officers with automated computer software that allows them to select “wild animal” as a cause of the collision, and to report crash locations by selecting the location on maps within the programs. These data are uploaded to SDDPS where the entries are checked for accuracy and uploaded to the South Dakota Accident Reporting System (SDARS) database. This database houses the collection of crash data points that then can be used to create a map of WVC crashes across the state on SDDOT maintained roads.

Mapping of WVC Crash Data

The SDDPS crash dataset was queried by SDDPS and researchers in this project using the term "wild animal" to identify all reported crashes on both state and local roads that involved wildlife. The 2004-2013 database included 46,960 records. Of these records, 46,650 had correct geographic coordinates and were mapped in a Geographic Information Systems (GIS) for exploration and analysis (Figure 1). This map displays the crash rates with colors for each highway-segment ranging from green, which indicates lower crash rates for reported wildlife-vehicle crashes, to orange and red for the road segments with the highest crash rates.

Road segments with the highest rates of WVC crashes, orange and red segments on the map, contained 34 percent of all the reported crashes, and occurred on just nine percent (770 miles, 1,239 kilometers, km) of all the SDDOT administered roads. These locations help focus efforts to locations where mitigation is most needed.

Over the ten-year period, 2004 – 2013, 28 percent of all reported crashes involved a wild animal.

Sixty-seven percent of all reported WVC reported crashes were on SDDOT administered highways

This initial step of mapping and categorizing the reported crashes with wildlife can help agency personnel begin to address problem areas with the data and actions described below.
The top recommended improvement on the current crash reporting system is to:

1. Create an entry field in the electronic data and paper data forms so that officers may indicate the species of wild animal involved in crashes.

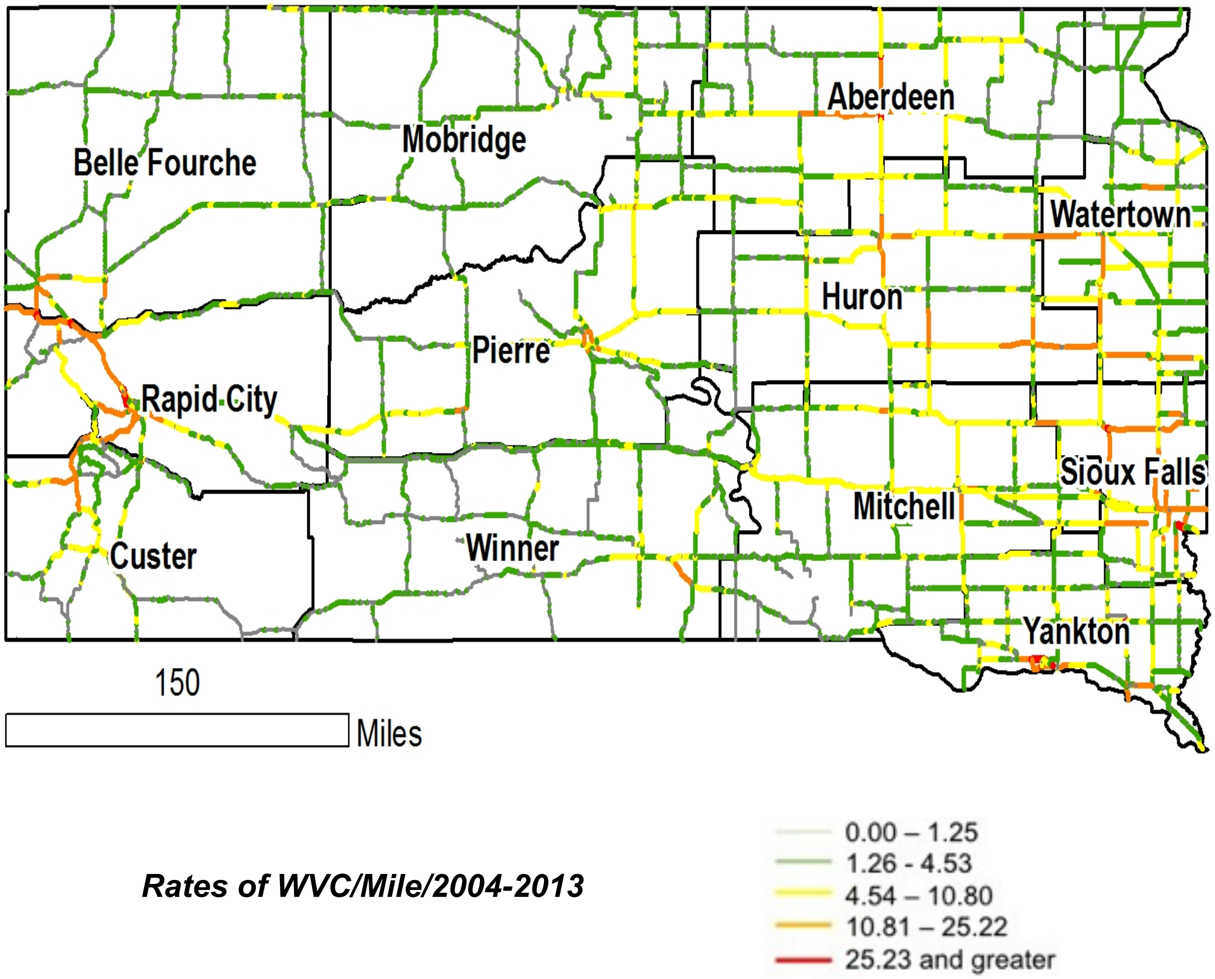

Figure 1. WVC Reported Crashes Hot Spots Within South Dakota 2004 -2013. Mapped WVC are over the 10-year time period.
Note: Divisions Among Colors Were Created with Jenks Optimization Method.

WVC Carcass Data

Third party contractors clean up wildlife carcasses on select SDDOT administered roads and record this information on paper or electronic data sheets that record the date, species of animal, gender, and latitude and longitude of the location of the carcass. However, the collection and accuracy of data, and how the data are compiled and shared are inconsistent. The unreliable nature of the data and processes for transferring data to a central location severely limit the utility of these data in evaluating the magnitude of WVC including the species involved. Ideally, both SDDOT and SDGFP would:

1. Enforce a standardized process within the state to ensure all carcass data reports from every region and district within SDDOT are turned into the SDGFP Wildlife Damage Program Administrator on a quarterly basis (at minimum).

2. Cleary write carcass pickup contracts so that contractors are not paid until complete and accurate data sheets are submitted.

3. Standardize a process by which SDGFP personnel manage the carcass data on a quarterly basis, make the resulting databases available to personnel in both agencies, map the data, and send notice to agency personnel that the data processing is complete and the resulting database is available. SDGFP should also report what contractors and areas are not submitting data. SDGFP should also create a quality assurance process for the data to help eliminate incorrect data and delete repetitive entries.

Wildlife Habitat Maps

Maps of wildlife presence and distribution in areas near roads are extremely important to a thorough analysis of WVC hotspots and associated mitigation solutions. In order to select mitigation measures, it is important to know where habitat for different species are located in relation to roads and what species of ungulates and carnivores may be most likely involved in WVC. Mitigation actions are very species-specific. The researchers worked with SDGFP personnel to determine GIS data layers available to address wildlife habitat and movement areas near roads. Although the researchers compiled spatial GIS data layers from a variety of sources, there were no state-wide or region-wide maps of large ungulate or carnivore locations or habitat maps other than the very coarse general hunting maps provided to the public. For SDDOT to better evaluate the wildlife species and their potential to become involved in WVC, SDGFP will need to:

1. Retroactively review past SDGFP-sponsored studies to retrieve maps of studied populations of large ungulates and carnivores and make compiled maps available to SDDOT.

2. Ensure that all future wildlife studies maintain a stipulation in researchers' contracts that all wildlife habitat data and actual location maps be uploaded to a SDGFP site that is also available to SDDOT. This will be typically done between academic institutions and SDGFP.

3. Annually review and update wildlife habitat and wildlife locational maps and make updates known and available to SDDOT.

Tribal WVC Data Collection and Identification of Problem Areas

The research team contacted representatives from all nine Tribal reservations' departments of wildlife or natural resources. The Oglala Sioux Tribe and the Rosebud Sioux Tribe collect data on WVC, but only the Oglala Sioux reported these crashes into SDDPS' standardized state data collection system, Traffic and Criminal Software (TraCS). For the majority of roads within reservations, the SDDPS does not receive WVC crash data from Tribes. However, Tribal agencies and the Tribal public expressed awareness of where WVC hotspots were believed to occur. The researchers attended the 2015 Tribal Transportation Safety Summit and worked with the South Dakota Tribes in an expert workshop to identify WVC hotspots on each reservation. The researchers identified a need for SDDOT to:

1. Engage Tribes in WVC data collection and the continued identification of problem areas.

The Role of Cooperation and Collaboration

There is a level of collaboration between SDDOT and SDGFP for identifying where WVC carcasses are collected, and between SDDOT and SDDPS in collecting crash data. The SDDOT-SDGFP partnership does not often extend beyond tending to carcass collector contracts and data reporting. The two agencies displayed a willingness to work together during this research in issues dealing with WVC. On June 1, 2015 members of the Rapid City SDDOT region and SDGFP met at the SDGFP offices and worked together in an expert workshop to identify problematic WVC hotspots across the region. These 76 hotspots were listed, and cross-checked with the top WVC reported crash hotspots reported in the present study. Twenty-eight of the expert chosen hotspots were among the top hotspots in the state identified by the team. The researchers found a variety of situations and efforts that could be improved with interagency collaboration for relationships among the three agencies. Ongoing cooperation between SDDOT and SDDPS is also necessary to ensure that crash reporting includes elements that are important for WVC crash data analysis. Specific needs for enhanced interagency collaboration in South Dakota include:

1. Clear standards that support WVC crash data analysis, such as a required species field.

2. Interagency agreements that establish roles and protocols for addressing WVC data collection, planning and project development related to collisions with wild animals.

1.3.3 Guidance to Improve WVC Reporting, Analyses, Collaboration, and Mitigation

For South Dakota to reduce WVC, there is a need for agencies to embrace the processes of identifying the extent of the WVC problem and to develop targeted strategies to address this problem. These processes build upon systems already underway at SDDOT and SDGFP. In this report, guidance was provided for improving WVC reporting and analysis, assessing wildlife habitat distribution with relation to roads, and improving collaboration among stakeholder organizations. The report provided a framework to assist agencies in implementing WVC mitigation measures with decision support tools.

Three primary steps for effectively addressing and mitigating for WVC are identified in Figure 2, below.

Step 1 – Identify the WVC problem areas.
Step 2 – Integrate wildlife considerations into transportation planning and projects.
Step 3 – Select, Create, and Adaptively Manage Mitigation solutions.

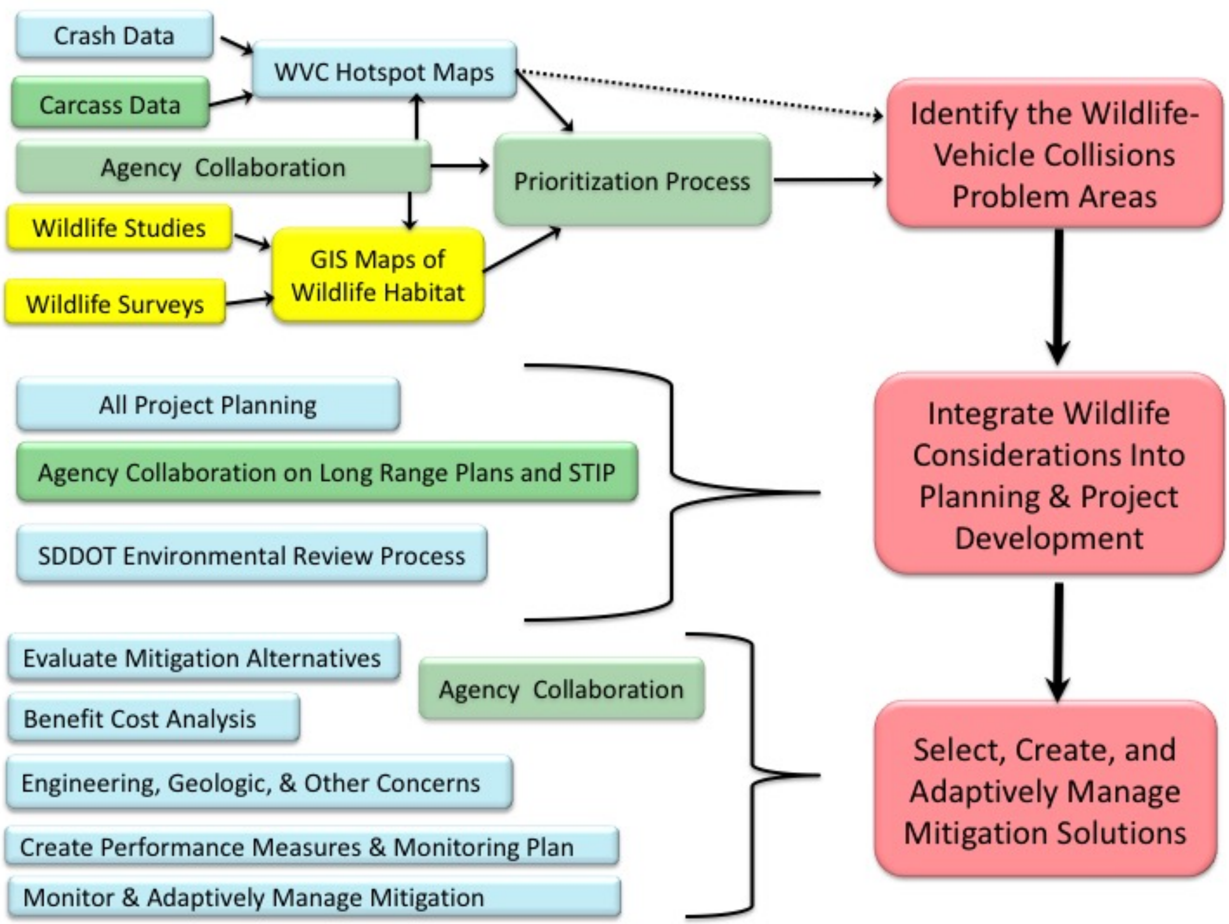

Figure 2.The Three Key Processes to Mitigate Roads for WVC (Pink Boxes) and the Information and Actions That Support These Processes.

Blue Boxes Represent SDDOT actions, Yellow Boxes are SDGFP Actions, and Green Boxes are the Responsibility of Both Agencies. Tribes may participate in all processes. Solid lines represent the standard process among Western U.S. States, whereas the *dotted line represents a temporary solution for beginning to identify WVC priority areas using hotspot mapping.*

Step 1: Identify WVC Problem Areas

The first step in the process of mitigating for WVC in South Dakota was initiated by the current research project. A primary need identified by the research team and further validated by interviews with agency personnel was for standardized, consistent and spatially accurate WVC crash and carcass data that are compiled on a consistent and timely basis across the entire state. Multiple interviewees expressed a need for reliable data on where WVC are occurring, and the habitats and terrain features with which these collisions are associated. The recommendations below in section 1.4, outline how these can be accomplished.

Once crash and carcass data are accurately collected and compiled, they are used as the basis for WVC maps with priority areas marked based on mile sections of roads with the highest number of collisions recorded. Typically, these are crash maps. This is a short term solution, as represented by the dotted line in the figure. As transportation departments integrate other data sources, geo-referenced wildlife locations based on surveys, and wildlife habitat based on wildlife agency studies are combined to help produce GIS maps of wildlife habitat. This data layer is then combined with the WVC hotspot maps, along with other information, to inform a standardized prioritization process. This process in turn delivers a state-wide map and regional maps of the areas in most need of WVC mitigation. This process is conducted annually across the state and regions. This process is a standard long term method, as represented by a sold line to the pink box to identify WVC problem areas.

Step 2: Integrate Wildlife Considerations into Transportation Planning and Project Development

This step represents the integration of wildlife considerations into the highest and lower levels of transportation planning within SDDOT. This includes SDGFP involvement in the State Transportation Improvement Program (STIP), and long range transportation plans. Actions recommended will assist in the success of the steps above and below. The recommendations below, detail how these can be accomplished.

Step 3: Select, Create, and Adaptively Manage Mitigation Solutions

This step encompasses the standard actions agency personnel use as they work together to consistently select, build, monitor and adaptively manage wildlife mitigation for WVC. This step is further described as the framework for Task 7, and decision support tools are presented to assist with these actions. This step is to be conducted in tandem with transportation planning. The six main sub-steps are:

1. Evaluate Mitigation Alternatives – agency personnel work together to select types of methods to mitigate the area under consideration.
2. Conduct a Benefit-Cost Analysis of the WVC Problem Site and Potential Solutions.
3. Consider Engineering, Geologic, and Other Concerns.
4. Create Performance Measures and Monitoring Plan – wildlife and transportation agencies work together on these measures and plans.
5. Research and Adaptively Manage Wildlife Mitigation.
6. These steps are repeated over time with each mitigation opportunity.

1.4 Recommendations

The following 15 recommendations are presented below to assist SDDOT, SDDPS, SDGFP, and Tribes in formulating actions that address the problem of WVC in South Dakota. These actions are in the order of actions needed, presented above, to collect accurate data, map the WVC and wildlife habitat data, create a prioritization process for actions, and increase interagency collaboration. Many of these actions can take place concurrently.

Recommendation 1: Memorandum of Agreement to Increase Interagency Crash Data Collection Efforts

Recommendation 2: SDDOT Requests That SDDPS Establish Standards for WVC Crash Data

Recommendation 3: Memorandum of Understanding with Multiple Agencies to Collect Carcass Data

Recommendation 4: Strengthen the Contract Language and Standards for Carcass Collection

Recommendation 5: SDDOT Creates an Electronic Data Entry Method for Carcass Data

Recommendation 6: Establish a Single, Centralized, Statewide Database for WVC Carcass Data

Recommendation 7: Update the Statewide WVC Crash Hotspot Map with Mile Posts and Accuracy Verification

Recommendation 8: Create SDDOT Regional WVC Crash Hotspot Maps Using a GIS

Recommendation 9: Conduct Interagency Regional Expert Workshops to Create Expert Maps

Recommendation 10: Create an Annual Procedure to Map WVC Crash Data and Examine Trends

Recommendation 11: SDDOT Requests SDGFP to Generate GIS Wildlife Maps

Recommendation 12: Initiate a Standardized Prioritization Process for WVC conflict areas

Recommendation 13: Integrate WVC Priority Area Identification into the SDDOT Environmental Review Process

Recommendation 14: A Memorandum of Understanding for SDDOT and SDGFP Collaboration in Transportation Planning and Wildlife Mitigation

Recommendation 15: Initiate a Phase 2 of This Study to Help Bring About Recommendations

The recommendations would come about over time, with SDDOT addressing certain recommendations immediately, and other recommendations over the course of the coming months and years. The overall objective of all these recommendations would be to help decrease WVC in South Dakota, while helping wildlife to move across the landscape. The results would be increased motorist safety, and protection of wildlife populations from the effects of roads and traffic.

1.5 Research Benefits

This research marks the first step toward defining the scope of the WVC problem across South Dakota. The research project has put a value on the problem of WVC in South Dakota, with an average 4,696 reported crashes with wildlife, with an average cost of $107.9 million each year to society from these reported crashes, and as many as 24,700 large wild animals killed at an estimated loss of $29.6 million annually. The recommended steps provided in this report can potentially save millions of dollars in prevented WVC over the coming years and decades.

The cost savings to the state agencies and the traveling public in South Dakota hold great potential. If the recommended actions prevented just 58 property damage only WVC, they will have saved South Dakota one million dollars in costs to the public and individuals involved. As the efforts increase over time, the cost-savings would be projected to be in the millions of dollars every year.

2 PROBLEM DESCRIPTION

South Dakota Department of Transportation (SDDOT) recognizes that WVC (WVC) are a safety and financial concern for motorists, and an ecological problem for wildlife populations across the state. The solutions for reducing these collisions necessitate accurate data collection and mapping, collaboration among agencies, and the implementation of appropriate wildlife mitigation along transportation corridors. This research project was an initial phase in the effort to address the challenges of WVC and to work toward solutions to reduce these collisions. Below, an assessment of the monetary and ecological costs of these collisions can help frame the extent of the problem in South Dakota.

2.1 Financial Costs to Society of Reported WVC Crashes

South Dakota averages close to 5,000 reported WVC on its roads and highways each year (data from South Dakota Department of Public Safety, SDDPS). The total accurate crash entries with codes for the severity of the WVC accidents were tallied for 2004 through 2013. In the 10-year period, 46,960 collisions with wildlife were reported, and 15 people died as a result of those collisions (Table 1).

Table 1. Number of of WVC Crashes of Different Severity Types Reported to SDDPS 2004 through 2013.

Crash Injury Type	Number of Reported WVC Crashes 2004 – 2013	Average Reported Crashes per Year
Fatal to Human	15	1.5
Serious, Visible, and Possible Injury to Human	735 for all injury types	73.5
Property Damage Only	46,210	4,621
Totals	46,960	4,696

These crashes can be translated into monetary costs to the South Dakota public, based on SDDOT use of national standards for average monetary values for each crash type. South Dakota uses the U.S. Department of Transportation (US DOT) values as a base for costs of each crash types (U.S. Department of Transportation 2013). US DOT estimates a human fatality costs an average of $9.4 million to the U.S. public, and each of the other severity types are a certain percentage of that value, with the lowest value of $17,343 for the average value of a property damage only crash (U.S. Department of Transportation 2013). These costs include medical bills, vehicle repair and towing, loss of income, crash clean up and other factors. Vehicle insurance industry estimated costs are strictly those claimed for insurance purposes.

In South Dakota, the US DOT values are used by SDDOT to estimate the value of crashes in a section of road under scrutiny, with some modifications for average monetary values (A. Vandel, SDDOT Traffic Safety Engineer, August, 2015). In order for the value of WVC to be considered in the same manner as carried out by SDDOT's traffic engineer and how other state traffic safety engineers calculate the safety concerns of a road section, this report used the SDDOT values. In Table 2 the annual average number of WVC reported crashes of the three types of severity are assigned monetary values in the exact amounts used within SDDOT in 2015, to generate an average annual cost of WVC reported crashes.

Table 2. Average Annual Estimated Costs to Society of WVC Reported to South Dakota Department Public Safety 2004 through 2013.

Crash Injury Type	Average Reported Crashes per Year	SDDOT Average $ Value per Crash of This Type Based on US DOT Estimates	Total Monetary Value per Crashes of Each Severity Type (Number x Cost)
Fatal	1.5	$ 370,800*	$ 556,200
Serious, Visible, and Possible Injury	73.5	$ 370,800*	$ 27,253,800
Property Damage Only	4,621	$ 17,343	$ 80,142,003
Totals	4,696		$107,952,003

* = The value South Dakota Department of Transportation uses is an overall average of US DOT estimates for injury and fatal reported crashes.

Reported WVC crashes on all South Dakota roads cost the public an average of $107.9 million every year.

2.2 Estimated Costs to Society of Wildlife Killed in Collisions

Estimates of the number of large ungulates killed and their monetary worth lost to WVC are difficult but not impossible to generalize. The above crash value estimates are calculated based on transportation agency estimates and are considered costs to society. The value of wildlife is not listed as a factor in these calculations. Research in Utah investigating the ratio of mule deer and other large wildlife carcasses found along the road as related to reported crashes generated a ratio of 5.26 carcasses found for every one reported crash (Olson 2013, Olson et al. 2014a). In Virginia, the ratio was as high as 9.7 white-tailed deer carcasses collected for every reported WVC crash (Donaldson and Lafon 2008). The magnitude of unreported collisions with wildlife is largely due to the fact that under insured motorists, or those lacking insurance have little to gain in reporting collisions and that tractor trailer trucks receive little to no damage from large ungulate collisions and their drivers may incur punitive actions if they report collisions. Of reported collisions, as many as 40 percent are reported via phone for insurance purposes and officers do not visit the scene (J. Serbousek, SDDPS, personal communication, October 2015). Notably, there is a time investment for motorists to report collisions that may hinder on-the-scene reporting.

If the 5.26 correction value from Utah is used, South Dakota's yearly average of 4,696 WVC reported crashes may equate to as many as 24,700 large ungulates lost to WVC in South Dakota annually.

A calculation of the ecological effects of this reduction in white-tailed and mule deer, elk, and bighorn sheep among other wildlife species is partially understood, but the monetary values of healthy ecosystems and healthy ungulate populations have not been calculated. To begin to calculate the monetary effect of WVC, the value the South Dakota Game Fish and Parks (SDGFP) places on individual animals can be used. SDGFP places a value of $1,000 for a single mule or white-tailed deer and upwards of $5,000 for a trophy buck of either of the species (South Dakota State Legislature 2015) when the state is prosecuting individuals for poaching those animals. These values are used in the cost estimates of WVC.

The value of the animals killed in WVC is derived from estimating how many animals of each of the types above are killed. The WVC crash data do not report types of wild animals involved; for estimating costs it is assumed that all wildlife involved are deer. It is reported by insurance companies (Insurance Information Institute 2012) that 95 percent of insurance claims for collisions with wild animals is for collisions with deer. For estimates of the number and type of deer killed in WVC, five percent will be assumed to be trophy buck deer, based on South Dakota estimates, (C. Huxoll, SDGFP, personal communication, October, 2015), and estimates for Utah, where Olson et al. (2014b) identified 1,257 mule deer carcasses along roads and found that 35 percent of the carcasses were male, and 98 percent of those were bucks in prime age, two to seven years old). In Olson et al.'s study, male mule deer were killed on roads at rates 2.1 to 3.0 higher as a proportion of the population, than their estimated numbers in the areas their carcasses were found, according to estimates provided by Utah Division of Wildlife Resources from aerial and ground surveys. An estimate that five percent of the deer killed on South Dakota roads were trophy deer is therefore considered a conservative estimate of the total trophy deer killed in collisions. If all the estimated WVC were with deer, and if five percent of those collisions were with trophy bucks, the worth of the animals would be $29.6 million annually in lost individual wild animals: (24,700 x 0.95 x $1,000 for general deer) + (24,700 x 0.05 x $5,000 for trophy deer) = $23,465,000 + $6,175,000 = $29,640,000. WVC also involve elk and bighorn sheep, which are valued more highly by SDGFP, as well as other species, and it is likely that this lost value remains an underestimate.

It is estimated that each year South Dakota loses an average of over 24,700 large ungulates due to collisions with vehicles, at a cost of over $29.6 million to the South Dakota public.

These costs are presented separately from the SDDOT crash cost estimates because US DOT crash cost estimates which are the base of SDDOT estimates, are considered the overall cost to society; they do not include value of wildlife. The value of the wildlife is presented as an individual number so SDGFP can better understand the toll of WVC on ungulates, and include these figures in proactive steps to reduce these costs to wildlife populations and the South Dakota public.

With large monetary consequences and impacts to both the motoring public and the survival of wildlife populations, it is recommended that South Dakota create standardized protocols for evaluating and addressing WVC. These protocols include a systematic, reliable system for reporting WVC crashes and carcasses; coordinated data collection and sharing among agencies; the incorporation of WVC data and maps of wildlife habitat into transportation planning, and processes for using this information to implement wildlife crossing structures and other mitigation. These needs were the base of the impetus for this study.

This study is a beginning step for South Dakota to becoming more proactive in identifying problem areas where wildlife need to move across roads, in finding out where there are risks of collisions with wildlife, and in developing the necessary mitigation to help preserve wildlife populations while protecting the motoring public. South Dakota will be collecting, mapping, and integrating reliable WVC data into transportation planning and project designs, and creating wildlife mitigation infrastructure. This will allow SDDOT and its partners to better address the

WVC problem in the state in a scientifically, cost-effective, and efficient manner. In turn these actions have the potential to save the South Dakota public millions of dollars in reduced WVC, and to save the state's large wildlife populations from further animal deaths with vehicle collisions.

3 RESEARCH OBJECTIVES

This study addressed three primary objectives:

3.1 Evaluate Existing WVC Systems and Identify Improvements

Evaluate existing WVC tracking and data collection systems and coordination among stakeholder agencies and identify needed improvements.

3.2 Develop a Plan to Improve Collaboration

Develop a plan to improve collaboration among multiple South Dakota organizations and agencies with common goal of reducing WVC.

3.3 Develop Guidance Premised on Best Practices

Develop guidance premised on best practices for reducing WVC in South Dakota

The objectives were accomplished through the completion of the tasks of this study. The first objective, to evaluate and identify improvements to existing WVC tracking methods and coordination among agencies, was accomplished through Tasks 3 and 4. This resulted in the review and description of the current systems in South Dakota that allowed for WVC crash and carcass reporting and agency coordination. A final list of recommended improvements to the systems of data collection and sharing were completed in Tasks 6 and 7. Objective two, to develop a plan to improve collaboration among South Dakota organizations to reduce WVC, was also accomplished through the completion of Task 4 where the current processes were examined and improvements recommended. These recommendations were also developed in Tasks 6 and 7, which were dedicated to the development of guidance and outreach materials to improve data collection and agency collaboration. Objective three, to develop guidance premised on best practices, was based on the data and information gathered in Task 2 where the team examined the state of the practice in other U.S. states and a Canadian province. From the information gathered on best practices from South Dakota and other examples, a list of recommendations for how to reduce WVC was developed in Tasks 6 and 7.

4 RESEARCH TASK DESCRIPTIONS

4.1 Task 1. Kick Off Meeting

Meet with project technical panel to review project scope and work plan.

Research team members Patricia Cramer, the Primary Investigator (PI), Julia Kintsch, and Cheryl Chapman met with the project technical panel in Pierre, South Dakota on March 13th, 2015. This meeting resulted in:

1. An agreed-upon scope of work and detailed work plan;
2. Initial assessment of WVC reporting and mitigation planning processes in South Dakota; and the beginnings of the
3. Contact list for key personnel from various agencies and organizations. Meeting notes were posted to the SDDOT File Transfer Protocol (FTP) site for this project.

4.2 Task 2. The State of the Practice of WVC Reporting, Analyses, and Mitigation

Through a review of the literature and consultation with experts, identify and describe prevailing and best practices across the nation for animal collision reporting and analysis, mitigation of WVCs, and application of wildlife habitat and ecosystems and WVC occurrence and distribution models.

Task 2 efforts included phone interviews, email correspondence, internet and literature searches, and updates of earlier research efforts. The research team interviewed environmental personnel within western and plains states and Ontario, Canada, all of which were known to be most progressive in dealing with WVC and wildlife mitigation. Results from previous research (Cramer et al. 2014) were updated through phone interviews, email correspondence, internet searches, and literature review. Work in Task 2 was critical to meeting objective three, to develop guidance premised on best practices for reducing WVC in South Dakota. Results can be found in brief form in Chapter 5, Findings and Conclusions, and in greater detail in Appendix A.

4.3 Task 3. The Current State of South Dakota Practices Dealing with WVC

Review and describe current systems in South Dakota for WVC reporting, associated data collection and analysis, and information exchange among stakeholder agencies, including the *auto insurance industry. Look for potential for streamlining overlapping activities among agencies, identify needed system improvements, and formulate recommendations*

Tasks 3 and 4 were conducted simultaneously and involved data and information gathering that were closely intertwined. The methods, results and recommendations for these two tasks were presented together.

4.4 Task 4 South Dakota Processes and Agency Improvement Recommendations

Examine internal processes in place at SDGFP and SDDOT guiding wildlife management and protection, and WVC mitigation actions. Describe current process and interaction of agencies, identify needed improvements, and formulate recommendations.

Two kinds of information were obtained during these tasks: how South Dakota collects and shares WVC crash and carcass data, and the Geographic Information Systems (GIS) data layers available within the state that could be used to help map WVC priority road segments within South Dakota. Methods on how the team learned of these different data are presented under separate headings below. The GIS WVC crash data were then analyzed and mapped to produce a statewide WVC crash hotspot map.

Interviews with South Dakota Agency Personnel and Tribal Reservation Personnel

The project technical panel played a critical role in helping the research team identify key people to contact within different divisions of SDDOT and SDGFP, as well as non-agency contacts (e.g., Tribal associations, a carcass contractor, and a representative of the automotive insurance industry). The focus of Tasks 3 and 4 was a series of interviews conducted with agency personnel from both SDDOT and SDGFP, as well as with Tribal representatives. See Appendix C for the list of interviewees and their affiliations. The focus of these interviews centered on the following items:

- Current processes for reporting, compiling, mapping and analyzing WVC **crash** data, and opportunities for improving usability of the WVC crash dataset;
- Current processes used by different entities to report, compile and share WVC **carcass** data, and opportunities for improving usability of the WVC carcass dataset;
- Compiling available GIS data layers pertinent to understanding the interface between transportation and wildlife.
- Current processes for interagency coordination regarding issues concerning wildlife and roads.

Tribal Game and Fish, Wildlife, and Public Safety departments were contacted for the nine South Dakota Tribes to determine the following:

1) If the Tribe collects data on WVC,
2) If the Tribe conducts carcass pick-up,
3) Location of "Hot spots" or areas with incidence of wildlife vehicle collisions,
4) Availability of wildlife surveys or GIS maps that identify wildlife habitat or wildlife populations within their jurisdiction for use in the study, and
5) Recommendations for mitigating roads.

A representative from the auto insurance field was contacted to learn of potential data sharing opportunities for WVC crash data.

GIS Data Layers Compilation and WVC Crash Data Mapping

Through phone and email communications, the research team compiled relevant GIS data layers from various sources. With this compilation the team identified the availability of data that can be used to assess the patterns and processes contributing to WVC in South Dakota. Relevant data were then investigated to determine the limitations of available datasets, identify gaps, and begin assessing how the available spatial data may contribute to the identification of WVC hotspots and priorities across the state. All GIS layers and GIS analysis layers are compiled in a Geodatabase for the final project deliverables and were made available on the SDDOT FTP site and folder for this project

The work on Tasks 3 and 4 were key to the project addressing objectives one and two: to evaluate existing WVC tracking and data collection systems and coordination among stakeholder agencies and identify needed improvements and; to develop a plan to improve collaboration among multiple South Dakota organizations and agencies with common goal of reducing WVC.

Results can be found in brief form in Chapter 5, Findings and Conclusions. Greater detail of personnel contacted can be found in Appendix C, forms used for carcass pick up in Appendix D, and Tribal entities' data collection methods and personnel contacted in Appendix E.

4.5 Task 5. Interim Report and Second Meeting with Technical Panel

Deliver an Interim Report and Meet with the Technical Panel

Task 5 was completed with the submission of the interim report that summarized findings and recommendations from Tasks 2 through 4, and with a meeting of the technical panel and the two prime researchers, P. Cramer and J. Kintsch in June of 2015.

4.6 Task 6. Outreach Materials to Improve WVC Reporting, Analyses, and Collaboration

Based on accepted best practices, develop guidance and outreach materials for improving animal collision reporting and analysis, assessing wildlife habitat/ecosystem/distribution, and improving collaboration among stakeholder organizations (SDDPS, SDGFP, SDDOT, insurance industry) on matters pertaining to animal collision incident reporting and mitigation activities in South Dakota.

The team's work on earlier tasks was used to develop guidance and outreach materials. A June 1, 2015 workshop of SDGFP and SDDOT personnel to create an expert opinion map of problem WVC areas in the SDDOT Rapid City Region was well received and became a model for future expert workshops across the state. GIS modeling of WVC crash and carcass data allowed for a robust presentation of the scope of the problem, and laid the groundwork for future actions on collecting, analyzing, mapping, and collaboration on WVC data. Section 5, Findings, sub section 3 presents guidance recommendations for future action.

4.7 Task 7. Develop Guidance to Implement WVC Prevention Measures

Develop guidance to assist agencies with implementation of WVC mitigation measures recommended in South Dakota, which include decision support tools supported by cost-benefit analysis, and updated region-specific information on habitat and ecosystems, species distribution, and migration corridors.

Results derived from previous tasks helped to develop Task 7. Information from Task 2, describing the mitigation options available to reduce WVC was used to develop guidance and options for South Dakota. WVC crash and carcass and other GIS layers gathered in Tasks 3 and 4 were used to develop informative maps and databases. Contacts with the SDDOT traffic safety engineer and the SDGFP chief conservation officer helped to develop values for the cost of WVC and the value of the individual wild animals lost to such collisions. These in turn were used to document the extent of the WVC problem in monetary terms and to help evaluate how well potential wildlife mitigation measures would pay off over time in reduced collisions. Section 5, Findings, sub section 3, presents guidance recommendations for future action.

4.8 Task 8. Meet with Technical Panel to Review and Approve Materials

Primary Investigator meets with Technical Panel to review and approve materials

The researchers met with the technical panel in October of 2015 to review the first draft of the final report and to discuss how the panel would like to see the final product developed.

4.9 Task 9. Final Report

In accordance with Guidelines for Performing Research for the South Dakota Department of Transportation, prepare a final report and executive summary of the research methodology, findings, conclusions, and recommendations.

The draft final report was developed in accordance with the *Guidelines for Performing Research for the South Dakota Department of Transportation,* and delivered to the Project Manager for this research in September 2015. In March 2016, the second draft of the final report was submitted to SDDOT. In May of 2016 the third draft of the final report was submitted to SDDOT. In July of 2016 the final report was delivered to SDDOT.

4.10 Task 10. Executive Presentation

Make an executive presentation to the SDDOT Research Review Board at the conclusion of the project.

The Primary Investigator for the project, Dr. Patricia Cramer, presented research results to the SDDOT Research Review Board on November 11, 2015.

5 FINDINGS AND CONCLUSIONS

This chapter begins with results from Task 2, reporting on the state of the practice with which others across North America identify problem areas for WVC, use techniques such as linkage analyses and wildlife distribution models, and integrate these wildlife considerations into transportation plans and projects that in turn result in wildlife mitigation strategies (5.1). The second part of the chapter (5.2), presents the systems currently in place in South Dakota to record WVC crashes and WVC carcasses, and to identify the potential problem areas for WVC, and how these practices can be improved. In section three of this chapter (5.3), recommendations are given to provide guidance in the adoption of standardized data collection, data compilation, analyses, and mapping and a step-wise guidance process. These recommendations will assist South Dakota in progressing toward a more reliable and robust process to address WVC via the creation of effective mitigation approaches. The final section (5.4) describes how a second phase to this research could assist in accomplishing many of the next steps in these recommendations.

5.1 The State of the Practice of WVC Reporting, Analyses, and Mitigation

In Task 2 the researchers brought together information from across North America pertaining to WVC data collection, reporting, mapping, analyses, and mitigation. The results are presented in three parts:

- 5.1.1 The state of WVC carcass and crash data collection, reporting, mapping and prioritization,
- 5.1.2 WVC occurrence and distribution models,
- 5.1.3 An overview of wildlife mitigation techniques.

These results are presented at the beginning of this section of the report to give the reader a better sense of the state of the practice to identify and mitigate WVC.

5.1.1 State of WVC Data Collection, Reporting, Mapping, and Prioritization

Various U.S. western states and the Canadian provinces are in different stages of addressing the issue of WVC and have developed different levels of practices that help them collect, analyze, and map WVC crash and carcass data and use these data to inform transportation planning decisions. In Appendix A, the results are presented for each state and province with four sub-sections: how WVC carcass data are collected, how WVC carcass and crash data are mapped, if there are any wildlife linkage maps and where they can be found, and if there is a wildlife mitigation and WVC prioritization process or a way the information is included in transportation planning. These results built upon previous research conducted for Idaho Transportation Department (Cramer et al. 2014).

Overall the research results indicated:

1. All states and provinces surveyed have WVC crash data from law enforcement and safety departments, but in almost all cases the data do not specify the species involved.

2. The WVC crash data are the most commonly used data to map WVC problem areas across a state or province.

3. The WVC crash database is the one data source Departments of Transportation (DOT) environmental personnel, planners, and safety engineers regularly consult to discern if there is a road-wildlife conflict of existing road under planning consideration.

4. WVC carcass data collection is typically described as part of the responsibility of those that collect carcasses in most states, but the data are often collected inconsistently across most states, thereby challenging the ability of personnel to use the data for mapping spatial and temporal trends and patterns, and therefore unreliable for decision-making.

5. Few states create WVC hotspot maps based solely on WVC carcass data. Maps are typically created and priority areas identified from WVC crash data, and in some states, through a combination of other data sources such as wildlife habitat maps, wildlife linkage analyses, models, and systematic prioritization process (see Idaho's, by Cramer et al. 2014). WVC hotspots maps are typically created one time and are static, but some states have GIS websites for DOT personnel to create interactive WVC hotspot maps at any time with real time information.

6. Not all states have wildlife linkages mapped. Wildlife linkages are hypotheses of where wildlife most likely use areas as habitat and to move among habitats, and may or may not be an accurate reflection of wildlife movements. They are typically the best data available for predicting potential wildlife-traffic conflict areas.

7. Three states are highlighted as leaders in this area:

- Arizona for its commitment to wildlife mitigation projects,
- Washington for its integration of wildlife mitigation planning into transportation planning, and

- Idaho for its advances in WVC carcass reporting and as the only state that has adopted a systematic statewide prioritization processes for determining priority areas for wildlife mitigation (Cramer et al. 2014).

5.1.2 WVC Occurrence and Distribution Models with Wildlife Habitat and Ecosystems

Wildlife occurrence and movement models can be developed to help predict areas where wild animals may be attempting to cross the road and where there may or may not be a WVC problem. Predictions of where wildlife need to move across roads are based on empirical (scientifically gathered) data and models that predict wildlife movements. These models may integrate both road-related and landscape-related explanatory factors that influence occurrence of WVC (Gunson and Teixeira 2015). In turn, these models can be used to predict state-wide general areas where roads bisect wildlife habitat and areas of potential wildlife movement, as well as specific sections of road where wildlife may be crossing or attempting to cross the road to access important habitat.

Wildlife must move among different parts of their habitat for populations to thrive and survive (Hanski 1998). Roads and highways are barriers to this movement, fragmenting wildlife populations (Pimm et al. 2001). When wildlife move near roads their movements can result in several actions: they may be involved in a WVC, they may safely cross over the road or under using existing structures or wildlife crossing structures, or they may avoid the road altogether. WVC carcasses are therefore one type of wildlife occurrence, where a moving animal was fatally "sampled" at the roadway through a collision. Lack of WVC carcasses does not mean that particular species do not occur in an area. This is because different wildlife species may have varying sensitivities to traffic and roadways. Some species may avoid the road area while others may be safely crossing. Therefore, identifying locations with the highest numbers of WVC carcass and WVC crash data are only two of several approaches to identifying potential problem areas for wildlife and motorists.

When there are little data about wildlife occurrences (empirical data), often habitat mapping is used as a substitute for knowing where wildlife may be moving and occurring. For conservation and transportation planning, this usually involves using information about a species habitat preferences and known occurrences to predict where it may occur on a landscape and potentially interact with roads and traffic. In a GIS mapping environment known habitat types (where species may occupy) and known sources of disturbance (e.g., towns, agriculture) can be combined to predict potential hotspots of interaction between wildlife and traffic on roads, which may lead to WVC. The map created from these map data is a static representation of what the researchers believe represents how the landscape might be used by the target species. Once this type of map is created, it can be used to predict the most important areas for wildlife movement.

One type of wildlife movement mapping is linkage mapping, where possible pathways for wildlife movement are modeled for a landscape composed of potential wildlife habitat and sources of disturbance. The analyst selects where wildlife might start and based on the assumption that wildlife avoid disturbances, propose a hypothetical linkage to another place on a landscape (Figure 3). This approach is still commonly used (e.g., Spencer et al. 2010 for California), but has received criticism in the scientific literature because it can fail to accurately predict wildlife movement (e.g., Boitani et al. 2007, Shilling and Waetjen, 2015), because it uses hypotheses with little empirical data based on real wild animals. In addition, even if one area is predicted to be used for movement during a given year, in following years, different areas may be used based on changing landscapes, resulting in different locations along a highway where traffic and wildlife may collide (Shilling and Waetjen 2015). LaPoint et al. (2013) critically evaluated the development of corridor/linkage models and discussed common weaknesses among these type of models that include:

1. Generalization of habitat selection information,

2. The assumption that animals have complete knowledge of landscapes, or completely naïve experience with landscapes,

3) Modelers do not base models on animal movement information (empirical data), and

4) Very few model predictions have been tested with animal movement data. Most studies of how wildlife move through their habitat suggest that animals may choose several different paths; connectivity mapping should reflect this variation (Fischer et al. 2004, Fischer and Lindenmayer 2006).

An alternate approach to the habitat modeling approaches described above uses empirical wildlife movement data to determine the locations of movement paths. This approach has been carried out for a wide range of taxa (different species), suggesting that new approaches to connectivity modeling are already possible (Cushman et al. 2009, Janin et al. 2009, LaPoint et al. 2013). This can be done in a number of ways:

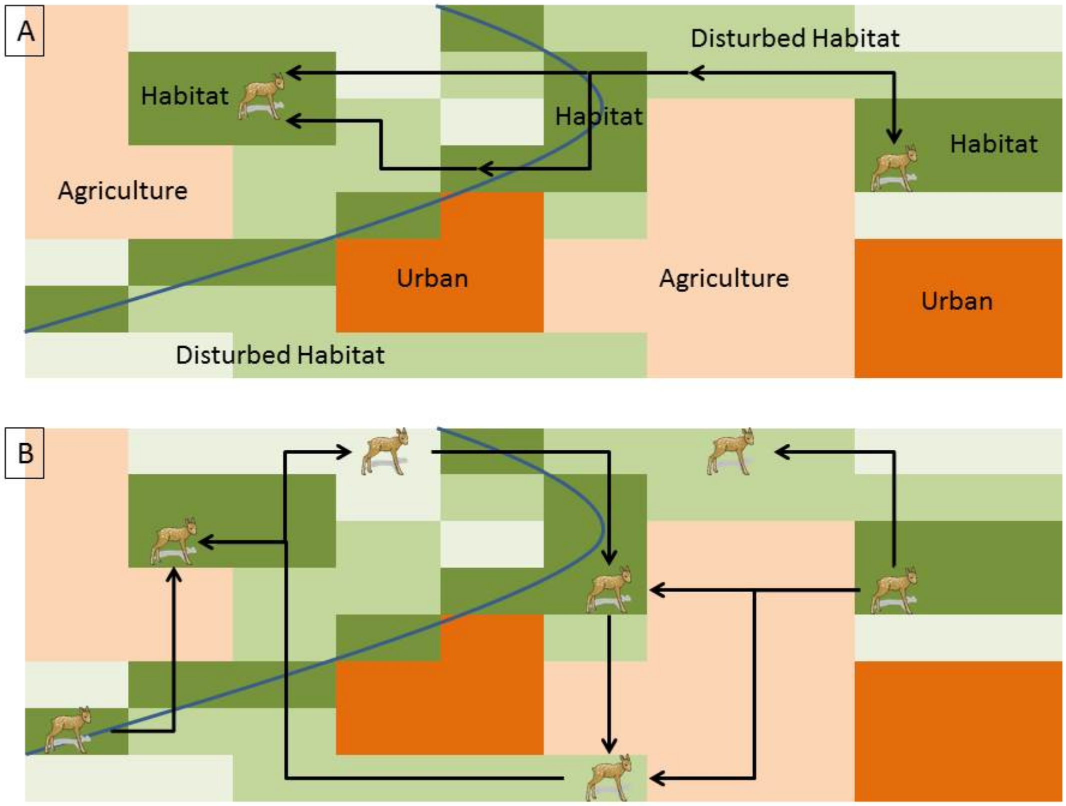

Figure 3. Predicted Movement Decisions of Animals Through an Idealized Landscape.

Dark green represents good habitat, lighter green represents disturbed habitat, light orange represents agriculture, and dark orange represents urban areas. A) Modeled movement of animals between habitat patches based on assumption that movement follows lowest-disturbance paths, resulting in hypothetical linkages. B) Possible movement paths if disturbance-tolerance varies and if multiple species are moving, resulting in many possible paths.

1. Based upon tracking movement of individual animals of different species using Global Positioning System (GPS)-collars, and

2. Using monitoring methods to track occurrence at or near roadway structures, or within habitat areas, such as using camera traps, tracks, and scat.

Models of wildlife movement based on empirical data can be scientifically and rigorously developed to help determine the landscape and road factors common to WVC hotspots, or areas where wildlife safely move near and across roads. The models can then be extrapolated to other roads where WVC and other wildlife movement data do not exist. This is especially valid when species observational data are minimal because a species is rare or data are not routinely collected for the species, e.g. small and mid-sized animals, or large ungulates in South

Dakota. Extrapolation of models should be done only for roads in habitat types similar to where the model was developed. Another important caveat is that extrapolation can only be conducted where the factors that determine movement can be measured in both the region where the model was developed as well as the area where where the model is to be extrapolated.

In South Dakota, although large ungulates have been studied, statewide maps of their occurrence could not be located by the researchers, other than coarse scale maps for the public. Without known occurrences of the populations of animals that are at greatest risk of WVC, hypothetical linkage analyses would be the next best approach to predicting the places these wild animals need to cross roads. This type of analysis would occur chiefly with existing coarse scale habitat maps and could be partially validated with expert opinion workshops of wildlife and transportation professionals. The WVC crash and carcass data could be used to help validate the linkage models, and if they were found to be sufficiently accurate, the models could be used to predict high WVC areas in greatest need of mitigation. If the models are found to not predict locations of WVC, or safe movement, then the linkage models would not be an appropriate basis for mitigation planning, and further wildlife occurrence data would need to be collected.

A more detailed presentation of the application of wildlife habitat and ecosystems and WVC occurrence and distribution models in best practices for WVC reporting, analyses, and mitigation is presented in Appendix A, Section II.

5.1.3 Wildlife Mitigation Types

Once the decision to mitigate an area along an existing road or future road has been made, the next step is to determine the potential mitigation alternatives that are best suited to a particular location based on multiple considerations including:

- Mitigation objectives, typically, reducing WVCs and/or providing connectivity;
- The needs of the target species;
- Terrain and other landscape characteristics;
- Adjacent land ownership and land management;
- Cost of mitigation; and
- How mitigation can be incorporated into other transportation planned projects, or
- How existing infrastructure can be retrofit to accommodate targets species.

Figure 4 provides a basic decision framework for guiding SDDOT through the initial process of assessing potential mitigation alternatives based on these considerations. Each mitigation alternative is more fully presented in Appendix B, with support and links to more information.

These mitigation alternatives are generally categorized as 'Actions that Target Wildlife Behavior' and 'Actions that Target Drivers' (adapted from Cramer et al. 2014). The information presented herein is a summary of the most common WVC mitigation strategies and their currently understood effectiveness, and does not constitute a full review. This information is further developed in Section 5.3 where guidelines on incorporating wildlife mitigation into transportation planning are presented.

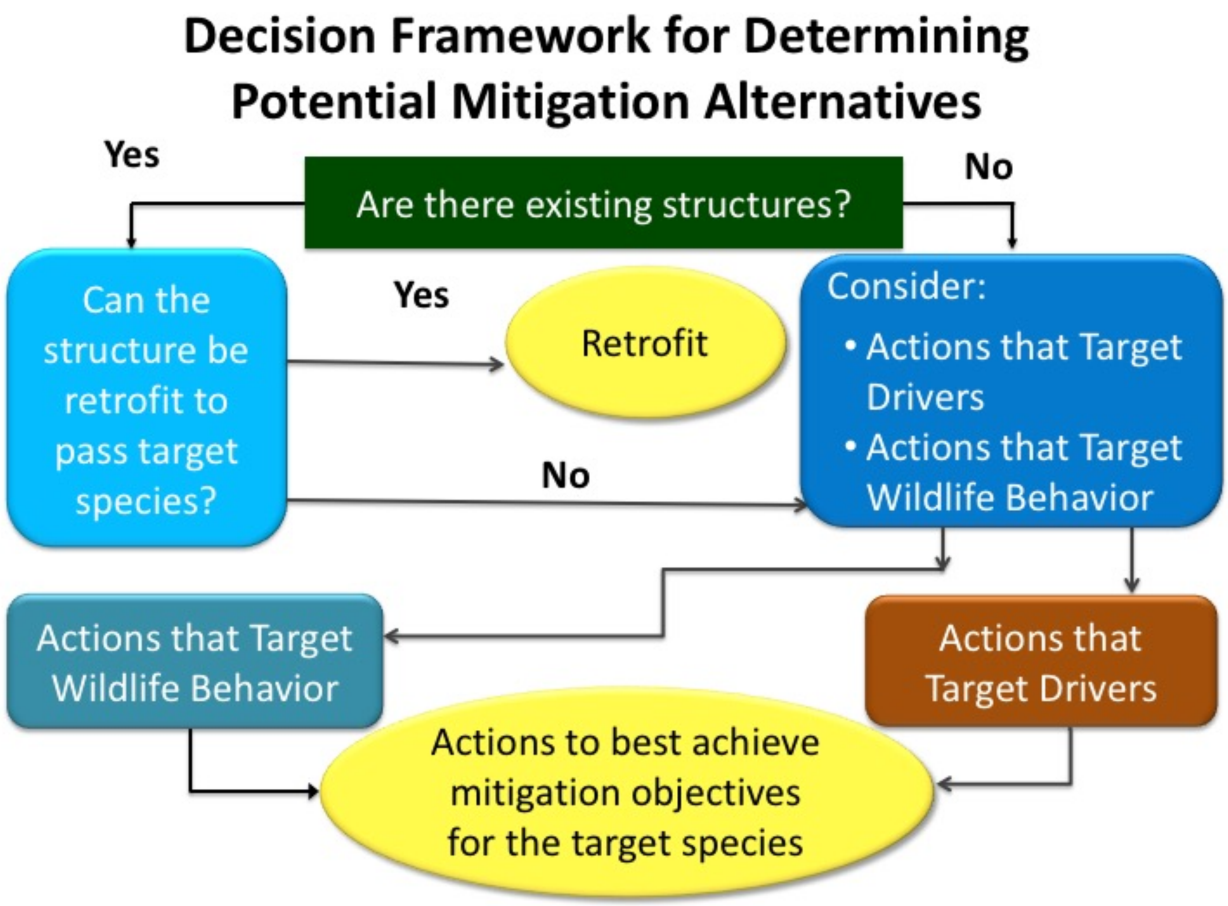

Figure 4. Decision Framework for Selecting Wildlife Mitigation.

5.2 The State of the Practice: An Evaluation of South Dakota Systems to Identify WVC

In the following sections, the data collection and compilation methods currently used in South Dakota are presented, as well as how these efforts can be improved, including for use within a GIS to map hotspot areas. Information was obtained through interviews conducted in person, through emails, and via phone conversations with South Dakota agency personnel (Appendix C). In addition, traditional collaboration and newly developed interagency coordination efforts to facilitate the processes to identify problem areas of WVC are presented.

5.2.1 WVC Data Collection

A WVC dataset includes both WVC reported crash data and carcass data that was developed with methods to collect the data that ensures the accuracy of each record through quality controls. We describe methods used by various entities in South Dakota to collect and compile WVC crash data, and present WVC crash hotspot maps at a statewide and regional level to demonstrate how these data may be used. Methods for accurate collection of carcass data are presented, as are methods to map carcass data to find hotspots, and to map WVC hotspots based on expert-identified problem areas.

5.2.1.1 How WVC Crash Data Reported, Compiled, and Used

In South Dakota WVC crash reports are created for each crash that is reported by law enforcement, generally state patrol, the county sheriff's department, city police departments, or Tribal law enforcement, depending on the location of the accident. The threshold for reporting WVC crashes at the time of this writing was $1,000 in property damage incurred by one individual vehicle, or $2,000 total property damage in a crash. Even with these thresholds, many WVC crashes that exceed these thresholds may not have been reported to law enforcement due to the reluctance of the motorists involved to contact law enforcement because they did not understand the value in reporting, did not carry insurance that would cover the damages, or were the drivers of large vehicles that sustained no damage. When reporting does occur, WVC crash reports are either entered in patrol vehicles directly into the electronic TraCS (Traffic and Criminal Software) database system, typically done by State Patrol officers and Sheriffs' deputies with in-vehicle laptops, or from paper crash reports that are submitted to the SDDPS for manual entry into the TraCS database.

TraCS database was developed by Technology Enterprise Group, Inc. (TEG, 2015). TEG maintains the TraCS database and server under a contract with the South Dakota Department of Public Safety (SDDPS). Nineteen U.S. states currently use the TraCS system to report and compile motor vehicle crashes reported to law enforcement. The TraCS system supports electronic crash reporting and is specifically designed to reduce the time it takes to complete a report in the field, while improving accuracy and eliminating the need to transcribe paper reports back in the office. TraCS only addresses WVC and other types of crashes where drivers file an accident report. While law enforcement may also be called to respond to an incident in order to dispatch an injured animal or to remove an animal carcass from the roadway, law enforcement officers from any agency have no means to report WVC that are not formally reported as crashes.

Overall, most of the state's counties and city police jurisdictions use the TraCS system for submitting crash reports. SDDPS estimates that at least 90 percent of all crash reports are submitted electronically via TraCS. Notably Pine Ridge Indian Reservation is the only Tribal entity using TraCS. Crash data are property of the SDDPS Accident Records Division and are not maintained by SDDOT. They are used in this report with permission.

Table 3, below, displays the number of WVC crashes reported by agency type for the period of 2004 through 2013. On average, 4,696 WVC crashes are reported annually. County sheriff's report nearly two-thirds of WVC crashes across the state (all 66 counties are represented in the database), with state highway patrol reporting just over one-quarter of WVC crashes. Local police, Tribal police, or the Bureau of Indian Affairs report the remaining WVC crashes. Notably, these reported WVC crash numbers only lightly represent these areas because of the remote nature of many Tribal areas, smaller cities and towns, and certain counties that are very rural where reporting is chiefly done over phone lines due to the long timer periods for law enforcement response times. The majority of WVC crashes (67 percent) occur on state roads, including interstates and state highways, with 23 percent occurring on county roads, and the remainder on city roads or ramps. Reported crashes during this time period include 15 fatalities and 735 injuries, with the remainder resulting in property damage only. Most WVC that involved human fatalities occurred on state roads (73 percent). WVC crashes are fairly consistent year-round and from one year to the next, except for a consistent spike during the fall months when, on average, 1,750 WVC crashes are reported from September through November.

Table 3. WVC Crash Reporting by Agency, in the South Dakota Accident Reporting System (SDARS) Database 2004-2013.

Agency		Reported WVC Crashes	Percent
Bureau of Indian Affairs		24	0.05
City Police		3,324	7.10
County Sheriffs		30,725	65.40
Highway Patrol		12,770	27.20
Tribal Police		112	0.20
	Total	46,955*	

**Note: The total number of WVC crashes reported is based on the number of reports for which a reporting agency was listed, which is fewer than the total number of WVC crashes in the SDARS database.*

When crash locations are recorded in TraCS by officers using in-vehicle computers, TraCS maps the location of the crash site by using Global Positioning System (GPS) data and converting the location information into latitude and longitude. Alternatively, officers may submit paper reports to SDDPS, where office personnel manually enter the crash report, including location information, into TraCS.

The TraCS system tracks accidents types, including those involving wild or domestic animals, but does not include a description of the species involved. Species may be noted in the narrative section of the report; however, this narrative information is not included in the Microsoft Excel file exported from SDARS. Even when species is recorded in the optional 'narrative' field, species may be misidentified.

Inevitably, many WVC incidents across South Dakota are never reported to law enforcement and are never captured in the SDARS database. This is similar to other states, for example, Olson (2013) found mule deer carcass surveys in Utah reported 5.26 times more carcasses along the road than were recorded in WVC crash reports on those same roads. Unreported WVC incidents include:

- Collision resulting in minor or no property damage;
- Individuals or groups of animals hit by tractor trailer trucks;
- Collisions involving uninsured or under insured drivers;
- Collisions where the drivers do not involve law enforcement.

Since WVC crash data are derived from accident reports, it is expected that reporting effort is generally consistent, and dependent on drivers reporting WVC crashes in which they have been involved. Protocols for reporting, submitting and compiling crash report data in the SDARS database are largely consistent from one year to the next and across reporting agencies.

Although there is consistent WVC crash reporting, analyses of the database output found the following gaps or errors likely to occur in this dataset:

- Locational errors. When crash locations are recorded as a highway number and the nearest MRM, and later translated to latitude/longitude using the Incident Location Tool (ILT), locational accuracy is compromised as the nearest MRM may be up to 0.5 miles (0.8 km) from the actual crash location. In addition, Gunson et al. (2009) found that the spatial error (mean ± standard deviation) was higher for WVC data referenced to nearby landmarks (0.3 miles ± 0.5 miles, 0.5 to 0.8 km) than for data reference to the closest mile marker (0.3 miles ± 0.1 miles, 0.5 to 0.2 km).
- Transcription errors. When crash reports are submitted as paper forms that must be manually entered into the SDARS database, illegible or smeared handwriting as well as data entry mistakes can result in inaccurate information being entered into the electronic database (See Appendix D for examples).
- Submission errors. Of the counties and Tribes that do not use the TraCS system to submit accident reports, it is unknown whether all paper accident reports are submitted to SDDPS for entry into the SDARS database.

WVC crash data compiled in the SDARS database are used by the SDDOT traffic safety engineer to create reports for transportation project scopes that identify clusters of reported crashes. However, there are no threshold standards to define the number of hits to determine an area is a hotspot and when wildlife mitigation measures should be incorporated into projects.

To date, incidence of WVC crashes have not been a major driver for safety improvement projects in South Dakota. The recently completed Strategic Highway Safety Plan (SDDOT 2014) notes that WVC crashes accounted for only four percent of fatalities from 2007-2011. The top priorities for road safety include addressing crashes that occur as a result of winter conditions or alcohol, those involving motorcycles or young drivers, and those that occur at intersections. Because WVC incidents are not geographically constrained and occur across the state, driver education is perceived as a key component for reducing WVC (A. Vandel, SDDOT Traffic Safety Engineer, personal communication, May 2015).

WVC crash data are also available within the auto insurance industry. One of the major auto insurance companies, State Farm Insurance, was contacted to learn about accident information collected by their company. The representative, Nate McHargue, at the State Farm Corporate Law Office, provided information: in 2013 – 2014 there was a 1 in 82 chance of a collision with a deer in South Dakota. Those odds increased 12.3 percent in 2014 – 2015 to 1 in 73, ranking South Dakota the fifth highest state in the country for the likelihood of a collision with a deer. The representative did not respond to requests to share the data.

5.2.1.2 How Tribal Reservations Collect WVC Data and Identify WVC Hotspots

Tribal departments or programs from the nine South Dakota Tribes, such as the Game and Fish, Wildlife, and Public Safety, were contacted via emails and phone calls to gather information on how the Reservations collect data on WVC and wildlife presence. Individuals contacted are presented in Appendix C. The following questions were asked and the summary of responses are presented below.

1. Does the Tribe collect data about WVC?
The Oglala Sioux Tribe at Pine Ridge and Rosebud Sioux reservations are the only Tribal entities that collect crash data. The Oglala Sioux Tribe reports its data through the TraCS system. The Yankton Sioux Tribe and Crow Creek Sioux Tribe are interested in collecting this information in the future.

2. Does the Tribe conduct carcass pick-up?
The Lower Brule Sioux Tribe and Sisseton Wahpeton Oyate conduct carcass pick-up. The Oglala Sioux Tribe only collects data on endangered species, such as the bald eagle. Further information on carcass collection is provided in the next section on statewide carcass collection.

3. Can you identify “hotspots” or problem areas with incidence of WVC or wildlife populations?
In order to capture information on WVC problem areas, follow-up emails with maps of the respective Reservations were sent to contacts requesting information (route and milepost) about hotspots or problem areas with incidence of WVC (i.e., specific features, mile markers, or stretch of highway). Additional information was obtained during the 2015 Tribal Transportation Safety Summit. The specific information obtained during interviews, by email, or at the Safety Summit are incorporated into Appendix E.

4. Are wildlife surveys or GIS maps available that identify wildlife habitat or wildlife populations within their jurisdiction?

Several interviewed participants indicated there were: big game surveys, elk and deer surveys, and aerial surveys for big game. Results are presented in Appendix E.

5. Do you have any recommendations for mitigating roads on Tribal lands?
Participants' responses included: adding road signs, eliminating blind spots, and the need for outside entities to provide assistance in data collecting and more information about the different types of assistance available.

To further engage the South Dakota Tribes in providing information on how WVC and wildlife data are collected, two members of the research team attended the 2015 South Dakota Tribal Transportation Safety Summit in Mobridge, SD on October 14, 2015. This Summit was attended by a variety of Tribal personnel, including public safety, law enforcement, and transportation planning personnel. Dr. Cramer gave a presentation about current research and the SDDOT study at the Summit. As part of the presentation, large (40" x 40") maps of the nine reservations provided by SDDOT were displayed in the back of the room and participants were asked to mark areas within their Reservation where WVC occur most heavily or to identify areas with significant wildlife populations. Team member Mary Kenner helped participants delineate hotspots on these maps. The information recorded on the maps was incorporated into a table, Appendix E, making it accessible for this report. Information in the table indicates who provided information on route, milepost, species (if identified), and additional notes. The maps can be used in future phases of this research and are kept with the PI.

5.2.1.3 How WVC Carcass Data Are Collected, Reported and Shared

WVC carcass reports are derived primarily from SDDOT-SDGFP contractors who pick up wildlife carcasses from the roadway. Wildlife carcasses are considered an eyesore in South Dakota and the carcasses may present additional safety concerns for drivers. Complaints from the public about carcasses are the primary reason for hiring contractors to conduct the carcass pickups. While funding for the carcass pick-up program is managed at the state level; the costs of which are borne equally by SDDOT and SDGFP through a cooperative agreement, individual contracts are administered at the SDDOT area or region level. Carcass contracts may assign designated routes to be driven periodically, typically twice a week, or seasonally; or pickups may be conducted on an as needed basis. Carcass contracts are typically issued for Interstates 90 and 29, and some segments of state highways. Carcass contractor routes are displayed in Figure 5.

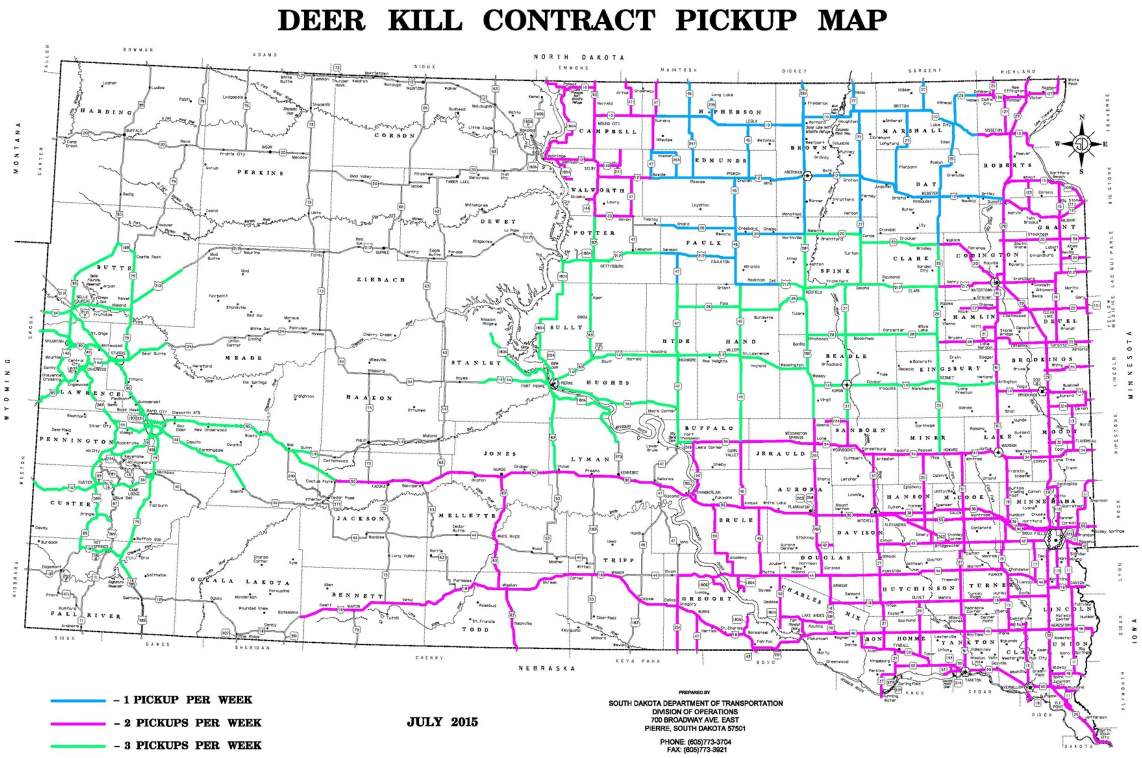

Figure 5. WVC Carcass Collection Routes of Contractors Employed by SDDOT and SDGFP on South Dakota State Maintained Roads 2015.

WVC carcasses may be marked for pickup and called in to SDDOT by law enforcement officers, SDDOT maintenance personnel, SDGFP personnel, or the public. On roads that are not covered by a carcass contract, SDGFP, SDDOT maintenance personnel, or local law enforcement may remove carcasses from the road, particularly if they are located near a home or business. Carcasses that are not picked up are often scavenged by other wildlife, or picked up by members of the traveling public. Areas with carcass contractors are the only locations where personnel make reports; WVC carcasses in areas without contractors can go unreported. Law enforcement officials have no way to officially report these carcasses because they can only report crashes.

A variety of paper forms are used for reporting WVC carcasses (see examples in Appendix D), however, the fields included on the form are fairly consistent. For each WVC carcass, contractors record the date; location using geographic coordinates measured using a GPS device, or highway number and mile reference marker; and species, or if reporting deer only, then record whether the animal was a mule deer or white-tailed deer and sex.

Compliance in reporting all of these fields varies among contractors, and not all contractors have a GPS available for recording coordinates.

SDDOT regional and district offices inconsistently share carcass data with SDGFP. The format of the submitted data may either be scanned copies of the paper reports and/or an Excel spreadsheet of the reports compiled on a monthly or annual basis. In addition, some SDDOT offices send carcass data to the Wildlife Damage Program in the SDGFP headquarters office, while others send their data to the regional SDGFP managers. As a result, WVC carcass data are not compiled into a single database on a statewide level. The lack of a standard process for sharing WVC carcass data with SDGFP state and regional offices reduces the usefulness of the reported data, because it is not compiled in one place and no office has access to complete coverage for their region or the state. Improved interagency communication and standardized protocols for sharing WVC carcass reports could improve SDGFP access to the data and enhance their usefulness.

In the Black Hills and surrounding areas, SDGFP engages in additional WVC carcass contracting and reporting. High levels of tourism and a major population center account for increased effort in cleaning up wildlife carcasses in this area. Specifically, SDGFP Region 1 issues another carcass contract complementing the SDDOT contracts to provide additional coverage on state and local roads. SDGFP personnel also pick up less common species, such as bighorn sheep and mountain lion, and maintain these carcass data in a separate Excel database. Table 4 lists the various entities recording WVC carcass data – including SDDOT offices, SDGFP offices and Tribes – and notes which species are reported, the spatial accuracy of the data, what format the data are in, and where they are housed.

Table 4. Sources of WVC Carcass Data in South Dakota as of 2015.

COVERAGE	HOUSED AT	FORMAT	ACCURACY	SPECIES	NOTES
SDDOT Carcass Contracts	Administered Through SDDOT Area or Regional Offices				
Various SDDOT Areas	SDGFP HQ office	Scanned reports from SDDOT offices compiled in spreadsheet	Variable (GPS or Hwy and nearest MRM)	Deer	Annually compiled spreadsheet of scanned reports submitted to SDGFP from across the state by DOT Area offices (24 counties of 66 collected 2,619 carcasses in 2014).
Pierre Area (Interstates & some State Highways)	Area office	Paper reports compiled in spreadsheet	Hwy and MRM	Deer	Compiled spreadsheet sent to SDGFP Region 2 office.
Rapid City Area	Area office	Paper reports compiled in spreadsheet	GPS	Primarily deer, & record small species	One contract for interstate; one for secondary roads. Copies of reports sent to SDGFP Region 1 office.
Winner Area	Area office	Paper reports compiled in spreadsheet	GPS	Deer	Other species picked up but not recorded. Compiled spreadsheet sent to SDGFP headquarters (Keith Fisk).
Mitchell Region	SDGFP Regional office	Paper reports	Hwy and nearest MRM	Primarily Deer	In most DOT area/regions carcass pickups coordinated by DOT office, but in Mitchell Region carcass pickups called into SDGFP Region 4 office.
SDGFP					
Region 1 (Western) carcass contract for Black Hills area and other major highways	SDGFP Regional office	Paper reports	GPS	Primarily deer	Contractor has switched from paper records to using a tablet in last 1-2 years.

COVERAGE	HOUSED AT	FORMAT	ACCURACY	SPECIES	NOTES
Region 1 (Western) rarer species carcass pickup	SDGFP Regional office	Paper reports compiled in mortality spreadsheet	GPS	Bighorn sheep, mountain lion	1998- Ongoing. Black Hills and Prairie regions.
Statewide rare species road mortality database	Natural Heritage Program	Shapefile	GPS	River otter	Incidental pick-up of rare species. NHP also has data for swift fox, snakes, and other rare species.
Tribes*					
Lower Brule Sioux Tribe	Tribal Department of Fish, Wildlife and Recreation	Unknown	Unknown	Deer	Tribe picks up carcasses; data not recorded
Oglala Sioux Tribe	Department of Public Safety	Unknown	Unknown	Protected species only	No carcass pickup unless a protected species; data recorded.
Sisseton Wahpeton Oyate Tribe	Fish and Wildlife Program	Unknown	Unknown	Deer	Pickup only; data not recorded
Rosebud Sioux Tribe	Police Chief	Unknown	Unknown	Deer	State picks up carcasses; data recorded.

**Tribes not listed do not conduct carcass pickups.*

As of 2015, available WVC carcass data are not compiled into a useable electronic format and are not used by SDDOT to complement WVC crash data to more fully frame the WVC problem across the state. Within SDDOT, WVC carcass numbers are used solely for the purpose of making payments to contractors and are not included in safety analyses. Local SDDOT offices may compile the submitted paper reports in an Excel spreadsheet to assist in this accounting; other SDDOT offices scan the paper reports to share with SDGFP without compiling the data. Crash reports are the only WVC data that are used to inform transportation project designs. Yet unreported WVC incidents still constitute a safety issue of concern for the state.

Comprehensive WVC crash and carcass databases are instrumental in order to implement safety improvements and address wildlife mitigation needs. Another benefit of carcass data is that they have species information that can be used to inform species-specific wildlife mitigation measures.

Identified gaps in WVC carcass data collection and compilation include:

1. Incomplete Geographic Coverage and Reporting Systems for WVC Carcass Reports

   No WVC carcass reporting occurs in the more remote areas of the state or on less travelled routes, including some state highways and all county and local roads. Officers may remove carcasses from the roadway when they are encountered or called in, however they have no means of reporting these events. In addition, some WVC carcasses are scavenged by other wildlife before they can be reported, or may be salvaged by passers-by interested in taking trophy species such as elk or bighorn sheep, or game species such as deer, even though this is not legal unless a permit was obtained to take the animal's carcass.

2. Incomplete Carcass Reporting

   Carcass contractors are paid by route, or on a per-animal basis. Complete, accurate, and legible reports are not incentivized in the current payment system and, as a result, many reports have incomplete information.

3. Locational Inaccuracies

   Many carcass reports are submitted with only the highway number and nearest Mile Reference Marker (MRM) provided for the pickup location. These approximate locations are not translated into latitude/longitude. For example, of the 24 counties that submitted carcass data to the SDGFP Wildlife Damage Program Office, approximately 62 percent of the 2,619 records did not include latitude/longitude collected by a GPS. In the Pierre Area, WVC carcass data are tallied in an Excel spreadsheet on a monthly basis; however, the compilation includes highway number and MRM only.

4. Inconsistent Data Compilation and Sharing Protocols

Most SDDOT area or region offices that administer carcass contracts compile the hard copy reports into a spreadsheet where the number of carcass pickups is tallied. Typically, the scanned hard copy reports and the compiled spreadsheets are shared with SDGFP; however, across the state, offices were not consistent in sending these data to both SDGFP headquarters and to SDGFP regional offices. As a result, carcass data are not compiled on a statewide basis for all the highways with active contracts.

5. Inaccurate Notation for Latitude and Longitude

In several of the WVC carcass data spreadsheets the latitude and longitude was entered in the notation of xx.xx.xx which is most likely degrees, minutes, and seconds. However, the data are often also in the notation of xx.xxx.xx or xx.xx.xxx and these values need to be translated into a standard mapping system in a GIS which is typically in decimal degrees (xx.xxxxx). The notation is challenging and in some cases is impossible to translate for mapping purposes.

Many interviewees at both SDGFP and SDDOT noted a need for comprehensive WVC carcass reporting and standardized protocols for reporting and centralized data compilation so that it may be used in identifying WVC hotspots at the state and regional levels, and also further contribute to SDGFP's understanding of WVC impacts to wildlife populations. Interviewees noted that the current process for reporting WVC carcasses is cumbersome and insufficient, and that it is time consuming to compile and map the reported WVC carcass locations for analysis purposes. Several interviewees also commented how some carcasses may not be picked up in a timely fashion, and concern was expressed about lack of accountability required from carcass contractors. These concerns lend credibility to the idea that South Dakota would be best served by standardizing the manner which carcass data are collected and reported, and how contractors are paid. Below an example of an alternative process is provided, based on Utah's system of carcass collection.

5.2.1.4 How a WVC Reporter Smartphone Application Be Implemented South Dakota

In interviews, the research team presented the concept of a WVC Reporter smartphone app, similar to what contractors for the Utah Department of Transportation (UDOT) are now required to use (Olson et al. 2014a). The WVC Reporter is designed to improve consistency and accuracy in wildlife carcass reporting, is compatible with iPhone and Android GPS enabled smartphones, and can be used on computers as well. The app is simple to use, entries are required for only three pieces of information when using the smartphone app: the species, its gender, and age class information (juvenile vs. adult) of the animal. The app automatically populates the rest of the information including highway number, mile marker and region based on the GPS location, date and time. Released in Utah in 2012, the app has demonstrably decreased staff time entering data and improved the accuracy of those data for mitigation planning. App usage eliminated all errors associated with location information; decreased mean times for data recording by 49-58 percent, and entirely eliminated the need for data transcription; and removed the majority of data entry errors, compared to the pen/paper method which had an introduced error rate of 10 percent (Olson et al. 2014a). The app uploads all entry points into a statewide map available immediately, and is used by agency personnel in mapping WVC carcasses to distinguish problem areas.

The target users of the WVC Reporter app in South Dakota include:

- Carcass contractors (Contracts could require app use, see Appendix F for Utah example);
- SDGFP conservation officers and other SDGFP personnel (voluntary use);
- SDDOT personnel (voluntary use); and
- Local law enforcement officers (voluntary use).

Where use of the WVC Reporter app is voluntary, it is important to conduct appropriate trainings and outreach to educate users on the value of these data and to institute incentives to motivate use. While implementing such an app in South Dakota to facilitate WVC carcass reporting would require some initial set-up and a change in requirements for carcass contractors, the use of a smartphone app may be the best means of improving consistency and accuracy in carcass data collection. Unfortunately, at this time Utah does not have a system to eliminate double counting of carcasses. This would include one more step with the data: comparing locations that are within 10 meters of each other, and within a week of reporting.

Implementation of the WVC Reporter app for use in South Dakota offers a number of benefits, including streamlined reporting across users and automatic data compilation to a centralized server. The resulting statewide carcass database would support existing needs, such as payments to contractors, as well as enhanced carcass data reporting and compilation to assist in addressing the WVC problem in South Dakota.

Alternatively, another approach is to develop a web database front end that can be used through a browser on any computer or smartphone. This approach avoids the need to update an app with new smartphone operating systems at additional cost to the agency. Systems that use the computer to upload data include those in California (See Appendix A), and Idaho (Idaho Fish and Game 2015).

5.2.2 How WVC Hotspots Are Mapped

5.2.2.1 WVC Crash Hotspots

WVC **crash** data can be mapped to help identify road segments with greatest number of reported WVC per mile relative to other road segments, referred to as hotspots. The researchers further developed the above reported crash database to create WVC crash hotspot maps. In this section the methods for developing WVC crash hotspots maps for the state and one local SDDOT region are described.

In South Dakota the reported WVC crash dataset is the only consistently collected WVC data across the entire state and, therefore, is currently the only dataset suitable for WVC mapping and analysis at a statewide level. The researchers completed a hotspot analysis in a GIS to calculate road segments with the highest WVC rates on roads from 2004-2013.

The WVC crash dataset was queried for all reported WVC crashes for both state and local roads by using the search term “wild animal.” The 2004 - 2013 database included 46,960 records. Of these records, 46,650 had correct geographic coordinates and were mapped in a GIS for exploration and analysis (Figure 6). The remaining 310 crash reports, which were 0.007 percent of the total crash records, were not included in the analyses due to missing latitude and longitude values.

Over the ten-year period 28 percent of all reported crashes involved a wild animal.

Table 5 lists the distribution of WVC crashes by SDDOT area on all roads (state and county) compared to those on SDDOT administered roads, (US Interstates, US Highways, and State Highways).

Sixty-seven percent of all reported WVC crashes were on SDDOT administered highways, (US Interstates, US Highways, and SD Highways).

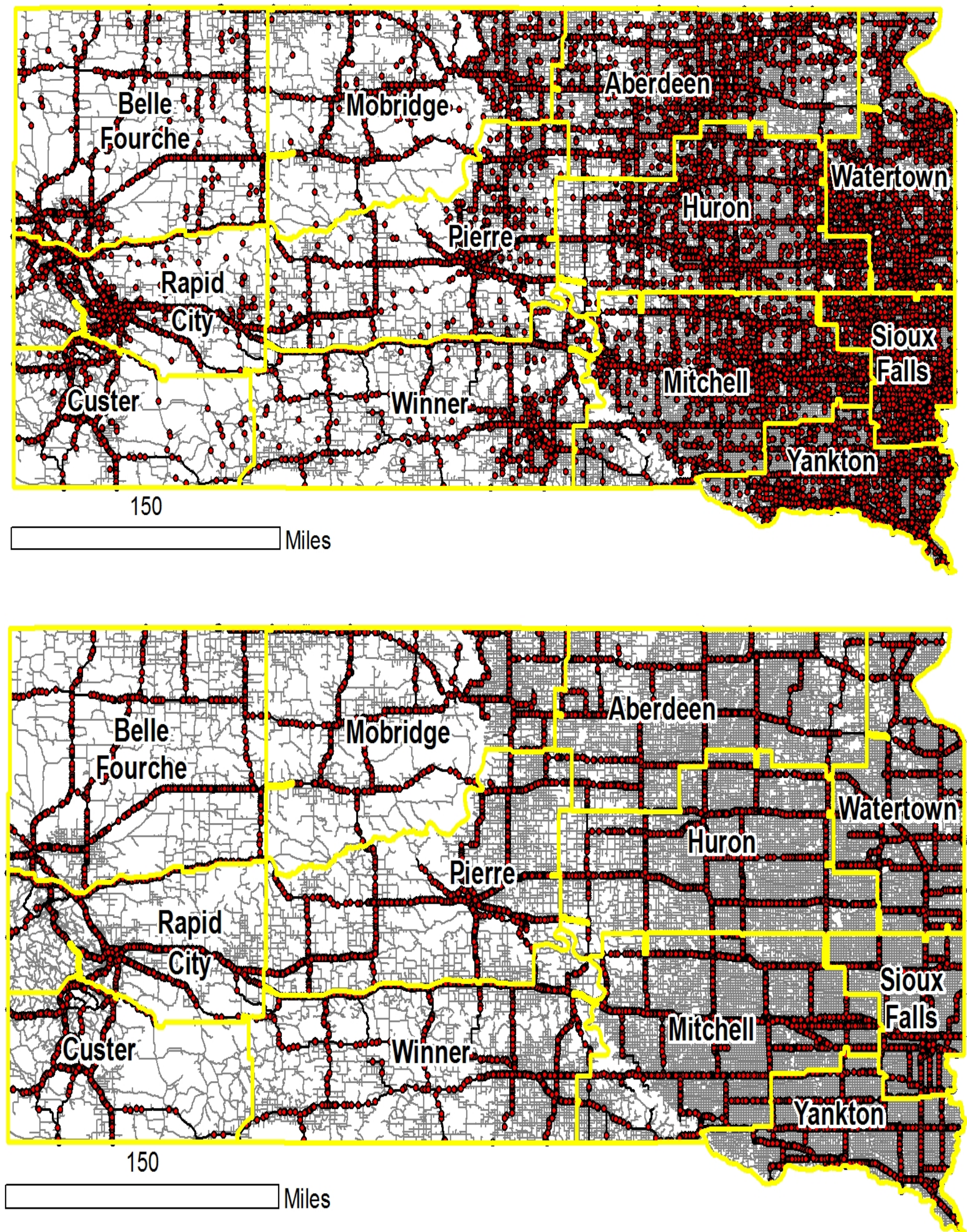

Figure 6. WVC Reported Crashes from 2004 to 2013 on all South Dakota Roads, top and on SDDOT Administered Roads, bottom.

The highest number of reported WVC crashes were reported in the Sioux Falls SDDOT Area, followed by the Rapid City Area, and then the Mitchell Area.

Table 5. WVC Reported Crashes by SDDOT Area.

Area Name	Count All Roads	Count SDDOT Primary Highways
Aberdeen	4,599	3,097
Belle Fourche	1,721	1,487
Custer	1,647	1,473
Huron	4,473	3,201
Mitchell	5,855	4,125
Mobridge	1,245	1,044
Pierre	2,562	2,215
Rapid City	5,859	4,558
Sioux Falls	8,030	4,867
Watertown	4,990	3,465
Winner	2,120	1,820
Yankton	3,549	2,608
Total	**46,650**	**31,352**

A master map of the statewide reported WVC crashes was created in a GIS with the WVC crash data from 2004-2013. Road segments with highest WVC crash rates were color coded to create the hotspot map; colors ranged from green on road segments with low WVC crash rates, to red on road segments with the highest WVC crash rates (Figure 7).

The GIS analysis was similar to a nearest neighbor software analysis, conducted by researchers for the Ministry of Transportation in Ontario (Ministry of Transportation Ontario, unpublished report). The nearest neighbor program or algorithm aggregated hotspots along the state highway network. The algorithm grouped all crashes that were within 0.3 miles (0.5 km) of each other into a hotspot along the road. This was the minimum length of the algorithm. A hotspot terminated where no additional WVC crashes were located within 0.3 miles (0.5 km) in either direction of the road from that initial hotspot. This resulted in varying frequency of crashes per length of road. To standardize these rates across varying lengths of roads, a WVC crash rate for each segment was then converted to the number of crashes reported per mile. This WVC crash rate was calculated by counting the number of WVCs and dividing by the length in miles. Then the Jenks Optimization Method was used to classify the continuous values of WVC crashes per mile into four classes. This process allowed hotspots to be standardized and compared across the state.

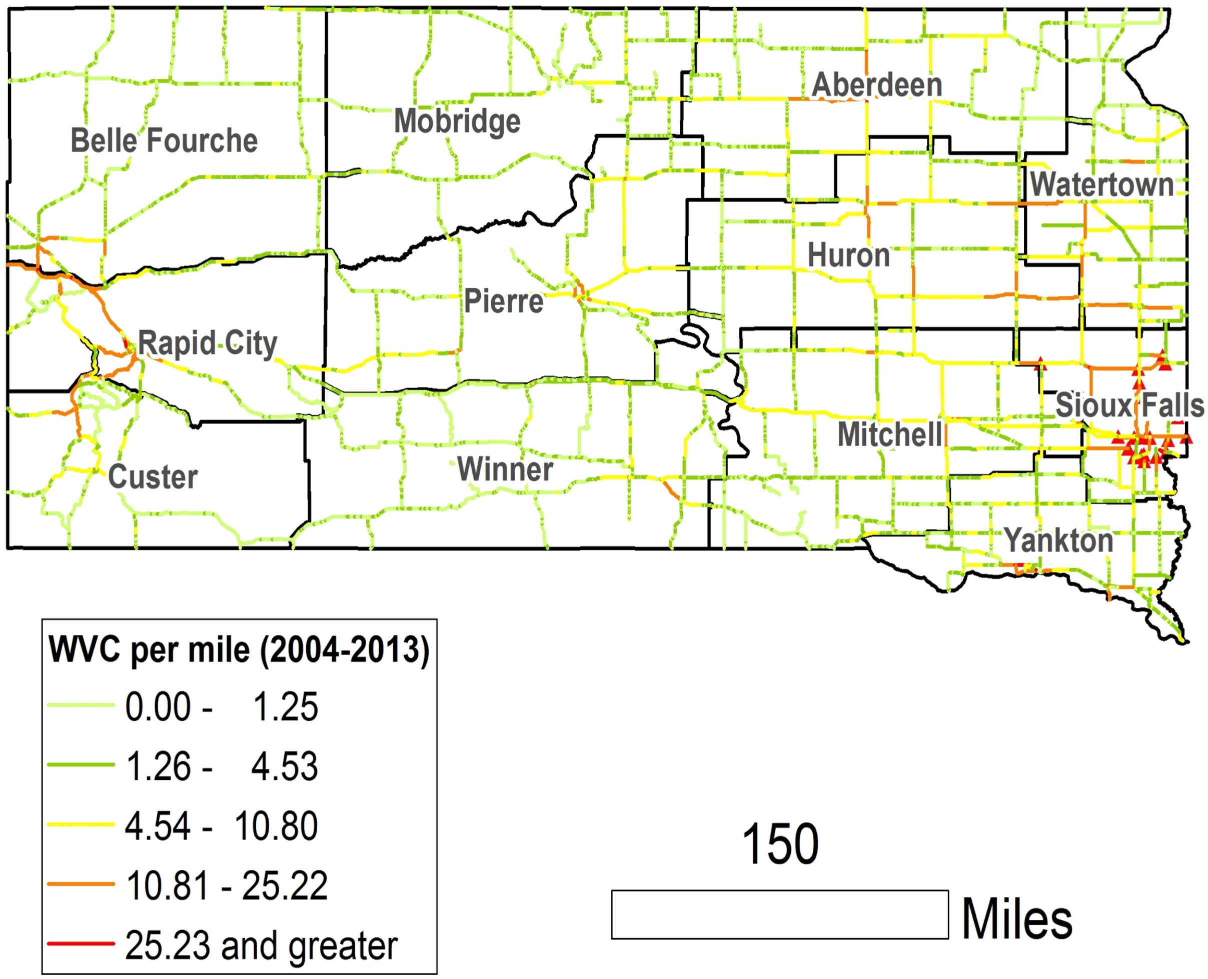

Figure 7. Reported WVC Crash Hotspots Rates per Mile per 10 Years on South Dakota Department of Transportation Administered Roads. Names Portray SDDOT Areas and Not Cities.

The road segments with the highest number of reported crashes, represented by the orange and red value segments that had 10.8 or more crashes per mile for 10 years, encompassed 34 percent of all the reported WVC crashes and occurred on just nine percent (770 miles, 1,239 km) of all the SDDOT administered roads. These segments begin to indicate priority areas where SDDDOT can focus mitigation efforts where the greatest WVC rates occur. Table 6 summarizes the top 20 South Dakota WVC crash hotspots with the highest number of reported crashes.

Table 6. Top 20 Hotspots for Reported WVC Crashes for South Dakota 2004-2013. Rates for Annual Basis.

Rank	Road	Description	Mile Post Segment	Length in Miles	WVC/ mile/yr.	SDDOT Region	Nearby City	County
1	I-90	END RAMP EAST & WEST EXIT 10	9.9 - 10.2 and 10.7 - 11.1	0.25 and 0.36	12.50	RAP	SPEARFISH	LAWRENCE
2	SD 50	BETWEEN SD 52 AND SD 153	374.8 – 375	0.20	5.27	MIT	YANKTON	YANKTON
3	44	EAST ST PATRICK ST RAPID	48.6	0.08	5.23	RAP	RAPID CITY	PENNINGTON
4	12 E	END EBL IN ABERSEN	288.3	0.04	4.95	ABR	ABERDEEN	BROWN
5	SD 45	SD 45 NORTH OF JCT W SD 26	129.6-129.7	0.11	4.40	ABR	POLLO	HAND
6	SD 50	BETWEEN SD 52 AND SD 153	MP 375 - 378	3.00	4.10	MIT	YANKTON	YANKTON
7	231 N	ELM ST BLACK HAWK	86.1 – 86.2	0.13	3.91	RAP	RAPID CITY	MEADE
8	SD 42	BEG AT SIX MILE RD SIOUX F	371.3 - 373.2	1.93	3.67	MIT	SIOUX FALLS	MINNEHAHA
9	016	END WBL NE OF HILL CITY	45.1	0.03	3.64	RAP	HILL CITY	PENNINGTON
10	29 N	END RAMP N2 EXIT 83	83.7 – 83.9	0.22	3.63	MIT	SIOUX FALLS	MINNEHAHA
11	85 S	BEGIN AT JCT US 85 S, JCT	10.2 – 45.1	34.9	3.54	RAP	SPEARFISH	LAWRENCE
12	I-90 E	Black Hawk	51	0.1	3.50	RAP	RAPID CITY	MEADE
13	231	#2 PINE HILLS ROAD - RAPID	82.3 – 85.3	2.9	3.10	RAP	RAPID CITY	PENNINGTON
14	SD 46	NEAR THE VERMILLION RIVER	356 - 357	0.6	3.06	MIT	CENTERVILLE	CLAY
15	314	S OF YANKTON, N OF JCT W US 81	382 – 382.1	0.1	3.06	MIT	YANKTON	YANKTON
16	SD 212	END DIVIDED SOUTH OF NEWE	36.3 – 36.4	0.1	3.05	RAP	NEWELL	BUTTE
17	83	JUNCTION OF SD 248	88.1 – 88.2	0.1	3.02	PIR	VIVIAN	LYMAN
18	34 W	JUNCTION SD 19	389.8 - 390	0.2	3.02	MIT	MADISON(?)	LAKE

Rank	Road	Description	Mile Post Segment	Length in Miles	WVC/ mile/yr.	SDDOT Region	Nearby City	County
19	I-90 E	END RAMP W2 EXIT 23	23.4 – 24.1	0.7	2.99	RAP	WHITEWOOD	LAWRENCE
20	79	JCT SD 79 MAVERICK JUNCTIN	26.5 – 26.7	0.2	2.92	RAP	HOT SPRINGS	FALL RIVER

The top reported WVC crash rate area is Interstate 90, between MRM 9.97 and 11.10 in Spearfish. There were five separate entries for this 1.13-mile stretch in the database produced by the GIS analysis. This was due to separate reporting for west bound and east bound lanes, and three distinct sections where reported WVC crashes occurred. These sections are: MRM 9.97 to 10.22, section MRM 10.22 and 10.72, and MRM 10.72 to 11.1. Combined, these segments had a total of 125 reported WVC crashes from 2004 – 2013, for an annual average rate of 12.5 per mile.

The second highest WVC crash rate reported hotspot was on SD 50, from MRM 374.8 to 375. This 0.2-mile section had a WVC rate of 5.27 crashes per mile per year. This road from MRM 375 to 378 had the sixth highest ranked WVC crash rate hotspot, with 4.09 WVC per mile per year. Combining these two sections would have lowered the ranking of the section from MRM 374.8 to 375 to the sixth ranked spot, which may have distilled the severity of the WVC crash rate at that location, thus the two locations were kept separate.

The WVC crash hotspot map (Figure 7) should be considered preliminary, and a generalization. The map needs to be further validated for accuracy. There was limited amount of time and funds for this GIS component of the study, and thus validation steps were not fully accomplished. There may be spatial errors in the resulting database of hotspots due to the underlying raw crash data used, and the road and MRM maps. For example, there may be spatial errors at highway intersections where the highways are denoted with two lines. There needs to be further GIS analyses with the data. This would include verifying every entry in the WVC crash database, cross referencing areas where the crash report noted “near intersection,” combining nearby hotspot locations, locating hotspots on maps to verify accuracy, cross referencing with agency personnel on the ground, and presenting accurate start and finish ends to segments. It is strongly recommended that this map be used as a general guide to begin the consideration of WVC hotspots in transportation planning. Users of the WVC hotspot map can further explore WVC hotspot areas by: mapping individual WVC crash hotspots; learning of the species involved and the animals’ needs to move; and other information such as nearby streams that pass beneath the road where existing bridges could be retrofit to pass the species of concern.

An example of how the statewide WVC crash hotspot map was and could be used as the base of exploration is given for the I-90 Spearfish hotspot. In 2015-2016 SDDOT personnel began looking at this hotspot to work toward mitigation efforts. This stretch of highway is listed in Table 6 as the number one highest WVC rate area, with two distinct hotspots within 1.13 miles

(1.8 km). The Primary Investigator of this study and SDDOT engineer M. Rippentrop strategized on how wildlife exclusion fencing could be placed between MRM 9.9 and 10.22 to guide deer to existing bridges over the local stream, to pass beneath I-90 and entrance and exit ramps. Then SDDOT traffic safety engineer A. Vandel mapped more recent data on the map location at a much finer scale than the original statewide map, and found an even higher concentration of WVC crashes at MP 10.7 to 11.1. This changed SDDOT strategy on mitigation efforts, and the more highly concentrated WVC crash area became the focus of initial mitigation efforts (see Figure 8).

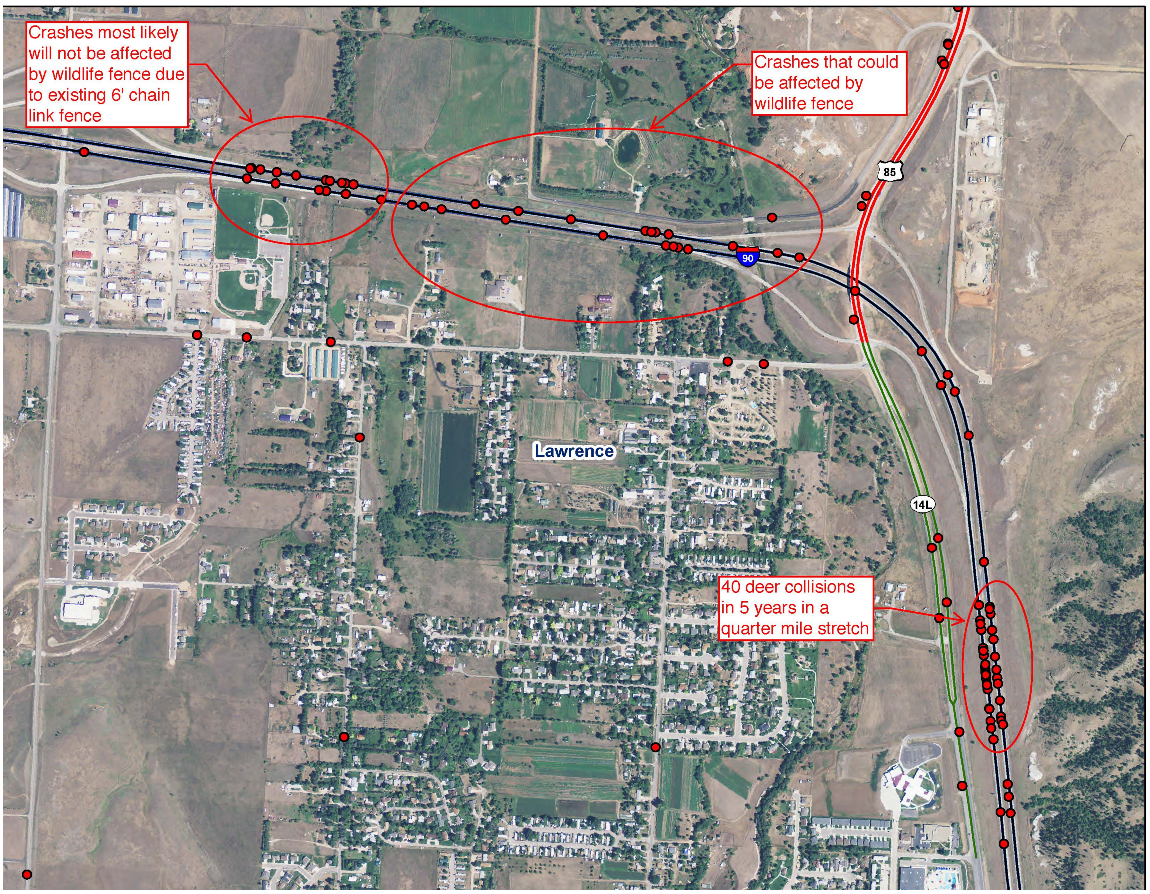

Figure 8. Map of WVC Reported Crashes on Interstate-90 Near Spearfish, South Dakota. Map Demonstrates Two Hotspot Sections Within 1.2 Miles (1.9 km). Map Created by A. Vandel, SDDOT, Used with Permission.

The WVC hotspot analysis for the entire state may also be conducted in a GIS at a finer scale, such as the region or area level. Figure 9 depicts a WVC analysis for the Rapid City and Custer SDDOT Areas. The Rapid City area highways with the most WVC were I-90, SD-44, US-385, and US-16E. Future research could be conducted that addresses every SDDOT Region in this mapping manner.

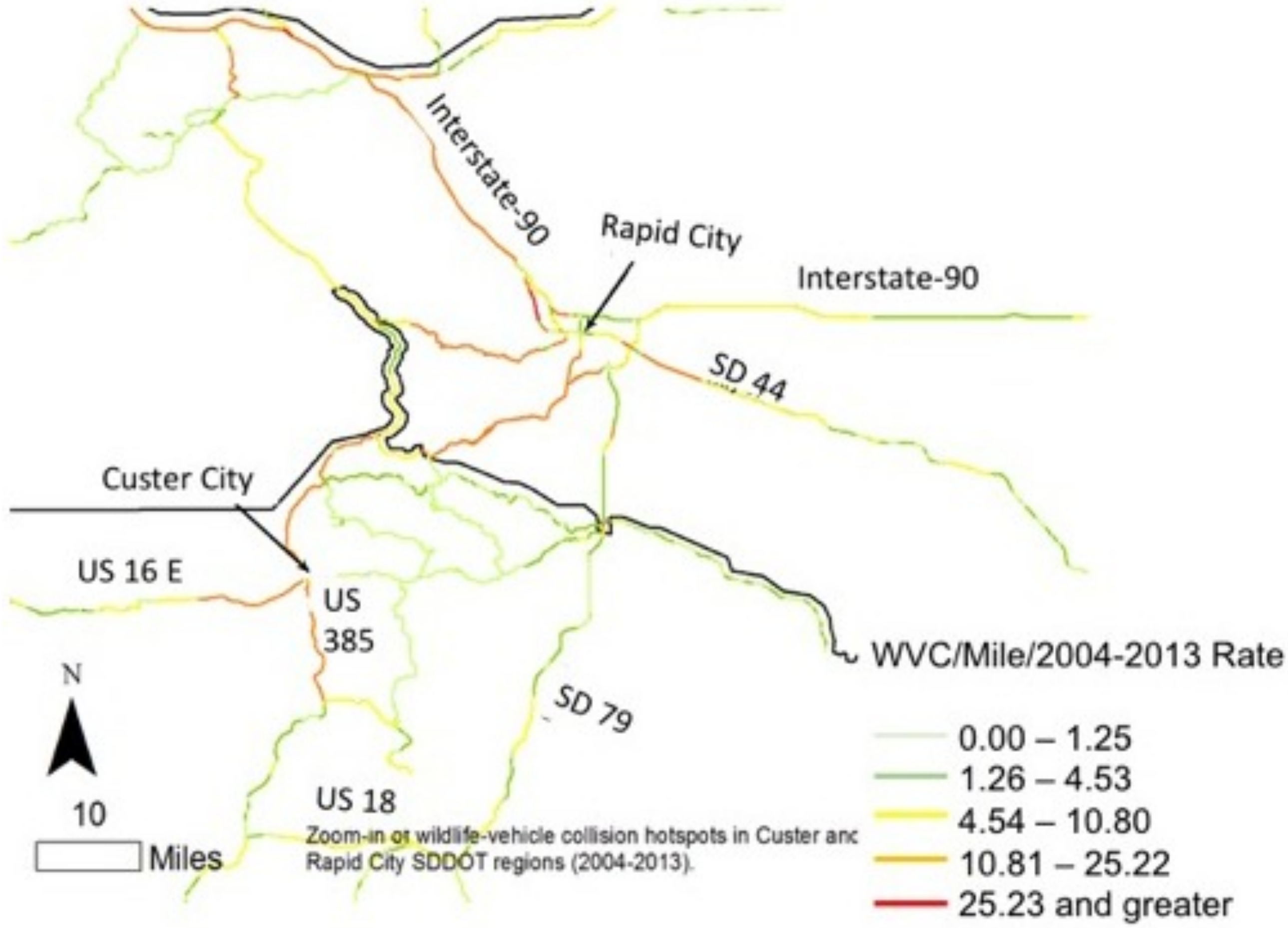

Figure 9. Reported WVC Crash Hotspots in Rapid City and Custer SDDOT Areas, 2004-2013.

These hotspots may be further prioritized by identifying where motorist fatalities and injuries occur more often than expected; where a higher proportion of WVCs are occurring as per total crashes; or where the risk of WVC are high relative to the number of vehicles on the road, as was calculated by Dodd (2014), and Gunson et al. (2012). Determining the metrics for prioritizing WVC hotspots for mitigation may vary across jurisdictions. Multi-criteria assessments to weigh and evaluate important metrics may be performed with stakeholders and experts within each jurisdiction. These methods would need to be decided upon by SDDOT and SDGFP in an established prioritization process, much like the one created in Idaho (Cramer et al. 2014).

Figure 10 demonstrates how crash data can be mapped to evaluate the road segments with the most severe WVC accidents. From 2004-2013, 46,960 reported WVC crashes resulted in 15 human fatalities, and 735 injuries. By mapping the locations of these injuries and fatalities it becomes apparent that the large concentration of injuries in the Rapid City and Sioux Falls areas coincide with the WVC hotspots depicted in Figure 7.

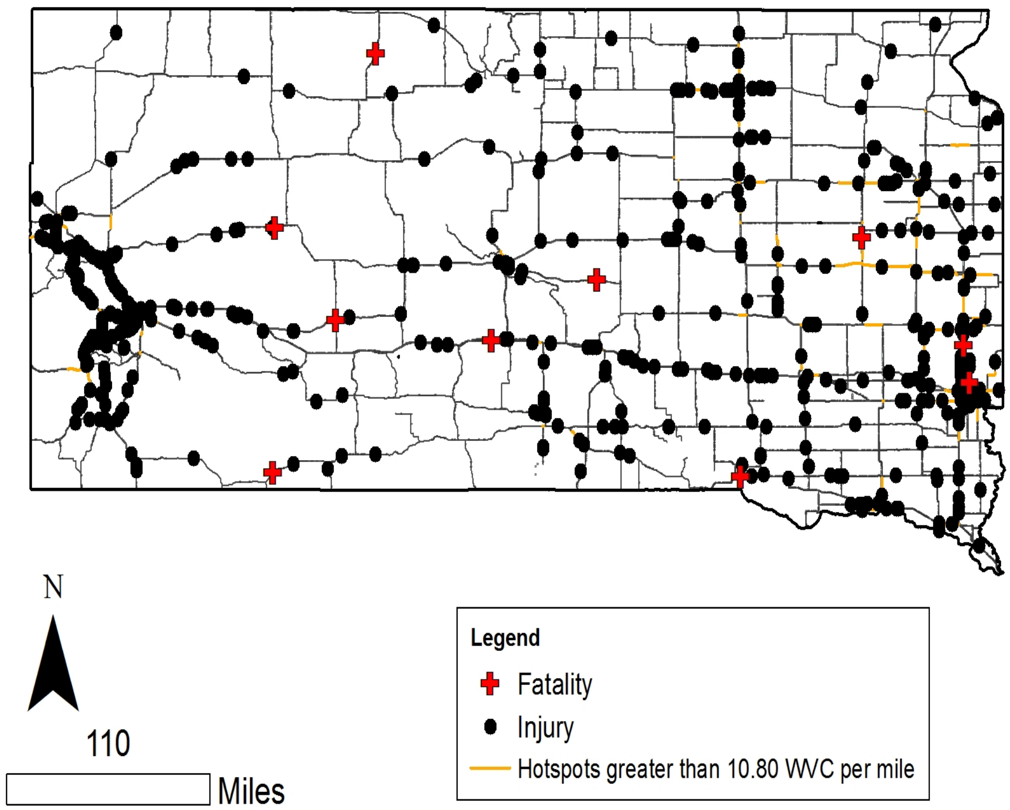

Figure 10. Human Injuries (Black Dots) and Fatalities (Red Crosses) From Reported WVC in South Dakota from 2004-2013.

One limitation of analyses based on crash data is that these data typically underrepresent the actual WVC rate because the statewide analysis is dependent on reported crashes, which is the only consistently-reported WVC across the state. Ultimately, the objective is to conduct hotspot analyses based on WVC crash and carcass datasets, as described in the following section.

5.2.2.2 WVC Carcass Hotspots

Despite the limitations of the WVC carcass data, the researchers mapped the available WVC carcass data to demonstrate how these data could be used to help identify WVC hotspot areas, and how the current data range from fairly accurate to less than suitable for mapping accurate locations (Figures 11 and 12). The 2014 WVC carcass database used in Figure 11 was obtained from SDGFP. The Rapid City region's carcass contractor that works under a different contracting system than the other state contractors gave his data to the researchers, and these were mapped in Figure 12. The Rapid City contractor's data were not added to the statewide database obtained from SDGFP, thus are not represented in Figure 11. Although substantial efforts were made by the research team to clean up inaccuracies in the database, the researchers found multiple shortcomings with the data including:

1. Inaccurate locations of the carcass data points for a large segment of the data, such as the northeast corner of South Dakota where carcass locations were reported in decimal degrees differently than the standardized method, and as a result there were many outliers in the figure and a majority of the data did not occur on roads. These inaccuracies were largely due to data entry notation of the latitude and latitude in a non-standardized format. The data needed to be translated to decimal degrees, and in some cases the decimals were not in the correct places.

2. Figure 11 demonstrates there is incomplete reporting for many areas of the state, including those with active carcass pickup contracts.

The best example of a WVC carcass dataset accurately collected, was obtained from Chris Mueller, a contractor who conducts carcass pickups for both SDDOT and SDGFP in the Custer District of the Rapid City Region, and records his pickups in an Excel spreadsheet for payment purposes. Figure 12 displays these data for the fall months of 2011, 2012, 2013, and 2014.

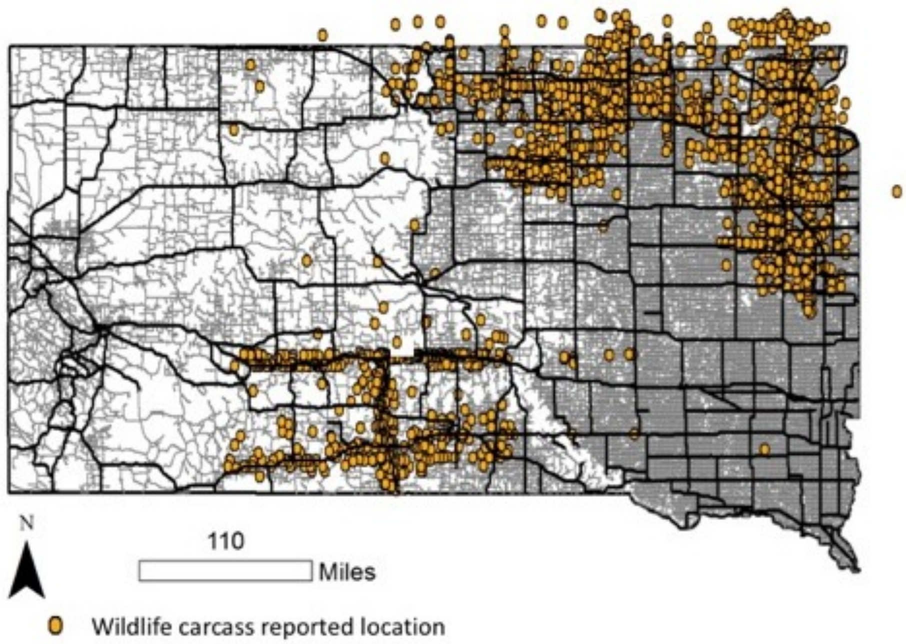

Figure 11. The 2014 Reported Carcasses Picked up by Carcass Contractors and compiled by SDGFP.

Note: Carcass points outside of state suggest locational inaccuracies, and lack of carcasses along contracted roads suggest incomplete data reporting.

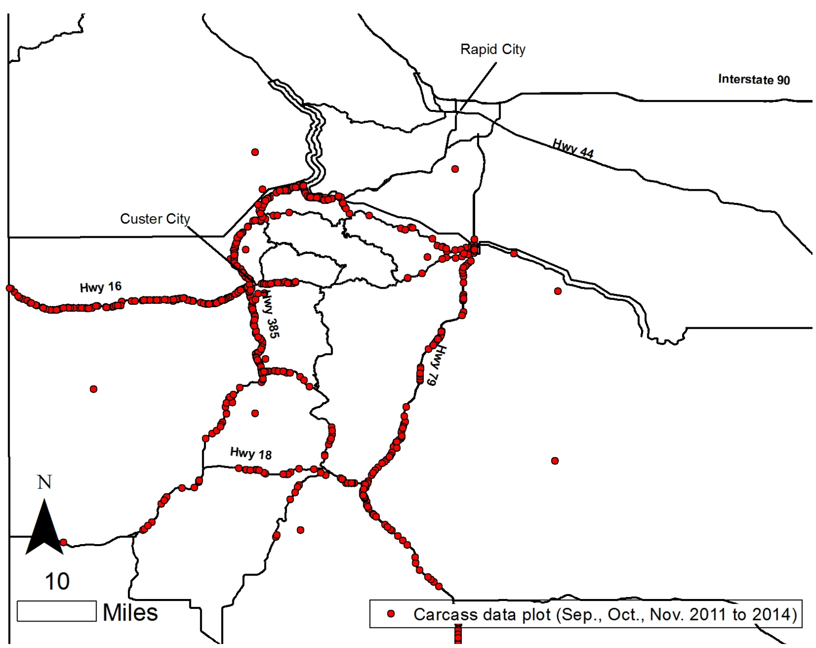

Figure 12. South Dakota Department of Transportation Custer District of the Rapid City Region WVC Carcass Pickup Locations from the Fall (September, October, and November) Months of 2011 - 2014.

5.2.3 Incorporation of Wildlife and Habitat Data Into Hotspot Analysis

The identification of problem WVC hotspots does not typically end with mapping crash and carcass data. For a more robust analysis, other types of data should also be incorporated for the purpose of identifying and prioritizing road segments with the potential or actual wildlife-vehicle conflicts. These data include: maps of wildlife populations based on location occurrence data, maps of suitable habitat for the species of interest, and wildlife linkage maps based on either empirical data of wildlife locations, or modeling of habitat to create hypothetical population locations and linkages.

Wildlife presence in areas near the road is extremely important for a thorough analysis of WVC hotspots and selecting mitigation solutions. In order to select mitigation measures, it is important to know what species of ungulates and carnivores are accessing the road and becoming involved in WVC. Mitigation actions are very species specific. The researchers worked with SDGFP personnel to determine which GIS data layers are available for addressing wildlife habitat and movement areas near roads, to help identify the species most likely to be involved in a WVC. The team members compiled spatial GIS data layers from a variety of sources (Table 7). These GIS layers may be used to inform future analyses and prioritization processes, such as:

- Examining roadway characteristics such as number of lanes, traffic volume and landscape characteristics associated with WVC hotspots;
- Defining and locating WVC hotspots and identify patterns of WVCs by time of year or from year to year;
- Integrating these maps as part of a modeling exercise to identify landscape characteristics of WVC hotspot areas in different parts of the state;
- Creating models of potential WVC hotspots on future roads, such as SD 100 in Sioux Falls, in order to predict where mitigation measures should be placed.

Examples of these and other types of WVC analyses conducted in other states and Canadian provinces are provided in Appendix A. Notably, some GIS layers that are useful in conducting an analysis of road segments to prioritize wildlife mitigation actions are not readily available in South Dakota. These include:

- Consistently recorded WVC carcass data across the state, complete with geographic coordinates and species information;
- Spatially explicit statewide maps based on wildlife survey data and models of wildlife presence and potential habitat for target species such as mule deer, white-tailed deer, elk, bighorn sheep, mountain lion, and other species of interest (discussed further in the following section).

Table 7. Compiled GIS Layers. These Include Base Layers, Collision and Carcass Data Available for Import Into a GIS, and Available Wildlife and Environmental Spatial Datasets.

GIS LAYER	SPATIAL/TEMPO RAL RANGE	TYPE	SOURCE	NOTES
State Highways (Obtained as 'Surface Properties')	Statewide	Route layer	SDDOT	Represents the alignment and surface characteristics of the state's highway system; Includes surface and road shoulder type/condition attributes
Mile Reference Markers (MRM)	Statewide; SDDOT roads only	Shapefile	SDDOT	MRM type: uniform, structure, special,
Local Roads	Statewide	Shapefile	SDDOT	Numerous attributes (see data dictionary for Roadway Interactive System, RIS). Attributes: number of lanes, road type, speed limit, etc.
Bridges	Statewide; Includes all state, county, municipal, city & private)	Shapefile	SDDOT	Numerous attributes relating to bridge type and structure dimensions (height not included)
Culverts – State Highways	Statewide; SDDOT roads only	Shapefile	SDDOT	Does not include approach culverts. Attributes include type and materials; does not include dimensions
State Boundary	Statewide	Shapefile	(via SD GIS data portal)	
Jurisdictions	Statewide (counties, towns, cities)	Shapefile	SDDOT	Population numbers associated with counties
Reservation and Tribal Lands	Statewide	Shapefile	(via SD GIS data portal)	
SDDOT Region and Area Boundaries	Statewide	Shapefile	SDDOT	Four Regions, each comprised of three Areas

GIS LAYER	SPATIAL/TEMPORAL RANGE	TYPE	SOURCE	NOTES
SDGFP Region Boundaries	Statewide	Shapefile	SDGFP	Four Regions
Federal Lands	Statewide			Not currently included in project geodatabase
Wildlife Refuges	Statewide		SDGFP/US FWS (via SD GIS data portal)	Not currently included in project geodatabase
Parks and Recreation Areas	Statewide		SDGFP (via SD GIS data portal)	Not currently included in project geodatabase
School and Public Lands	Statewide		SDGFP (via SD GIS data portal)	State owned (undeveloped; not managed for wildlife). Not currently included in project geodatabase
Land Cover	Statewide	Raster	National Land Cover Dataset https://gdg.sc.egov.usda.gov/	Not currently included in project geodatabase
Reported Vehicle Crashes with Wild Animal	Statewide 2004-2013	Point	SDARS database (SD Department of Public Safety) http://safesd.gov/yearly-crash-data.cfm	Database imported into Excel, then plotted in a GIS using geographic coordinates (latitude and longitude)
River Otter Road Mortalities	Statewide	Point	SD Natural	Threatened species

GIS LAYER	SPATIAL/TEMPORAL RANGE	TYPE	SOURCE	NOTES
			Heritage Program	
Waterways	Statewide	Shapefile	(via SD GIS data portal)	
Fall Classification Survey	Statewide	Point	SDGFP	Opportunistic data set; Includes mule deer, White-Tailed deer, bighorn sheep, elk, pronghorn
Big Horn Sheep Locations	Hells Canyon (Jan-Sept 2014)	.xls (UTMs)	SDGFP (Chad Lehman)	Locations focused around local roads and -90 and SD 38
Elk Locations	Custer State Park & Southern Black Hills (2011-2013)	.xls (UTMs)	SDGFP (Chad Lehman)	Winter and parturition locations

Note: The projection for all layers is State Plane, Zone 14. The SD GIS portal is accessible at URL: http://arcgis.sd.gov/server/sdGIS/Data.aspx.

The researchers could not locate any statewide GIS layers of wildlife presence or wildlife habitat types, such as winter range or movement corridors that are useful in analyzing potential road and wildlife conflict areas. Notably, deer populations (mule and white-tailed) are spread across the state. Spatial data in the form of spreadsheets, shape files and maps generated in association with wildlife studies are generally available only to the researchers who conducted the studies, and not readily accessible by SDGFP and SDDOT personnel. Most of researchers who conducted these studies were affiliated with South Dakota State University. There is a clear need for SDGFP to track and organize wildlife maps and data resulting from agency-funded studies for future proactive efforts to help SDDOT identify WVC prone areas across the state. Future wildlife research will need to include studies of wildlife movement with respect to roads.

While a number of survival studies have been conducted for different species and populations, little research has been conducted on the population level impacts of WVC. The only South Dakota study on this topic found by the researchers was Haffley's (2013) research on white-tailed deer in Bon Homme County, which found the populations subject to high levels of road mortalities. Thirty-seven percent of the population was killed on highways; equal to the percentage of mortalities caused by hunting. This road mortality rate was much higher than the approximate 10 percent typically reported for most populations (Julie De Jong, SDGFP, personal communication April 2015). Future research on wildlife movements with respect to roads will help inform wildlife mitigation priorities benefiting both driver safety and wildlife population health.

Two potential sources of data that could be mapped at the state level to indicate mule and white-tailed deer populations are the Hunter Harvest Surveys and Fall Classification Surveys. The Hunter Harvest Surveys are sent to licensed hunters who supplied email addresses with their licenses (85 percent of all hunters, C. Huxoll, SDGFP personal communication, October 2015). There is a 50 percent response rate for these emails surveys, and for the remaining hunters that did not respond, paper surveys are sent via mail (C. Huxoll, SDGFP personal communication October 2015). The hunter responses at the time of this writing were being standardized into a model being developed at the University of Montana to better estimate deer populations (C. Huxoll, SDGFP personal communication, October 2015). As of 2015 the hunter survey results were used for mule deer and white-tailed deer population trends by the SDGFP. These data may be the most useful in future analyses of road and wildlife conflicts.

Fall Classification Surveys were conducted annually by SDGFP personnel for the three to four years prior to 2015 for big game species including mule deer, white-tailed deer, pronghorn, elk and bighorn sheep. Survey protocols are based on opportunistic observations during September and October. SDGFP biologists in each county count buck-to-doe and fawn-to-doe ratios until observers count 50 fawns in a given unit. The surveys are not conducted systematically and locations may vary from year to year. These surveys are not conducted in a manner that allows for deer population estimates or trends, thus are not useful for WVC prediction models. Other surveys are species specific, such as the deer survey aerial flyovers and helicopter flown elk and pronghorn counts, or are designed to quantify trends in recruitment rates, such as the daylight and spotlight surveys. Future refinements to these surveys may result in data that can be mapped and useable in transportation planning.

5.2.4 Interagency Collaboration

SDDOT and SDGFP work together to address the problem of WVC through their partner efforts to hire and manage carcass contractors and to share the carcass data, but beyond these actions, collaboration efforts are not fully embraced. In this section the current process for considering wildlife in transportation projects is presented, the mitigation efforts that have been previously implemented in South Dakota are identified, and the potential for holding expert opinion workshops with both agency representatives is demonstrated.

5.2.4.1 Incorporation of WVC and Wildlife Movement Information into Planning and Design

SDDOT does not have a formal, standardized process for considering wildlife conflicts and wildlife movement needs in the face of roads, outside of the regulatory framework required for projects impacting threatened or endangered species, and the safety aspects considered by the traffic safety engineer. Project needs are assessed at the regional level on a semi-annual basis and incorporated into the Statewide Transportation Improvement Program (STIP). SDDOT's environmental office oversees the National Environmental Policy Act (NEPA) process and interagency coordination with SDGFP, US Fish and Wildlife Service and other stakeholders. The SDDOT Environmental Office is responsible for working with project engineers to ensure that all environmental commitments are implemented. The office employed six staff in its headquarters office in 2015; no environmental staff is located in the regional offices.

Coordination between SDDOT and SDGFP occurs between their respective headquarters offices. There is no formal coordination at the local level, although regional SDGFP biologists are consulted regarding wildlife concerns when the SDGFP headquarters office requests that the SDDOT environmental staff reach out to these local offices. At the regional level, communication between SDDOT and SDGFP is inconsistent and varies among regions.

The focus of the SDDOT environmental screening process is on species of concern. SDGFP runs scans on databases to determine whether wildlife occurrences in the Natural Heritage Program database fall within a project area. The SDDOT environmental staff prepare maps of environmental data including occupied and potential habitat for threatened and endangered species to all interested stakeholder agencies. Environmental staff does not consider WVC crash data; however, the traffic safety engineer is responsible for summarizing WVC crash data for project scopes to identify clusters of WVC crashes. The review of WVC crash data as of 2015 has not yet resulted in mitigation. In the current system, there are no regulatory incentives for SDDOT to engage directly in WVC prevention and wildlife mitigation. The 2012 transportation act, *Moving Ahead for Progress in the 21st Century* (MAP-21) first established requirements for state transportation plans to include a discussion of potential environmental mitigation. The current transportation act, *Fixing America's Surface Transportation Act* (FAST ACT), extends these requirements, however there are no specific requirements for reporting or mitigating WVC.

Some formal coordination occurs between SDGFP and Tribal wildlife agencies, such as annual coordination meetings. In many cases coordination is unstructured and conducted on an as-needed basis. The focus of these efforts is on game species harvest and success rates; WVC and wildlife movement needs are not addressed in these meetings. Each year SDDOT sponsors a Tribal Transportation Safety Summit in coordination with South Dakota Tribes. In 2015 the researchers presented the results of this study and asked Tribal members to become involved in an impromptu expert opinion workshop to identify WVC hotspot on each reservation. The results of these efforts are presented in Appendix E. It is recommended the Tribal Traffic Safety Summit retain this issue of WVC on the agenda and continue asking for Tribal input on collaboration and solutions. Also, it is recommended that a representative from SDGFP be in attendance during this portion of the Tribal Traffic Safety Summit to strengthen collaboration and coordination between state and Tribal agencies

5.2.4.2 Current Status of Road and Wildlife Mitigation Efforts in South Dakota

Several efforts have been made to mitigate South Dakota Roads for wildlife. These include signs of various types, reflectors, culverts, and vegetation management. The primary wildlife mitigation strategy in use are stationary wildlife crossing signs on state highways. Locations for erecting signs are determined by the SDDOT regions, and are typically driven by local requests. In the Black Hills, drivers are alerted of crossing areas for bighorn sheep and mountain goats by signs with flashing lights. In addition, variable message signs (VMS) in the area around Rapid City are placed in key areas during seasonal spikes in WVC and display messages warning of wildlife to drivers. The researchers could find no evidence of counties that put up wildlife signage on county-administered roads.

In the early 2000's, reflectors were put up along segments of Interstate 90 and Interstate 29 (I-90, I-29). Vehicle headlights reflecting off the reflectors purportedly create a "visual barrier" to deter deer from entering the road. However, this mitigation strategy has proven ineffective in reducing deer-vehicle collisions (D'Angelo et al. 2006). No effectiveness monitoring was conducted in South Dakota, although anecdotally they were deemed ineffective, and when the reflectors were removed during a construction project they were not replaced (S. Neumeister, Project Engineer, Sioux Fall SDDOT, March 2015).

No structural wildlife mitigation strategies (e.g., wildlife underpasses or overpasses in conjunction with guide fencing) have been implemented for deer or other ungulates in South Dakota, although fish passages for the endangered Topeka shiner have been constructed in several areas since 2008. There is also a turtle crossing culvert in the Custer District of the Rapid City Region.

In 2012 and 2013 the Phillip Maintenance Unit (Pierre Area) experimented with a right-of-way vegetation management technique called double cutting, in which a 25-30 feet (7.6 - 9 m) wide area along the road shoulder is cut back instead of the typical 15 feet (1.6 m) cleared area. This extra mowing is conducted in the fall months to provide drivers with better visibility and allow them more time to react to wildlife approaching the roadway. No monitoring of this management technique and its reduction of WVC was conducted, although the use of this strategy does coincide with lower WVC rates both temporally and spatially. Notably, the local deer population was lower during this time frame, and a direct correlation between extra mowing and WVC cannot be confirmed (D. Van De Wiele, SDDOT Area Engineer, personal communication April 2015).

5.2.4.3 The Role of Expert Opinion on Wildlife Mitigation Needs Along Roads

If wildlife habitat maps and empirical data on wildlife presence are lacking for South Dakota, the logical next step for a more in-depth analysis of WVC hotspot areas in need of wildlife mitigation along roads would be to include expert opinions on problem areas in the state. This has been done in other states in early stages of wildlife linkages and in locating future wildlife mitigation strategies (Clevenger et al. 2002, Ruediger et al. 2004. Ruediger et al.

2009). Agency personnel and other experts impart their collective knowledge in workshops with maps and a facilitator. These meetings result in consensus of priority areas, but cannot be defended as scientifically sound because of the influence of personal opinions, and speaking styles. Conversely, these workshops were and are the basis of wildlife linkages and prioritizing actions in several western states, including Idaho, Utah, and Montana. These workshops were the beginning of wildlife crossing mitigation that resulted in several wildlife crossing structures in Idaho, dozens of structures in Utah, and over 100 in western Montana.

The researchers in this study convened an expert opinion workshop in the Rapid City area to demonstrate how expert workshops may be used to help identify WVC problem areas, particularly where other data may be lacking. On June 1, 2015 a SDDOT and SDGFP Rapid City area workshop was held in Rapid City at the offices of SDGFP. Large maps displaying roads and other infrastructure, public land ownership, waterways, and towns, were created by SDGFP and shared with the convened participants. SDDOT and SDGFP personnel were asked to share their on-the-ground knowledge to inform mapping WVC problem areas and other priority areas for wildlife movements across roads, as well as opportunities for mitigation. This meeting also served as a case study for additional expert workshops across South Dakota that could be used in further research or by the SDDOT when implementing recommendations.

Twelve attendees marked 76 hotspot areas within the Rapid City Region, and named the species most often involved in WVC in those areas. These expert identified hotspots were then compared with the WVC crash data hotspots generated by GIS modeling in the creation of the statewide map in Figure 7. These 76 expert-identified hotspots were listed by district and color coded to help establish how the perceived hotspots were compared to reported WVC crash data for 2004-2013, Appendix G. Twenty-eight expert hotspots (37 percent) were also high WVC crash data hotspots, ranking in the orange and red range of top crash hotspots.

The workshop was also successful in facilitating communication between local agency personnel from the wildlife and transportation departments. The conversation that ensued revealed that regional and district personnel from one agency were unfamiliar with and largely uninvolved in the planning and decision-making processes conducted by the other agency. This workshop marked the first occasion for interagency collaboration at the regional level and offers a basis for building ongoing communication systems to support comprehensive consideration of driver safety and wildlife movement needs, and mitigation to address the problem of WVC in South Dakota.

5.3 Guidance to Improve WVC Reporting, Analyses, Collaboration, and Mitigation

For South Dakota to reduce WVC, there is a need for continued work to define the extent of the WVC problem so that targeted strategies can be developed for individual problem areas. These processes build upon systems already underway at SDDOT and SDGFP. This section offers decision guidance for improving WVC reporting and analysis, assessing wildlife habitat distribution with relation to roads, and improving collaboration among stakeholder organizations, Task 6, and provides a framework to assist agencies in implementing WVC mitigation measures with decision support tools, Task 7.

Three primary steps for effectively addressing and mitigation WVCs are identified in Figure 13 and are described in greater detail in chapter sub-headings 5.3.1 through 5.3.3.

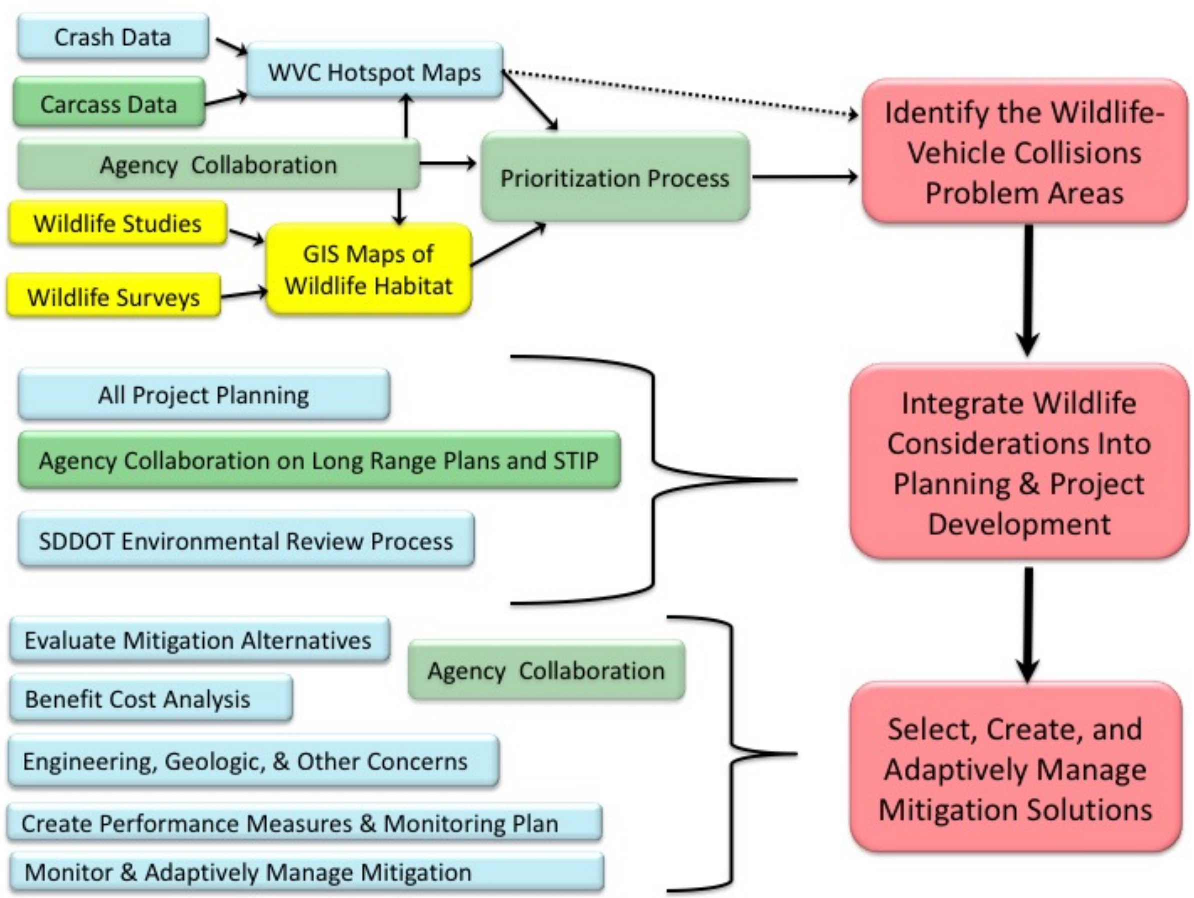

Figure 13. The Three Major Steps for Mitigating Roads for WVC and the Information and Actions That Support Each Step.

Pink boxes represent each major step in the process; yellow boxes are the responsibility of the wildlife agency; blue boxes are the responsibility of the transportation agency, and green boxes are the responsibility of both agencies. Solid lines represent the standard

process among Western U.S. States, whereas the dotted line represents a temporary solution for beginning to identify WVC priority areas using hotspot mapping.

5.3.1 Step 1: Identify WVC Problem Areas

This first step was initiated by the current research project. Below specific opportunities are detailed for improving WVC crash and carcass data and improving interagency coordination and wildlife data for the purpose of identifying WVC problem areas.

Once crash and carcass data are accurately collected and compiled, they are used as the basis for WVC maps with priority areas marked based on mile sections of roads with the highest number of collisions recorded. Typically, these are crash maps. This is a short term solution, as represented by the dotted line in Figure 13. As transportation departments integrate other data sources, wildlife locations based on surveys, and wildlife habitat based on wildlife agency studies are combined to help produce GIS maps of wildlife habitat. This data layer is then combined with the WVC hotspot maps, along with other information, to inform a standardized prioritization process. This process in turn delivers a state-wide map and regional maps of the areas in most need of WVC mitigation. This process is conducted annually across the state and regions. This process is a standard long term method, as represented by a sold line to the pink box to identify WVC problem areas.

5.3.1.1 Collect and Compile Consistent and Comprehensive WVC Crash Data

South Dakota WVC crash data need to be collected in a standardized and spatially accurate manner consistently by all law enforcement agencies across the state, including those on Tribal lands, and submitted to SDDPS on a timely basis. Specific opportunities for improving the WVC crash database are presented below.

- Memoranda of Agreement (MOAs) between SDDPS and local law enforcement agencies, including Tribes and counties, to consistently collect standardized and spatially accurate WVC crash data and submit to SDDPS on timely basis.
  Objective: Promote comprehensive, statewide WVC crash reporting.
  Responsible Agencies: SDDPS, SDDOT, Tribes, Counties, State Highway Patrol, other local law enforcement entities.

- In order to capture accurate crash locations in the field, equip all law enforcement with GPS or similar capabilities with in-vehicle computers and software or smart phones with crash and carcass reporting apps.

Objective: Improve location accuracy of crashes.
Responsible Agencies: State, county, Tribal and local law enforcement agencies.

- Equip all law enforcement with in vehicle laptops with TraCS software, preferably, or desktop computers, alternatively. Train and require officers to conduct all crash reporting electronically.
  Objective: Improve crash reporting effort and reduce reporting/data transcribing errors.
  Responsible Agencies: SDDPS, SDDOT, all state, county, city and Tribal law enforcement agencies, State Sheriff's Association. SDDPS may be able to distribute a limited number of extra laptops as they become available. Legislative support and funding for enhanced technologies among local law enforcement agencies.

- In the TraCS reporting system, include a required field with a drop down species list for all WVC incidents reported. Conduct outreach to law enforcement officers on the importance of entering species data in their reports.
  Objective: Enhance WVC crash data to highlight species-specific WVC patterns.
  Responsible Agencies: SDDOT and/or SDGFP should make a formal request to SDDPS to include a species field in TraCS. TEG would then need to implement this change in the TraCS software at the request of SDDPS.

5.3.1.2 Collect, Compile, and Share Complete and Accurate Carcass Data

Several improvements would benefit the creation of a standardized and comprehensive statewide WVC carcass database. The research team found inconsistencies in the methods the contractors used to collect WVC carcass data and record carcass locations, how the data were compiled in SDDOT and SDGFP offices, and in the timely and accessible presentation of the data to both SDDOT and SDGFP personnel across the state. Specific opportunities for improving the quality of WVC carcass data are presented below.

- Establish Memoranda of Agreement (MOAs) between SDDOT, SDGFP, state, county, city and Tribal law enforcement agencies to consistently collect and submit WVC carcass data. The researchers found that there are no designated avenues for agency personnel or law enforcement to report carcass data. Reporting standards and electronic forms, via smartphone app or a web-based computer system, for agency and law enforcement personnel to easily access and submit carcass reports would lend far greater accuracy to estimating the magnitude of WVC in South Dakota.

Objective: Improve the consistency and comprehensiveness of WVC carcass reporting, particularly outside of active carcass contracts, and facilitate the compilation of WVC carcass data in a single statewide database.
Responsible Agencies: SDDOT, SDGFP, state, county, city and Tribal law enforcement agencies, County Sheriff's Association.

- Strengthen the contract language and standards for carcass collection by state contractors. Institute a standardized WVC carcass reporting form for use by all carcass contractors at SDDOT and SDGFP. Train contractors and require complete reporting as a condition of contract payments, including GPS location, highway number, MRM location, and species, including mule deer or white-tailed deer. Require use of GPS and ensure GPS is set to collect location in decimal degrees. On an annual basis, keep all agencies informed of highway segments with active carcass contracts.
  Objective: Improve completeness and accuracy of WVC carcass reporting and facilitate the compilation of WVC data into a single database.
  Responsible Agencies: SDDOT, SDGFP, contractors.

- Create an electronic method to enter carcass data. Implement use of a WVC carcass smartphone app and/or a computer based internet system for recording WVC carcass data. Either an app-based or web-based system would be available to all carcass contractors, SDDOT maintenance personnel, SDGFP biologists and local law enforcement (county, city and Tribal) to record incidents of WVC carcasses that may not be captured in accident reports. Train personnel in use of the recording system and encourage its use. Implement Quality Assurance/Quality Control (QA/QC) protocols to remove duplicate records and maintain a clean dataset.
  Objective: Capture more complete WVC carcass data, particularly outside of active carcass contracts, and compile all WVC carcass data in a single, statewide database. Such a system will also facilitate payments to contractors.
  Responsible Agencies: SDDOT, SDGFP, County Sheriff's Association, Tribal law enforcement, city police.

- Compile WVC carcass data in a single, centralized, statewide database that is updated and communicated to SDDOT and SDGFP offices across the state. Implement protocols for compiling reports at the area or regional level and submitting locally compiled reports to a centralized, statewide office (e.g., SDGFP Wildlife Damage Program). Require all SDDOT and SDGFP offices with active carcass contracts to

submit data to the statewide office on a quarterly basis in a standardized Excel format. Institute QA/QC protocols to remove duplicates and maintain a clean dataset. Compile all carcass reports from across the state in a single database on a quarterly basis. Notify all SDDOT and SDGFP region and area offices of updates to the statewide WVC carcass database and make these data available for download.
Objective: Develop and maintain a statewide WVC carcass database that is available for wildlife management, safety, and WVC mitigation decision-making.
Responsible Agencies: SDDOT, SDGFP.

5.3.1.3 Map and Analyze Data and Identify WVC Hotspots in GIS

The value of WVC crash and carcass data is best revealed when they are plotted in a GIS to explore the spatial distribution and patterns of WVCs and, ultimately, to define WVC hotspots, which are helpful in prioritizing and identifying mitigation needs in the transportation planning processes. The WVC hotspots maps may then be overlaid with other information, such as wildlife habitat and movement patterns, and upcoming transportation projects as identified in the State Transportation Improvement Program (STIP) to best identify potential solutions.

- Take the current 2015 WVC crash hotspot map and overlay MRM every ten miles (16 km) to create a more explicit map. Ensure accuracy of the statewide WVC crash hotspot map through thorough examination of database output by GIS modeling, merging nearby hotspots into single hotspot entries, determining exact end point MRM, and cleaning up incorrect entries in crash database.
  Objective: Create this map to help agency personnel identify the WVC crash hotspots by MRM at the state level. Increase accuracy of map.
  Responsible Agency: SDDOT, or researchers on second phase of this research.

- Create WVC crash hotspot maps with every MRM for each SDDOT region. The researchers began this task to demonstrate how the results can very specifically be used to mitigate exact areas of problem WVC. See Figure 14, below for an example of how this was done for Sioux Falls.
  Objective: Create this map to help agency personnel identify the WVC crash hotspots by MRM at the SDDOT regional level.
  Responsible Agency: SDDOT, or researchers on second phase of this research.

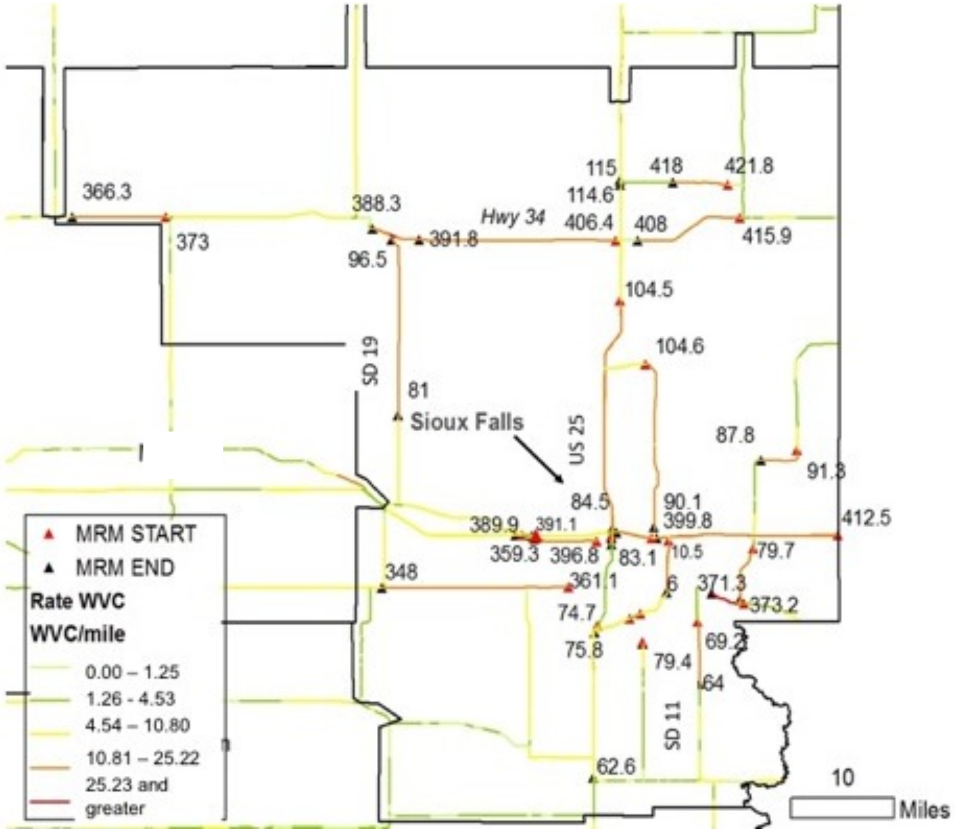

Figure 14. Sioux Falls Area WVC Reported Crash Hotspots from 2004-2013. Mile Posts Are Given for the Beginning and End of Each Hotspot.

- Conduct Regional Expert Workshops with SDDOT and SDGFP Personnel
  Expert workshops are a useful technique for filling in information gaps and complementing WVC crash and carcass hotspots for the purpose of identifying WVC priority areas. These workshops help identify important areas of wildlife movement that are both recorded by WVC data and that are successful enough not to have crash and carcass data because the animals are moving without being involved in crashes. Expert workshops also promote interagency partnership at the regional level, and may help catalyze locally driven efforts to reduce WVC. These workshops can be based on of the expert workshop held in Rapid City in June of 2015. SDDOT engineers and planners in each SDDOT region would meet with SDGFP biologists and conservation officers and other relevant local stakeholder, such as carcass collectors, to map perceived problem WVC areas within the SDDOT region and nearby Tribal reservations.
  Objective: Produce regional maps of expert-identified WVC problem areas to complement WVC crash and carcass data, and to further inform the process of identifying WVC priority areas.
  Responsible Agencies: SDDOT and SDGFP.

- SDDOT will need to create an annual procedure to map WVC crash data and if possible, carcass data. This procedure will need to be standardized with methods for delineating WVC hotspots, including how many WVC per mile constitute a hotspot, and if and how crash severity influences hotspot identification. There should also be a process for how trends are examined and reported. Each time a map is created, notify all partner agencies of updates. Maps should be made for the entire state and by SDDOT region. SDDOT regional hotspot maps should be displayed with mile markers (MRM) to provide users with reference points.
  Objective: Systematic standardized methods help in analyses and are defensible for future actions or no actions to mitigate roads for wildlife.
  Responsible Agencies: SDDOT.

5.3.1.4 SDDOT Request SDGP Generates GIS Wildlife Maps

In 2015 South Dakota had limited maps depicting ungulate and large carnivore distributions statewide. Such maps are essential for informing transportation planning with regard to WVC mitigation. The research team suggests the following opportunities for improving wildlife habitat and distribution data.

- Translate deer and other ungulate surveys into maps. SDGFP will need to institute clear, robust and repeatable standards for conducting all wildlife surveys to support population trend analysis. Improved systematic collection of population data would support game management, including the issuing of hunting tags, and to evaluate the impacts of WVC on populations and, where applicable, the effectiveness of implemented mitigation measures. In the future these maps would be updated annually and distributed to partner agencies.
  Objective: Improve wildlife habitat and distribution mapping to inform wildlife management and transportation planning.
  Responsible Agencies: SDGFP.

- SDGFP creates a centralized electronic database for all wildlife maps and data.
  Once wildlife habitat and locational maps are generated, the access to these maps warrants the creation of a central web-based database at SDGFP that other agencies can access for planning purposes. Recommendations below, would create other important data that would be stored in this database portal.
  Objective: Create a centralized repository for geo-referenced wildlife data in South Dakota and facilitate access to these data by interested agencies.
  Responsible Agencies: SDGFP.

- SDGFP designate a staff position to compile and manage wildlife data. This person would manage and maintain wildlife data, and compile statewide wildlife habitat data. They would need to query the Pittman Robertson Funding Database that details every wildlife study funded and gather all wildlife habitat maps and wildlife locations in a central database. The data, including GPS, GIS, locations and maps would be stored and available to all within SDGFP and ultimately made available to SDDOT personnel when needed for planning.
  Objective: A robust centralized repository for geo-referenced wildlife data in South Dakota would facilitate access to these data by wildlife managers and SDDOT environmental and planning staff.
  Responsible Agencies: SDGFP.

- SGDFP updates the clause in all SDGFP-funded research contracts stating that all geo-reference data, including point locations of collared animals, GIS files, and maps must be delivered to SDGFP via a designated web portal. In turn, this portal would allow SDGFP personnel access to this data when helping to plan for wildlife management or transportation projects. SDGFP would need to work retroactively to compile wildlife data from past SDGFP-funded research studies.
  Objective: Compiled SDGFP data on wildlife locations and habitat will help SDDOT and SDGFP identify areas where wildlife need to move and may become involved in WVC on SDDOT roads.
  Responsible Agencies: SDGFP.

5.3.1.5 SDDOT Initiate a Standardized Process to Prioritizing Wildlife Conflict Areas

WVC mitigation planning involves the incorporation of several sources of data added to WVC crash and carcass data. South Dakota has the potential to develop WVC priority hotspots for the state based on empirical wildlife locational data and wildlife habitat maps, traffic volume, future transportation projects, expert opinion, and other information added to WVC hotpots, similar to what the research team accomplished with Idaho (Cramer et al. 2014). This standardized prioritization process will be needed to support planning decisions and to focus mitigation efforts on the highest priority areas.

This future study would take the ongoing results of the recommendations of this study and create a systematic methodology for SDDOT and SDGFP to follow on the state and SDDOT regional level. The process would incorporate the improved data on WVC crashes and carcass locations, wildlife habitat maps, wildlife location data maps, land use maps, and facilitate collaboration between the agencies in selecting mitigation types, locations, and funds to address WVC.

Objective: Generate a comprehensive statewide analysis of WVC priority areas to inform the integration of wildlife considerations into transportation planning processes, including long-range planning, the STIP and project-level planning and design. This process would create a record of decision that could be use to explain why actions were taken or not taken for specific situations.

Responsible Agencies: SDDOT and SDGFP.

5.3.2 Step 2: Integrate Wildlife Considerations into Transportation Planning

This section represents the integration of wildlife considerations into the highest and lower levels of transportation planning within SDDOT. Actions recommended will assist in the success of the steps above.

5.3.2.1 Integrate WVC Priorities into the SDDOT Environmental Review Process

In 2015, the SDDOT environmental review process did not include an analysis of the WVC potential in future projects because this was done by the traffic safety engineer as part of the safety review. In the future, if the safety review finds a high incidence of WVC, the determination of potential mitigation will be the responsibility of the SDDOT Environmental section and SDGFP. If a species was not a state or federally listed endangered, threatened, or species of special concern, the SDDOT Office of Project Development environmental staff was not instructed to review maps, WVC crash and carcass data, or talk to SDGFP personnel to learn if there was a need to accommodate wildlife under the road or other types of mitigation.

The SDDOT Office of Project Development Will Need to Create a Standard Checklist

This list will be for the environmental review staff to evaluate WVC hotspots and the need for potential mitigation. The results of the evaluation may trigger consultation with regional or district SDGFP biologists and a benefit-cost analysis, performed by the traffic safety engineer, to determine whether mitigation can pay for itself in terms of WVC avoided. This added work on the part of the environmental staff would possibly incur the need for several new staff positions to help track these data and make these consultations. This process may need to be developed in a new research project. Create an early warning system to flag potential wildlife conflicts. When WVC priority area maps are incorporated into SDDOT

transportation planning systems, there needs to be mechanisms for flagging potential problem areas.
Objective: Incorporate WVC concerns into the environmental review process for transportation projects. Early identification of where future transportation projects intersect with WVC priority, or where high priority WVC conflict areas may warrant new safety projects to implement mitigation.
Responsible Agencies: SDDOT.

5.3.2.2 Create a Memorandum of Understanding for Transportation Planning

Consideration of wildlife in transportation planning is completely dependent on SDGFP participation in the transportation planning process. This was mandated in the 2005 transportation Act, SAFETEA-LU. An example Memorandum of Understanding (MOU) that Idaho Transportation Department executed with Idaho Fish and Game Department is presented in Appendix I.

Institute Protocols in a MOU for Consistent Coordination Between SDDOT and SDGFP at The State and Regional Levels

For SDGFP participation in transportation to become standardized, the MOU can specify the names of the positions of personnel to become involved with one another in each agency, the timing of the meetings, and the level of meetings at the headquarters for the state, and at the local SDDOT regional levels. These meetings would involve standardized (over time) reviews of the long-term transportation plan at the headquarters and SDGFP regional levels. Conduct regional interagency meetings as needed, but at least annually, to review the STIP and discuss upcoming projects in identified WVC priority areas, including existing and new road projects. SDFGP would be expected to provide input to assist with the planning process to help reduce the risk of WVC. These meetings would result in the development of a prioritized list of WVC mitigation needs, including needs for new, dedicated wildlife crossing structures, as well as opportunities for enhancing existing infrastructure. See Appendix I.
Objective: Establish framework for improved, consistent coordination between SDDOT and SDGFP to address WVC concerns and incorporate mitigation needs into transportation planning and project development. Timely consideration of wildlife concerns also reduces the cost of wildlife mitigation.
Responsible Agencies: SDDOT and SDGFP.

5.3.3 Step 3: Select, Create, and Adaptively Manage Mitigation Solutions for WVC

This step encompasses the standard actions agency personnel work together to create to consistently select, build, monitor and adaptively manage wildlife mitigation for WVC. This step is further described as the framework for Task 7, and decision support tools are presented to assist with these actions. This step is to be conducted in tandem with transportation planning and includes the following sub-steps:

1. Evaluate WVC Mitigation Alternatives,
2. Conduct a Benefit-Cost Analysis of the WVC Problem Site and Potential Solutions,
3. Consider Engineering, Geologic, and Other Concerns,
4. Create Performance Measures Based and Monitoring Plan,
5. Research and Adaptively Manage Wildlife Mitigation,
6. Repeat these steps over time with each mitigation opportunity.

The process of selecting mitigation requires a balanced, interdisciplinary approach, engaging engineers, transportation planners, land managers, wildlife professionals and other stakeholders. Each of these professional's considerations must be addressed on a case-by-case basis, as no two situations are identical.

In 2008, Bissonette and Cramer published a ground-breaking report for the National Academies', National Cooperative Highway Research Program, titled, 'Evaluation of the Use and Effectiveness of Wildlife Crossings,' NCHRP Report 615. The accompanying website, wildlifeandroads.org provides an overarching decision guide for creating project-level mitigation strategies to reduce WVC. The decision guide can be used to help conduct project-level planning, implementation and adaptive management of wildlife mitigation strategies. Mitigation implementation is site specific and will necessitate the following steps, presented below. These steps are the decision support tools for the project level planning and construction.

5.3.3.1 Evaluate WVC Mitigation Alternatives

Wildlife mitigation involves solutions that target drivers of vehicles, and those that target a change in wildlife movements. As presented in Section 5.1.3, selecting the most appropriate mitigation alternative for a given situation involves multiple considerations. Figure 4, above, and Appendix B, below, present the different types of wildlife mitigation and what could be implemented in specific places. There is a need for South Dakota to work with qualified wildlife and transportation ecologists to inform SDDOT and SDGFP on the cost-effective types and designs.

5.3.3.2 Conduct a Benefit-Cost Analysis of the WVC Problem Site and Potential Solutions

To perform a benefit-cost analysis, also known as cost-benefit analysis, the cost of WVC to society in a given area are calculated relative to the costs and benefits of mitigating the WVC problem in that area. Benefit-cost analyses involve the following steps, using data available from SDDOT and SDGFP:

1. Estimate costs of WVC from WVC crash data.
2. Estimate cost of WVC on wildlife populations estimated from WVC carcass data.
3. Estimate the percentage decrease in WVC crashes the mitigation is expected to provide.
4. Estimate life span of the mitigation.
5. Estimate cost of the mitigation plus its maintenance over time.
6. Input values into a Benefit-Cost equation to find the value of the project.
7. Determine how long would it take for project to pay for itself.

Appendix H details how this could be accomplished for a variety of projects in South Dakota.

5.3.3.3 Engineering, Geologic, and Other Concerns

All infrastructure planned, created, and maintained by SDDOT must meet multiple criteria for structural engineering, geologic concerns, cost-effectiveness, public support, and funding sources and constraints. These concerns are part of the process of evaluating solutions to WVC. As these concerns vary from location to location, they are only mentioned here to acknowledge these considerations are part of the full process of mitigating roads for wildlife.

5.3.3.4 Create and Implement Performance Measures Based on a Monitoring Plan

All wildlife mitigation of substantial cost (over $100,000) should be developed with performance measures in mind. The 2012 Transportation Act, MAP-21, Section 150 Title 23, (http://www.fhwa.dot.gov/map21/) dictates the need for performance measures to evaluate efforts to increase driver safety. Performance measures can be established with a monitoring plan to evaluate if they have been accomplished. Monitoring projects are designed to compare pre-mitigation conditions to post-mitigation conditions, for example, in terms of number of WVC or wildlife responses to mitigation, and thus evaluate if performance measures have been reached. Examples of how these kinds of studies have been carried out include: Cramer and Hamlin 2016 in Montana, Cramer 2012, 2014, and 2015 in Utah.

5.3.3.5 Research and Adaptively Manage Wildlife Mitigation

Once mitigation has been scheduled to be constructed, a research plan for monitoring the infrastructure should be initiated, if not before. The research prior to construction can help determine the animal species and numbers in the area that will need to be accommodated by the mitigation, and thus helps to determine the performance measures. The post-construction phase of mitigation should be seen as a time to update and manage the infrastructure to ensure it is working as well as possible toward meeting WVC reduction goals and established performance measures. For example, small changes in fencing, riprap along abutments, escape ramps, double cattle guards, and other parts of the infrastructure may be required to increase the efficacy of mitigation.

Establish a remote camera monitoring system at the site of the future mitigation that monitors wildlife activity pre and post mitigation. Protocols for number of monitoring cameras, camera placement, data management and analyses, and setting of performance measures will need to be created with a wildlife ecologist researcher with experience in transportation ecology. As the project is underway, any research results that indicate the mitigation system could be improved shall be communicated to SDDOT and SDGFP.

Once the research project is complete, a final report for each study will help SDDOT embrace the methods and infrastructure of the project that worked, and to develop better practices in future mitigation, based on limitations of the project. An example of how Utah research (Cramer 2012) helped Utah and the nation construct more efficient wildlife crossings can be viewed at the website for the 2013 Federal Highways Environmental Excellence Award for Research (see Federal Highway Administration 2013 in references).

5.3.3.6 Repeat Steps on an Annual Basis at the State and SDDOT Regional Levels

The above steps are a cycle of data gathering, mapping, prioritization, site selection, mitigation selection, mitigation creation and monitoring, and adaptive management. These guidelines are meant to help South Dakota to continue to consider the risks of collisions with wildlife to the motoring public and wildlife populations. The results of such actions will help create more safe roads and more robust wildlife populations.

5.4 Initiate a Phase 2 of This Study to Help Bring About Many Recommendations

This study began the effort to evaluate the state of the data and collaboration in South Dakota related to wildlife and transportation. The report details many steps that are needed to continue this process. The researchers in this study can continue the work with SDDOT and SDGFP in bringing these recommendations to fruition. Specifically, the Phase 2 of the research could help South Dakota in:

- Creating standards for WVC crash data.
- Establishing a single central database for WVC carcass data.
- Creating statewide WVC crash map with mile markers.
- Validating the statewide WVC crash hotpot map for accuracy.
- Creating SDDOT regional maps of WVC hotspots with mile markers.
- Conducting SDDOT regional expert opinion WVC mapping workshops.
- Creating the standardized annual procedure to map WVC and identify trends.
- Identification of SDGFP wildlife data of importance to SDDOT.
- Assisting in the creation of a central wildlife database.
- Developing standards for future wildlife mitigation prioritization process.
- Integration of WVC concerns into the SDDOT environmental review process.

The steps in Phase 2 of this research would come about over time, with SDDOT addressing certain steps or recommendations immediately, and others over the course of the coming months and years. The overall objective of all these recommendations would be to help decrease WVC in South Dakota, making roads safer for motorist, while helping wildlife to move across the landscape. The results would be increased motorist safety and protection of wildlife populations from the effects of roads and traffic.

6 RECOMMENDATIONS

The process of identifying the scope of the WVC problem in South Dakota and developing targeted strategies to reduce WVC builds upon systems already underway at SDDOT and SDGFP. This research project is the first step of a continuum of actions South Dakota should implement to reduce WVC. The next series of steps will require South Dakota to improve existing processes and establish new procedures using the recommendations presented below. These actions will enable South Dakota to accurately define the scope of the WVC problem, create accurate data and maps, integrate wildlife considerations into transportation planning, and implement targeted mitigation strategies to reduce WVC.

6.1 Recommendation 1: Initiate Interagency Memorandum of Agreement

This MOA would be between SDDPS and local law enforcement agencies, including Tribes and counties. It would be an agreement to consistently collect standardized and spatially accurate WVC crash data and submit the data to SDDPS on timely basis. To improve WVC crash data statewide, the MOA would also work toward equipping all law enforcement with TraCS software on in-vehicle laptops (preferably) or desktop computers (alternatively). These actions would help save South Dakota thousands of dollars in reduced efforts to collect data that is not standardized or automatically electronically created. These actions would also greatly advance South Dakota's efforts to reduce WVC with accurate, readily available and useable data.

6.2 Recommendation 2: SDDOT Requests that SDDPS Establish Standards for Crash Data

SDDOT will need to submit a request to SDDPS to implement standards that would create a required field within TraCS with a drop down species list for all WVC incidents reported. This would create a more complete and accurate data set that can in turn help SDDOT better direct mitigation funds to building wildlife crossing structures and fences that target the specific species of wildlife of the greatest problem for WVC, thus creating more cost-effective mitigation efforts.

6.3 Recommendation 3: SDDOT Establishes a Memorandum of Agreement with Agencies

SDDOT should establish a MOA with multiple agency partners to help improve the collection of WVC carcass data. This MOA would be between SDDOT and SDGFP, along with State, County, City and Tribal Law Enforcement Agencies to consistently collect and submit WVC carcass data. This would allow participants to electronically report any carcasses found along roads, regardless of crash information. In this MOA, carcass data collection would be standardized with state-wide forms that allow the reporting of the location in GPS coordinates or road and mile post if this is not available, the species of animal, the number of carcasses found, and gender expressed as adult female, adult male, or unknown age and gender. A process of marking carcasses with bright orange spray paint or other method such as state tags on rear legs would help eliminate double counts. This method would help make the carcass collection methods more efficient, with less time spent by agency personnel to call in and record carcasses with the time saved with using a standard electronic device. Future mitigation efforts would be better informed on the species involved in WVC, and thus better suited to the exact situation.

6.4 Recommendation 4: Strengthen the Contract Language for Carcass Contractors

SDDOT along with SDGFP will standardize the WVC carcass reporting process by outside contractors and dictate how it will be enforced, with such standards of no payment unless carcass data are reported correctly. SDDOT and SDGFP will train contractors and require complete reporting as a condition of contract payments, including GPS location, highway number, MRM location, and species, including mule deer or white-tailed deer. The contracts will require use of location coordinates in decimal degrees. On an annual basis or more often, SDDOT shall keep all agencies informed of highway segments with active carcass contracts. If the state spends hundreds of thousands of dollars each year on carcass collection, the economic advantage would be that the taxpayers would be receiving more accurate data that in turn could be used to help address the problems of WVC.

6.5 Recommendation 5: SDDOT Creates an Electronic Carcass Data Entry Method

SDDOT should initiate the development of an electronic method to report carcass data. This method could be through the adaptation of Utah's WVC carcass smart phone app and computer entry, or a simple computer entry through a SDDOT-sponsored website. Two examples of state-scale web-systems are in Idaho (Idaho 2015) and California (http://wildlifecrossing.net/california). Both the smart phone app and the web-based reporting system would allow instant mapping of the carcass data by agency personnel and the public using smartphones or on computers. The data would be stored in a single, centralized database within the state's data server systems that SDDOT would set up. South Dakota would then train and equip all carcass contractors and agency personnel who may be involved in WVC carcass reporting or removal (including rare and uncommon species) with the WVC carcass app or software to report on-line from a computer. SDDOT and SDGFP would then require all carcass pickups to be recorded by smartphone (using app or access to website using browser), or other device, and the locations would be recorded in decimal degrees. Carcass entries using either app or web-browser based approaches typically take 30-60 seconds per observation. The cost of this software would more than pay for itself in time saved collecting, organizing, and mapping the data by agency personnel.

6.6 Recommendation 6: SDDOT Establishes a Single, Centralized, Statewide Database

SDDOT should be responsible for creating a single centralized database for statewide collected WVC carcass data. The central database would store all the fields of data collected and would allow users to query data by road and mile markers, species, specific periods of time, SDDOT regions, and other important fields. The database could also include crash data where animals were involved in order to improve overall efficiency. There would be be clear lines of responsibility for what agency and Tribal entities gather and compile the various sources of WVC carcass data collected statewide, and what entities can access these data. In early phases of these recommendations, SDDOT in conjunction with SDGFP will then upload all the carcass data collected in forms and other non-electronic sources at minimum on a quarterly basis, to the established central database. Once the electronic method to enter carcass data is established, this data upload will become automatic and SDDOT and SDGFP can be relieved of the duties of uploading paper entries to the database, because there will be none. Quality assurance and control would need to be maintained by eliminating potential duplicate entries. Many hours of time would be saved by agency personnel, thereby realizing annual cost savings in personnel time.

6.7 Recommendation 7: SDDOT Updates the Statewide WVC Crash Hotspot Map

The WVC crash hotspot map created in this research will need to include mile markers placed every 10 miles (16 km) to help define general locations of the WVC hotspots statewide. This action would help the entire mapping and prioritization process for addressing WVC more efficiently. The statewide map should also be verified for accuracy. In a second phase to this research project, significant amounts of time (over 200 hours) should be dedicated by GIS personnel to cross check the resulting hotspot database from this GIS modeling exercise and map locations. Until then the WVC crash hotspot map is considered a generalization of areas with the highest WVC crash rates.

6.8 Recommendation 8: SDDOT Support the Creation of SDDOT Regional Maps

A needed extension of this research is to complete WVC crash maps for every SDDOT region, with mile markers placed to demonstrate the WVC hotspot sections, as was done in this research for the Sioux Falls Region reported WVC crash hotspots. This would help each SDDOT region prioritize financial expenditures in a cost-effective manner in the precise location where mitigation for wildlife is needed. SDDOT would be responsible for either creating these maps or sponsoring research to carry out this task.

6.9 Recommendation 9: SDDOT Conducts Interagency Regional Expert Workshops

SDDOT engineers and planners in each SDDOT region should meet with SDGFP biologists and conservation officers and other relevant local stakeholders to map expert-identified WVC problem areas within each SDDOT region and nearby Tribal reservations. These workshops will follow the model provided by the Rapid City expert workshop. SDDOT would be responsible for initiating these workshops. These workshops can save SDDOT much needed time in future project planning processes due to the new relationships formed with agency partners and the information these partnerships would add to transportation planning. These benefits could be translated into in agency personnel time saved from these partnerships.

6.10 Recommendation 10: SDDOT Create an Annual Procedure to Map WVC Data

SDDOT should spearhead efforts to annually map WVC crash hotspots, and if possible, WVC carcass data hotspots. This procedure will need to be standardized with methods for delineating WVC crash and carcass hotspots, including how many WVC per mile constitute a hotspot, and if and how crash severity influences hotspot identification. The maps would then be available to SDDOT and agency partners to assist in transportation planning. There needs to be a process for how trends are examined and reported. These actions would save agency personnel across the state in both SDDOT and SDGFP hundreds of hours of time not spent trying to track down these data.

6.11 Recommendation 11: SDDOT Requests That SDGFP Generate GIS Wildlife Maps

The distributions of populations of large mammals and other species of state concern are important for transportation planning. SDGFP needs to create these maps based on information from past wildlife research studies, ungulate surveys, hunter harvest surveys, and biologist input and review. All future wildlife study contracts would include a clause stipulating that all wildlife habitat data and associated maps be uploaded to a centralized site also available to SDDOT. In the future these maps would be updated annually and distributed to SDGFP district offices, the central SDDOT office, and partner agencies, including Tribal wildlife agencies. These maps and data would also be stored in a centralized electronic database. These actions may be included in recommended MOA. SDDOT and SDGFP personnel would save time annually in trying to locate these data.

6.12 Recommendation 12: SDDOT Initiates a Standardized WVC Priority Process

The future study for this recommendation will take the ongoing results of the recommendations of this study and create a systematic methodology/process for SDDOT and SDGFP to follow on the state and SDDOT regional level. This process would be similar to what Cramer et al. (2014) completed for Idaho. The process would include data on WVC crashes and carcasses, wildlife habitat maps, wildlife location data maps, land use maps, and collaboration between the agencies in selecting mitigation types, locations, and funds to minimize WVC. This standardized prioritization process will be needed to support planning decisions and to focus mitigation efforts on the highest priority areas. This study would help SDDOT and SDGFP in efficient transportation planning with methods of data analyses already created and data placed in one central location.

6.13 Recommendation 13: Integrate WVC Priority Areas Into Environmental Review

In 2015 the SDDOT environmental review process conducted by the environmental staff did not include an analysis of the WVC potential in future projects. This was done separately by the traffic safety engineer. The SDDOT Office of Project Development would need to create a standard checklist for the environmental review staff to evaluate WVC hotspots, wildlife linkages through wildlife maps, other wildlife presence and connectivity data, and the help determine need for potential mitigation with the input of SDGFP biologists. This evaluation will be a trigger for consultation with regional or district SDGFP biologists and a benefit-cost analysis to determine whether mitigation can pay for itself in terms of WVC avoided. This standardized process could save SDDOT personnel many hours each year in data searching, and ultimately save South Dakota taxpayers dollars each year because fewer WVC would occur in the state with the new wildlife mitigation.

6.14 Recommendation 14: Create a Memorandum of Understanding for Planning

Consideration of wildlife in transportation planning is dependent on SDGFP participation in the planning process. The MOU would institute protocols for consistent coordination between SDDOT and SDGFP at the state and regional levels. The MOU would identify specific positions within the agency that are responsible for coordination, the timing of meetings and the level of meetings at the headquarters for the state, and at the local SDDOT regional levels. The MOU would mandate SDGFP involvement in the Long Range Transportation Plan and the STIP. An example MOU is in Appendix I. These actions could help save SDDOT personnel hours each year trying to track down the correct people within SDGFP to learn of wildlife concerns. It could save SDDOT many dollars in lost time if they brought wildlife concerns into the planning processes sooner than rather than later.

6.15 Recommendation 15: SDDOT Initiates a Phase 2 of This Study

This study began the effort to evaluate the state of the data and collaboration in South Dakota related to wildlife and transportation. The work is not complete, and the researchers in this study can continue the work with SDDOT and SDGFP in implementing these recommendations. Specifically, A SDDOT funded Phase 2 of the research could help South Dakota in:

- Creating standards for WVC crash data.
- Establishing a single central database for WVC carcass data.
- Creating statewide WVC crash map with 10-mile markers.
- Validating the statewide WVC crash hotpot map for accuracy.
- Creating SDDOT regional maps of WVC hotspots with mile markers.
- Conducting SDDOT regional expert opinion WVC mapping workshops.
- Creating the standardized annual procedure to map WVC and identify trends.

- The identification of SDGFP wildlife data of importance to SDDOT.
- Assisting in the creation of a central wildlife database.
- Developing standards for future wildlife mitigation prioritization process.
- Integration of WVC concerns into the SDDOT environmental review process.

6.16 Recommendations Summary

The recommendations would come about over time, with SDDOT addressing certain recommendations immediately, and other over the course of the coming months and years. The overall objective of all these recommendations would be to help decrease WVC in South Dakota, which would help keep motorists safe, while helping wildlife to move across the landscape. The results would be increased motorist safety, and protection of wildlife populations from the effects of roads and traffic.

The cost savings to the state agencies and the traveling public in South Dakota hold great potential. If the any of the above actions could prevent just 58 property damage only WVC, they will have saved South Dakota one million dollars in costs to the public and individuals that would have been involved. As the efforts increase over time, the potential cost-savings would be projected to be in the millions of dollars every year.

7 RESEARCH BENEFITS

This research marks the first step toward defining the scope of the WVC problem in South Dakota. The research project put a value on the problem of WVC in South Dakota, with an average 4,696 reported WVC crashes, at an average cost of $107.9 million lost each year to society from reported WVC crashes, and as many as 24,700 large wild animals killed at an estimated loss of $29.6 million annually. The recommended steps provided in this report can help provide cost savings in prevented WVC over the coming years and decades.

This research has demonstrated the need in South Dakota for a systematic, reliable system of reporting WVC crashes and carcasses; for data collection and sharing to be coordinated among agencies; and for the WVC data and maps of wildlife habitat to be incorporated into transportation planning, including wildlife mitigation. This SDDOT study can be a stepping stone on the road to South Dakota becoming more proactive in identifying problem areas where wildlife need to move across roads, and creating the necessary mitigation to help preserve wildlife populations while protecting the driving public.

With this project, South Dakota will be positioning itself to collect, map, and integrate reliable WVC data into transportation planning and project designs, and create wildlife mitigation infrastructure. This will allow SDDOT and its partners to better address the WVC problem in the state in a scientifically, cost-effective, and efficient manner.

Through the identification of opportunities for the state of South Dakota to improve WVC crash data reporting, this research will help direct and inform future efforts by enhancing the quality of the WVC crash dataset, and thereby reduce the amount of time or money needed to address these data gaps in the future.

This research resulted in the identification of tangible and achievable actions to greatly improve the utility of WVC carcass data for the purpose of identifying WVC problem areas. Implementing the recommended improvements to WVC carcass reporting and data compilation will help SDDDOT and SDGFP to save both time and money, with clear standards for future data collection that are more streamlined, and useable in evaluations of WVC hotspots. Improvements to the WVC carcass reporting process will also streamline payments to contractors.

A major contribution of this research is the creation of maps of WVC crash locations, and identification of the top WVC crash hotspots in the state. These maps are important in helping SDDOT to immediately address how the solutions to these hotspots can be incorporated into planning for future transportation projects. In addition, the research provides a repeatable method for future WVC hotspot mapping, and saved time and money for agencies by creating the GIS analysis standards.

This research represents the first statewide effort to identify and begin to address the issue of WVC in South Dakota. Consequently, this research has created a greater awareness of WVC within SDDOT and SDGFP. This awareness resulted in new channels of communication about WVC between the two agencies at both the headquarters and regional levels. Specifically, this research project has helped SDDOT understand the need for SDGFP input in the transportation planning process. SDGFP involvement in the planning process could save SDDOT hundreds of hours of time annually that would have been spent trying to track down SDGFP data helpful in transportation planning. In the end, money, wildlife, and potentially human lives can be saved.

8 REFERENCES

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Appendix A: Task 2 Results: State of WVC Data Collection, Analyses, and Prioritization

Appendix A: Part I - State and Provincial WVC Methods

Task 2 instructed the researchers to: "Through a review of the literature and consultation with experts, identify and describe prevailing and best practices across the nation for animal collision reporting and analysis, mitigation of WVCs, and application of wildlife habitat and ecosystems and WVC occurrence and distribution models." Thus this Appendix A reports the results in detail, first with a Part 1 to address the national best practices for WVC reporting, analyses, mapping, and prioritization of WVC hotspot areas. Secondly, the appendix in Part II presents detail in the application of wildlife habitat and ecosystems with WVC occurrences and distribution models.

Arizona

WVC Carcass Collection Method

There is no standardized protocol for roadkill carcass documentation, and it is done very differently across the state depending on the district. Some do a good job of recording many species and logging them into a spreadsheet database. However, even the time tracking system that the maintenance crews charge their time through does not provide sufficient detail to track roadkill removal. There has been little effort within Arizona Department of Transportation (ADOT) leadership to standardize carcass data efforts and records.

WVC Carcass or Crash Mapping

No statewide effort to map carcasses. Crash data are used instead. See figure below.

Wildlife Linkage Mapping

Arizona conducted one of the premier wildlife linkage studies in the country in 2006. It was sponsored by ADOT and Arizona Game and Fish, and many other agencies, non-profits, and Northern Arizona University and involved a GIS least cost path analyses of whole state. The resulting document is used in the planning process, currently and the proposed process below. URL: http://www.azdot.gov/docs/planning/arizona_wildlife_linkages_assessment.pdf?sfvrsn=7. However, this analysis of hypothetical linkages has never been tested using wildlife occurrence data.

Planning and Prioritization Process

In 2014 ADOT (N. Dodd, retired biologist with ADOT) created a draft wildlife connectivity prioritization process. The original proposal was used extensively to inform the Idaho WVC mitigation prioritization process (Cramer et al. 2014). The Arizona process was predominantly based on GIS maps of: wildlife connectivity linkages from state created wildlife linkage maps, highway safety from WVC crash data, the barrier effect of roads on wildlife, taken from current Average Annual Daily Traffic (AADT) data, and wildlife habitat diversity taken from Arizona Game and Fish Department wildlife habitat maps. Other data incorporated into this process included: proportion of crashes on the five-mile stretch that involved wildlife, and on the ground surveys using the Passage Assessment System developed in Washington (Kintsch and Cramer 2011) to evaluate the ability of existing structures to serve as de facto wildlife crossing structures. The various information resources above, such as AADT are ranked and scored for a total of 100 point for each five-mile segment of ADOT road. From these scores, a GIS based map will be created for the state with the five-mile sections ranked in classes of priority. This map and report in turn can be used to prioritize which upcoming transportation projects have areas of WVC collisions in varying degrees of priority for the state. This process has not yet been adopted state-wide in Arizona.

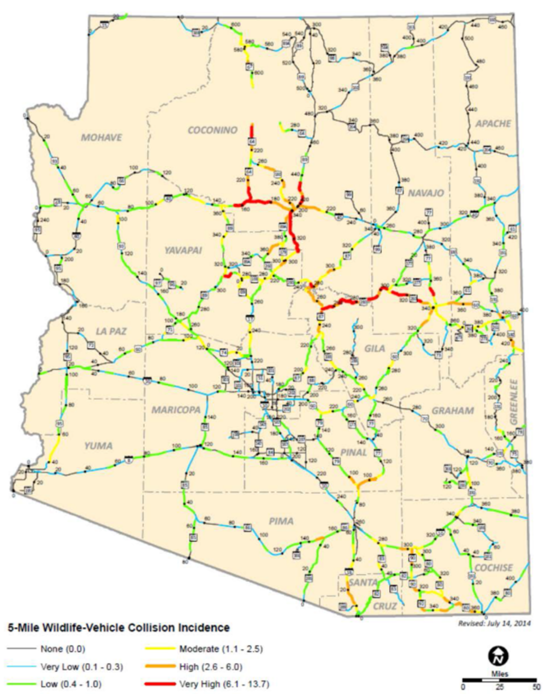

Figure 15. Arizona Hotspot Map of Five-Mile Segments with Highest WVC Incidences, Based on WVC Crash Data. Taken from Dodd 2014.

California

WVC Carcass Collection Method

Caltrans Maintenance Division staff at the district level carcasses on their daily rounds or when they receive a report from agency staff or the public. The carcass data are recorded incidentally during effort reporting both in the field and back in the office. Maintenance collects and keeps the data at the District level, not in a centralized database. Discussions in 2015 with Caltrans Environmental biologists revealed that these records were not regularly released to fellow Caltrans personnel, though most were aware of the existence of the data. Collision data (>15,000 records) back to the 1960s have been assembled by the UC Davis Road Ecology Center into an online resource (California Roadkill Observation System (CROS), URL:http://wildlifecrossing.net/california) that Caltrans staff and others can use to inform mitigation planning. The system allows data entry and visualization through smartphone and desktop browsers and currently includes both DOT and volunteer contributions of carcass observations. A team member Dr. Shilling is the creator and administrator of this site.

The UC Davis statewide database includes more than 49,000 observations of over 400 species that can be viewed online. Caltrans' queries for data are frequently fielded by the Road Ecology Center from Caltrans, as are those from consultants and academic scientists. Volunteer observers collect the data. Accuracy of species identification is greater than 95 percent (verified using uploaded photographs of carcasses). There is no formal system or process of data collection to support impact assessments or mitigation planning. Instead, Caltrans environmental scientists, consultants, the Road Ecology Center and others informally share data and data queries. This is primarily due to the efforts of just a few people, so as in most states, the backbone of data collection and sharing rests on the informal efforts of a few.

WVC Carcass or Crash Mapping

There is currently no website with WVC carcasses mapped by Caltrans. Some districts may hire consultants to map carcass data points, such as the District 10 project by Huijser and Begley (2014). Environmental personnel within Caltrans have very little access to GIS. When potential impacts of a project can be demonstrated, or have been discussed in the press in the event of driver-deaths from collisions with wildlife, then a crossing structure may be constructed as part of or independently from an existing transportation improvement project. UC-Davis, Road Ecology Center website has a mapping tool for the public to use for recently collected data, within the last 90 days, URL: http://www.wildlifecrossing.net/california/map/roadkill. The Road Ecology Center annually maps roadkill hotspots (Figure 16). This is currently the only statistically-based mapping of WVC concentrations/hotspots in the state.

Wildlife Linkage Mapping
There are several regional and one statewide linkage and corridor mapping projects in California. The statewide project is called the California Essential Habitat Connectivity Project: A Strategy for Conserving a Connected California, available at the URL: http://www.dfg.ca.gov/habcon/connectivity. It was completed in 2010 and there is no current plan to update it. Similar efforts have been completed independently in Southern California, the Central Coast, the Central Valley, the Sierra Nevada's, and the San Francisco Bay Area. In every case, a disturbance map was created based upon habitat fragmentation, urbanization, agricultural development, and/or road system impacts. None of the regional or statewide linkage mapping projects used actual wildlife movement data, see Part II of this appendix for greater detail of these efforts.

Planning and Prioritization Process
There is no standard process within California for including WVC and wildlife needs in transportation planning. The primary source of data and analyses for planning and prioritizing areas to mitigate impacts to driver safety and wildlife are WVC crash and carcass data. Secondary sources include camera trap data and mapping of adjacent habitat. The presence of mapped, unverified linkages has been used in Southern California areas where high levels of interstate traffic, greater than 200,000 AADT, results in few wildlife approaching highways and becoming roadkill. In these cases, existing road under-crossings or new structures are built to provide potential passage for wildlife, even if wildlife presence near structures is unknown.

In most other areas in the state, Caltrans or CROS carcass data are used in a range of approaches, from "eyeballing" the locations of carcasses in a digital map, to spatial analysis using spatial auto-correlation based methods. Typically, environmental scientists or biologists at Caltrans are asked to review transportation project proposals for impacts to wildlife movement. There has been discussion of how to bring these impact assessments earlier in planning to improve the process and outcomes of these internal discussions. So far, there is no requirement for consideration of impacts to wildlife movement in regional or corridor planning. However, in many Districts, there is increasing realization that at least for certain highways, these issues will come up at some point and it is wiser to treat them early. Formal prioritization of actions to reduce WVC is a desired end-goal, but Caltrans relies heavily on external partners to come up with the priorities. Caltrans' desire would be for the state Department of Fish and Wildlife (CDFW) to develop the priorities, which they could then include in regional and corridor planning. However, the CDFW is not tasked or resourced to do this and in turn relies upon external partners.

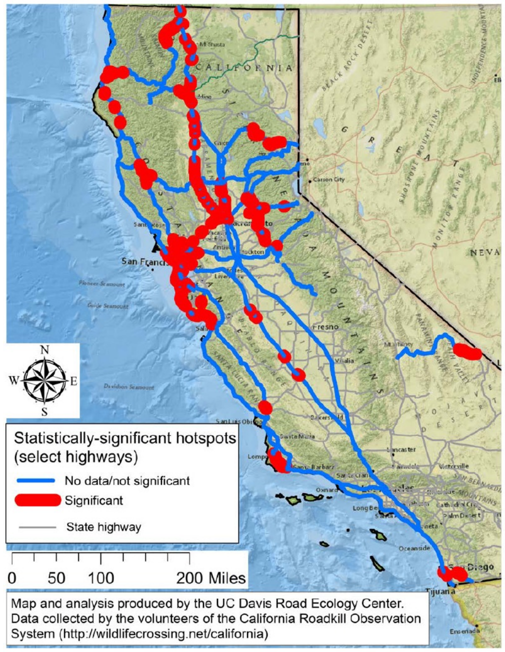

Figure 16. California WVC Carcass Data 2014 Hotspot Road Segments, Mapped for Entire State; Data from UC Davis Road Ecology Center (CROS).

Colorado

WVC Carcass Collection Method

Colorado DOT (CDOT) Maintenance workers collect carcass data to nearest 1/10th mile. Compliance is voluntary, thus reporting is variable by maintenance unit. Reporting effort for each unit is unknown and data are not comparable across a region or the state. Data are entered into an electronic program. Data are compiled regionally and submitted quarterly to a statewide manager. CDOT sends summary reports of WVC activity by region to multiple agencies, totaling about 85 people.

From 2005-2014, Colorado averaged 3,591 reported WVC crashes per year. Statewide, the reporting rate for WVC crashes remains unknown, however on State Highway 9 in Grand County - a road segment known to have high WVC - accident reports from state patrol captured just 18 percent of the carcass reports tallied by a private ranch over a four-year period (2009-2012; Blue Valley Ranch, personal communication). Carcass reports collected by CDOT maintenance captured 62 percent of this total.

WVC Carcass or Crash Mapping

WVC carcass data are not mapped and used for planning due to inconsistent reporting at CDOT. Crash data are analyzed to identify crash hotspots, including WVC. For local projects a Region may map carcass data for use in project planning. Crooks et al. (2008) created several maps depicting top WVC road segments based on crash data, see Figure 17 below.

Wildlife Linkage Mapping

In 2005 *Linking Colorado's Landscapes* (http://rockymountainwild.org/srep/linking-colorados-landscapes) resulted in the identification and prioritization of nearly 200 coarse-scale, species-based linkages across the state. While linkage identification was primarily based on a series of expert workshops and GIS linkage modeling, roadway segments with high WVC rates were also considered in the final linkage prioritization. Phase II of the project involved further analysis and field assessments of the top 12 high priority linkages, resulting in specific mitigation recommendations for each linkage. Detailed wildlife linkage mapping was completed in 2011 for the I-70 Mountain Corridor, resulting in the identification of 17 linkage zones.

Planning and Prioritization Process

In Colorado there is no statewide process. However, there is a national example: The I-70 Regional Ecosystem Framework evaluated both original and existing information including camera trap data, habitat data, WVC data, citizen reported wildlife observations, and an extensive survey of existing bridges and culverts. Through a transparent and repeatable process, and the application of clearly defined decision rules, 17 Linkage Interference Zones were identified and delineated. Within each Linkage Zone preliminary milepost-specific mitigation recommendations for new crossing structures or enhancements to existing structures were developed to guide future planning and budgeting.

In 2016, CDOT and Colorado Parks and Wildlife were embarking on a joint research project to identify and prioritize highway crossing zones for mule deer and other wildlife across the state's Western Slope. This project will result in the identification of priority highway segments and preliminary mitigation recommendations.

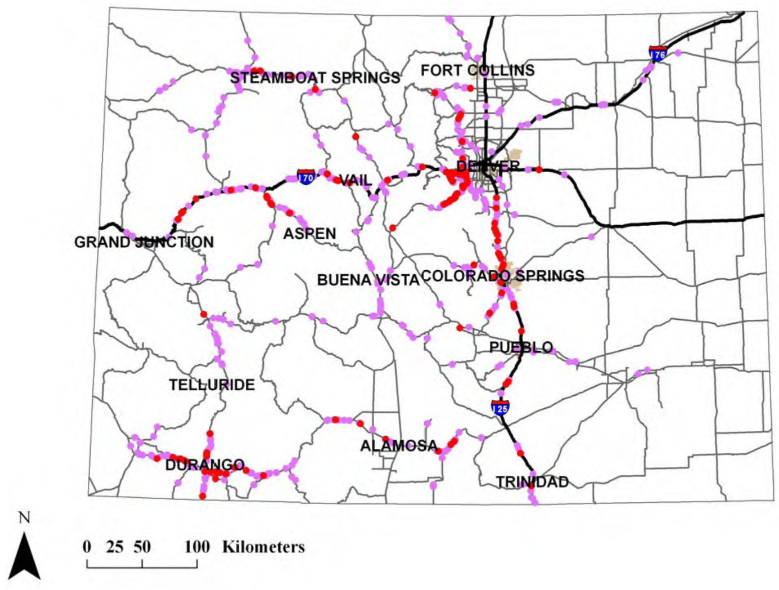

Figure 17. Distribution of Top 1 Percent and 5 Percent Counts of Animal-Vehicle Collisions (AVC, Both Wild and Domestic) Resulting in Fatality and Injury in Colorado from 1986-2004. Red dots Represent Top 1 Percent, Purple Represent the Remaining AVC. Taken from Crooks et al. 2008.
Note: U.S. Mile Measurements Were Not Available.

Idaho

WVC Carcass Collection Method

Idaho Transportation Department (ITD) Maintenance workers collect carcasses and enter data on: the time, Global Positioning System (GPS) locations or mileposts, and species into electronic database, named the Transportation Asset Management System (TAMS). They turn these data entries into ITD headquarters as part of their time cards. Compliance is considered part of standard operating procedure, but was highly variable among maintenance districts. Data formerly was uploaded in a spotty, once a year manner, but since the study by Cramer et al. (2014) a MOU between ITD and Idaho Fish and Game (IDFG) instructed ITD to upload data daily or at most weekly to the IDFG carcass website, see Appendix I.

Members of the public can both upload data on carcasses found along the road, and download data. The interactive website is: https://fishandgame.idaho.gov/species/roadkill. This is one of only four websites for entering roadside carcass data that the public can use.

In 2013 Idaho enacted a carcass salvage law that allows citizens to take carcasses as long as they report to the IDFG website. This law may decrease carcass numbers reported by ITD maintenance, but should be equally increased on public websites where the public applies for permits and reports carcasses collected.

WVC Carcass or Crash Mapping
Both the public and state agencies can use the above WVC carcass reporting website with various location methods. IDFG website brings up maps at user defined scales, of carcass locations, but does not cluster them, so there are multiple pin points, rather than a display of hotspots. This website is very advanced as compared to rest of the U.S. With the Cramer et al. (2014) study, the mapping process for carcasses became part of a new GIS initiative, IPLAN which is a GIS information portal available only to agency personnel. With this new portal and gathering of GIS databases, transportation planning can include the carcass data when creating maps of areas under consideration. Thus, the Cramer et al. (2014) report includes static map images of carcasses (Figure 18 below), and agency personnel can create their own GIS maps with mapping software tools.

Wildlife Linkage Mapping
In 2007 an expert consortium of agency personnel called a "Rapid Assessment "in each ITD District - IDFG Region. In 2005 District 6 convened the initial workshops on linkages. These workshops were conducted to identify wildlife linkage areas across roads in each district-region. Maps of all linages are available and were used in the 2014 Cramer et al. (2014) study. Anyone can download the shape files and other GIS files from the site: https://fishandgame.idaho.gov/ifwis/portal/opendata/idaho-highway-wildlife-linkages

Planning and Prioritization Process
In 2014 Idaho became the first state to create a systematic prioritization process for identifying WVC problem areas to target for wildlife mitigation. The ITD sponsored research project that produced the report was created by this study's Primary Investigator (PI) and three of this research's other team members. The report, (Cramer et al. 2014), is available at: http://itd.idaho.gov/highways/research/archived/reports/RP229FINAL.pdf.

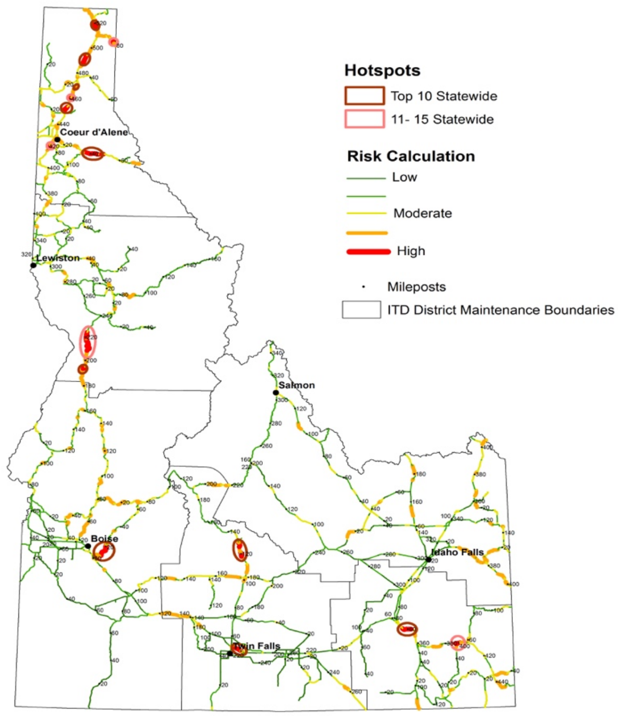

Figure 18. Idaho WVC Hotspots as Reported by Cramer et al. 2014.

Montana

WVC Carcass Collection Method

Montana DOT (MDT) maintenance workers collect data and fill out paperwork on carcass collection accurate to the 1/10th of a mile. Those district data sheets are sent to headquarters, where the traffic safety staff transpose to Excel spreadsheets. The spreadsheets are made available in internal ArcGIS software to allow for specific mapping for projects. MDT Maintenance is looking at how to start collecting all data with either tablets or smart phones.

WVC Carcass or Crash Mapping

There is no statewide mapping process. The individual personnel within MDT use the carcass data in mapping future projects. MDT noticed that for every one-tenth of a mile marker that had more than one carcass found, the maps only showed a single dot regardless if there were dozens of carcasses found there. They have adapted their GIS methods to use graduated sample routine within ArcGIS so that they have classes of data, such as 0 to 1, 2-3, 4-7 carcasses for each one-tenth of a mile location.

The WVC crash data does not come automatically to the environmental personnel, and is rarely used by environmental personnel, but is reviewed by traffic safety engineer.

Wildlife Linkage Mapping

There was no statewide mapping within MDT, but many other efforts, including: Montana Natural Heritage Program, Non-profit organizations, and the Western Governors' Association Crucial Habitats Assessment Tool (WGA CHAT) that was developed in Montana. The majority of MDT seeking knowledge of wildlife locations and habitat comes from requests to US Fish and Wildlife Service, and Montana Fish Wildlife and Parks (MTFWP).

Planning and Prioritization Process

Every two years MDT has STIP meetings with MTFWP personnel in each of their regions statewide. They spend an entire day with the MTFWP biologists asking their input on upcoming projects and their concerns. Once projects begin, MDT stays in touch with their MTFWP counterparts throughout the construction process. In 2015 MDT selected a consulting company to create a standardized prioritization process for the state.

Nebraska

WVC Carcass Collection Method

Within Nebraska DOT (NDOT) there is no systematic method to collect carcass data. The Nebraska State Highway Patrol records WVC as crash data when the collisions are reported by the driver. Most of these WVC incidents involve deer.

WVC Carcass or Crash Mapping

To the best of the knowledge to our respondent, no mapping is done with the WVC crash data. The Department of Public Safety and NDOT produced a Deer-Vehicle Collision Information Kit, which provides numbers of deer-vehicle accidents reported for each county: URL: http://www.transportation.nebraska.gov/docs/DVC%20Information%20Kit.pdf

Wildlife Linkage Mapping

Currently, there are no mapped wildlife linkages or designated wildlife corridors in Nebraska. In most parts of the state, the topography does not funnel/concentrate wildlife into specific locations resulting in a need for an overpass. There are also no major terrestrial wildlife migrations in the state. The state is divided into several Ecoregions and their associated species in need of conservation. This information is available in the Nebraska Natural Legacy Project, and personnel there are consulted in transportation planning. Fencing and wildlife specific undercrossing have been used along I-80 near Ashland to reduce deer-vehicle collisions. NDOT environmental staff is aware that wildlife use existing bridges and box culverts as crossing structures throughout the state.

Planning and Prioritization Process

NDOT looks at projects that will be constructed on new alignments, adds capacity to an existing roadway, or involve new fencing as the primary factors when considering wildlife mitigation. The majority of wildlife mitigation in Nebraska is a result of stipulations in the Federal Endangered Species Act (ESA) and Nebraska's Non-Game Endangered Species Conservation Act (NESCA) consultation. Mitigation and plans for conservation conditions for Threatened and Endangered (T&E) species are common.

Nevada

WVC Carcass Collection Method

Collection of WVC carcass is performed by Nevada DOT (NDOT) maintenance workers. Data collection on these carcasses has not been consistent in the past, but recent changes in reporting requirements hope to rectify these inconsistencies. Data on WVC are also collected by Nevada Highway Patrol and are reported in their crash records. Data are used in transportation planning on site specific cases, but has not been integrated into long-term planning.

WVC Carcass or Crash Mapping

There is no statewide effort to map WVC carcasses or crash data. Nevada DOT has used WVC data from Nevada Highway Patrol crash records and Nevada Highway Patrol databases to map occurrences across the state. This information has been used in various planning efforts.

Wildlife Linkage Mapping

Nevada implemented the I-80 Corridor System Master Plan which included a working group that investigate WVC and potential problem areas. The participants included professionals from various state agencies and nonprofits. A web-based GIS was created and highlighted linkage areas along I-80. URL: http://www.i80vision.org/home

The non-profit, the Nevada Wilderness Project identified 20 wildlife linkages statewide and are working to monitor and find partners for wildlife and land protection: http://www.wildnevada.org/index.php?option=com_content&task=&id=504&Itemid=1.

Planning and Prioritization Process

Each wildlife mitigation project has been put in motion by a few select people that are strong advocates within both NDOT and Nevada Department of Wildlife. The two agencies work closely together with constant communications between the biologists, planners and engineers. See Simpson et al. (2011). Gibby and Clewell (2006) also recommend that NDOT and Nevada Department of Wildlife create a collaborative planning process to include wildlife concerns in the transportation planning process.

New Mexico

WVC Carcass Collection Method

New Mexico House Memorial 1 established that New Mexico Department of Transportation (NMDOT) and New Mexico Game and Fish (NMGF) look to establishing a citizen monitoring program for collecting carcass data.

WVC Carcass or Crash Mapping

A WVC priority road segments map is presented below.

Wildlife Linkage Mapping

In 2003 there was a critical mass workshop on WVC & linkages. Sky Island Linkages created an interactive map found at the URL: http://www.skyislandalliance.org/map.htm.

Planning and Prioritization Process

Several efforts have been made to coordinate state agencies in the effort to reduce WVC in New Mexico. Alliance for Transportation Research Institute (2006) recommended WVC carcass collection, mapping, and agency coordination. The New Mexico State Legislature passed House Memorial 1 which requested that the NMGF and NMDOT work with the University of New Mexico, Division of Government Research to hold a critical mass workshop by June, 2013, in order to collect updated information showing where WVC occur, produce a list of road segments with the greatest number of collisions, and send a report to the appropriate interim legislative committee by October, 2013. It also requested that the departments apply for Highway Safety Improvement funding to establish additional wildlife safety zones. Additionally, it requested that the departments assess the possibility of establishing a citizen road monitoring program to collect data in the future. http://protectnewmexico.org/bills/wildlife-vehicle-collision-study/. See figure below for mapping efforts to show the priority WVC road segments. To view the 2012 legislative effort in New Mexico see URL:

http://www.nmlegis.gov/lcs/handouts/WNR%20101512%202.%20HJM%2010%20Report%20Final_June20%202012.pdf.

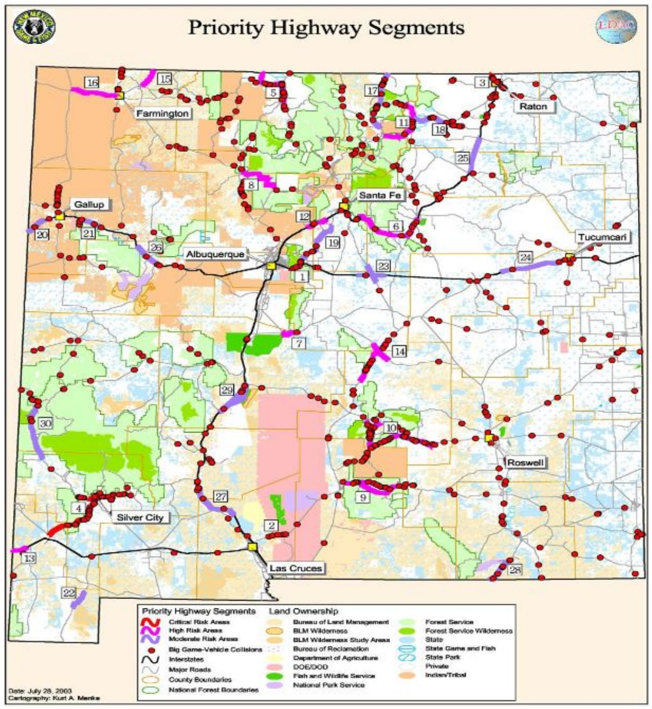

Figure 19. New Mexico Road and Wildlife WVC Priority Segments.

Ontario, Canada

WVC Carcass Collection Method

Since 2006 provincial highway maintenance crews collect carcass data for large animals. Spatial accuracy varies, sometimes the personnel use GPS in trucks other times the data are reported with only a descriptive location. Only the Ontario Ministry of Transportation (OMTO) Northeast Region conducts carcass data collection.

WVC Carcass or Crash Mapping

In 2013-2014, K. Gunson (team member of this study) conducted a study with the Ontario Ministry of Transportation (OMTO) using province-wide crash data collected by the Ontario Provincial Police. The crash data was mapped using the linear highway referencing system (LHRS), and hotspots were defined per 2-4 km highway segments around each LHRS station. Highway segment lengths were used to account for spatial inaccuracies when referencing WVC crash locations to the LHRS. See Figure 18 below.

Wildlife Linkage Mapping
The Ontario Road Ecology Group and K. Gunson created an analysis province-wide road of mortality hotspots for amphibians and reptiles across Southern Ontario in 2008. The analysis was based on preferred habitat surrounding roads in a 200 m buffer, and validation showed it was an effective planning tool. However, because over 19,000 km of roads were hotspots a prioritization process was needed to prioritize where transportation planners need to focus mitigation efforts (Gunson et al. 2012; Shueler and Gunson 2011, http://www.torontozoo.com/pdfs/gunson.pdf). Species-specific habitat modelling with respect to roads is being further refined as part of the development of a Wildlife Mitigation Strategy for the MTO.

Planning and Prioritization Process
The Ontario Ministry of Transportation developed a Wildlife Mitigation Strategy in 2014 to prioritize where short- and long-term mitigation for small and large animals are most required on provincial roadways. This was intended to improve the efficiency and effectiveness of MTO's ongoing wildlife mitigation efforts that are currently only considered on a project-by-project basis through the environmental assessment process. Two workshops were held, one for large animals and one for small animals, to determine a methodological approach for prioritizing where wildlife mitigation is required. The workshops looked at available data, e.g. wildlife and traffic volume abundance trends, to prioritize where mitigation is required for specific large animals. Criteria were compiled into a decision-planning tool and weighted importance can be determined by the stakeholders and experts within each planning region.

After the hotspots were mapped a prioritization process was used to further characterize hotspots based on WVC rate, where motorist fatalities and injuries occurred, where a higher proportion of WVCs occurred as per total crashes, and where the risk of WVCs are high as per total vehicles on the road (Dodd 2014; MTO in review). The metrics that characterize hotspots vary across regions and jurisdictions, therefore multi criteria assessments to weight and evaluate important metrics may be performed with stakeholders and experts within each jurisdiction.

These hotspots were depicted using WVC crash data and were not species specific, therefore species specific mitigation measures cannot be recommended. It can be assumed that the majority of the WVC were with large animals and therefore the hotspots may denote where large animal fencing is warranted. However, because the data are not based on any ecological data, mitigation measures such as underpasses and overpasses cannot be prioritized, because these structures are typically sited where wildlife movement corridors bisect roads.

Another limitation to a hotspot analysis that uses crash data is that it typically under-represents the ‘true’ WVC rate and is only illustrating those WVC that have been reported. On highways where many trucks are involved in WVC many crashes may be under-reported because property damage is negligible. Therefore, crash data may not represent an equal sampling effort for comparison across a region.

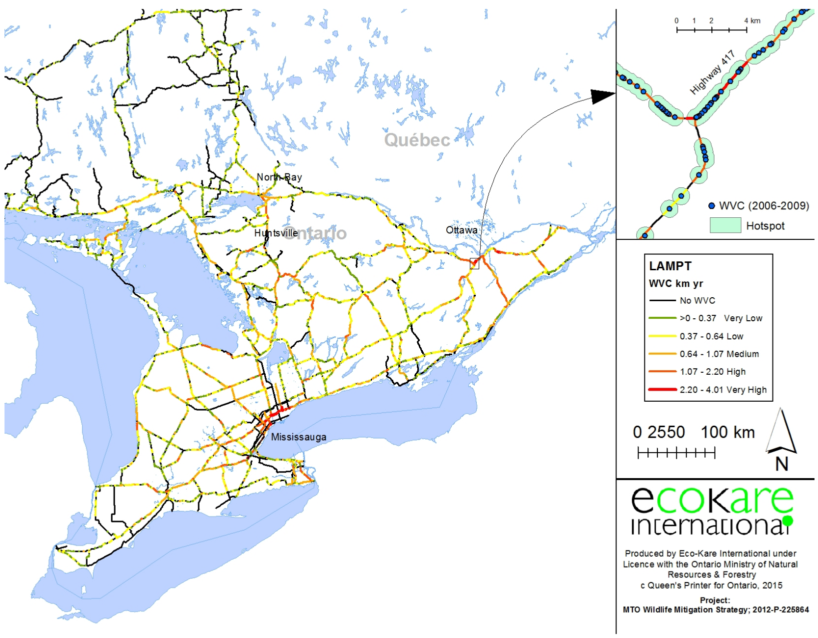

Figure 20. Ontario Map of WVC Hotspots.

Oregon

WVC Carcass Collection Method

Oregon Department of Transportation (ODOT) Maintenance workers fill out paperwork on carcass collection and data are accurate to the 1/10th of a mile. The state is moving from paper records to a statewide data collection in electronic data device.

WVC Carcass or Crash Mapping

Trask (2009) used Kernel Density Analysis to map WVC carcass data by ODOT region and for whole state (Figure 21, below). Static map resulted from the study but there is no GIS site to update data. In 2016 efforts were begun to update the WVC mapping in a more current study.

Wildlife Linkage Mapping

Oregon Wildlife Linkages was an effort created and organized Oregon Department of Fish and Wildlife (ODFW). There is a compilation of products from four workshops held throughout state in 2007-2008. Linkages were for focal species. This is considered the first step. There are 723 linage buffers digitized. The Linkage workshop was summarized at the website: http://www.dfw.state.or.us/conservationstrategy/docs/Linkages_Report_Final_2009.pdf

Planning and Prioritization Process

The single person within ODOT who was the motivating force for wildlife mitigation efforts at ODOT left the agency in 2013. Current planning efforts rely on earlier reports, maps, and websites. The 2009 WVC Collision Hotspot Analysis report (Trask 2009) gives each ODOT District a list of priority areas to work with, as well as a statewide list.

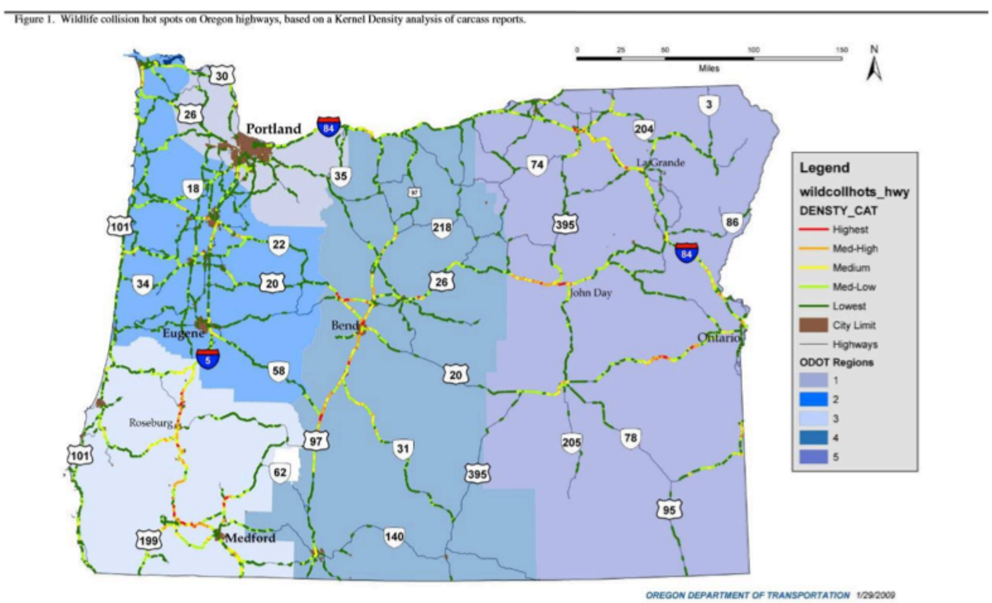

Figure 21. Oregon Priority WVC Hot Spots Mapped in 2009. Taken from Trask (2009).

Texas

WVC Carcass Collection Method

There is no statewide process to report WVC carcass data at Texas DOT, (TXDOT). TXDOT environmental staff in headquarters are unaware of the magnitude of WVC in state (P. Cramer, personal visit with TXDOT staff September, 2013).

WVC Carcass or Crash Mapping
None

Wildlife Linkage Mapping
None

Planning & Prioritization Process
Planning for wildlife in transportation is locally driven, and also driven by the US Fish and Wildlife Service (USFWA) for ocelot, a protected species. Texas rarely conducts any kind of wildlife mitigation. In September of 2013 Dr. Cramer met with TXDOT to discuss potential actions to change this in order to record WVC carcasses, find outside agency partners in addressing wildlife connectivity, and creating wildlife crossings. As of 2016 the USFWS was still working with TXDOT to include additional culverts for ocelots. In 2016 an engineering professor from the University of Texas at Austin, (Dr. K. Kockleman) contacted Dr. Cramer in developing a proposal (which was funded) to conduct research to map WVC and find priority areas within Texas, if this proposal is successful, Texas may map WVC priority areas in 2016-2017. TXDOT has 25 semi-autonomous districts, making it difficult to track actions and to raise awareness and support for wildlife mitigation actions.

Utah

WVC Carcass Collection Method
Outside contractors record GPS location and species, gender and age of every carcass on mobile phone application, URL: https://wvc.mapserv.utah.gov/wvc/desktop/. Phone app and use of mapping process are by permission only and include Utah DOT (UDOT), Utah Division of Wildlife Resources (UDWR), and other natural resource agency personnel. Data uploaded within minutes.

WVC Carcass or Crash Mapping
The GPS carcass data are immediately uploaded to map website and accessed by password protected users. Data points are clustered according to the user defined scale. User defined spatial and temporal filters help to view changes over space and time. See Figure 22, below.

Wildlife Linkage Mapping

Utah conducted a 2004 Rapid Assessment mapping of wildlife linkages; it is rarely used, and not publically available. Utah is looking to use the WGA CHAT map wildlife linkages in the future.

Planning and Prioritization Process

Prioritization process is heavily dependent on individuals in UDOT regions and UDWR districts. Currently each UDWR district is instructed to annually map and prioritize its wildlife mitigation areas on all roads in the district. WVC mitigation actions are prioritized with UDWR by UDOT regions. Each UDWR district works with its UDOT region counterpart. Most mitigation is conducted in UDOT Region 4, which established its own prioritization process:

1. Examine WVC crash and WVC carcass data on Excel spreadsheet graph with mile posts of road of interest;
2. Identify problem areas;
3. Meet with stakeholders;
4. Identify potential solutions;
5. Estimate costs and benefits;
6. Plan mitigation as part of future project, or find funds to support standalone wildlife mitigation project.

In this UDOT Region there are close working relations with the UDWR personnel in their counterpart district. UDOT engineers are beginning to use UPLAN, an interactive GIS mapping platform on the Internet, for such analyses of WVC.

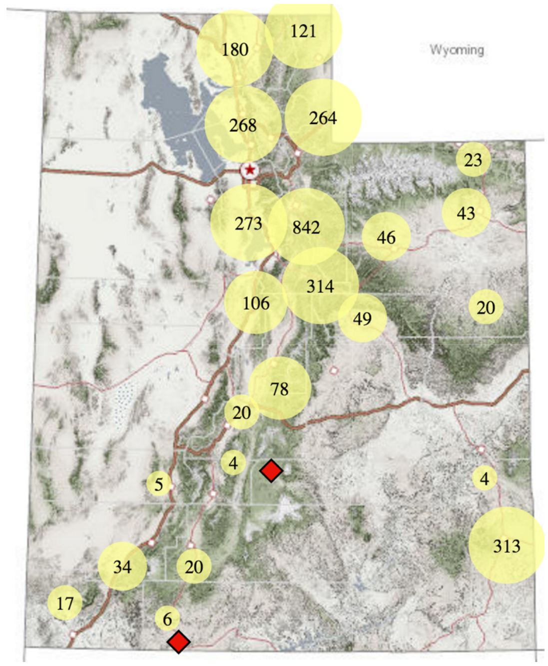

Figure 22. Interactive Utah WVC Carcasses Map, as of October 31, 2015. Yellow circles Represent Grouping of Nearby WVC Carcasses, Red Diamonds Represent Single Data Points of Carcasses.

Washington

WVC Carcass Collection Method

In the past, Washington DOT (WSDOT) maintenance workers filled out paperwork on carcasses they collected, with data to the 1/10th of a mile. In 2015 maintenance staff were being supplied with I-Pads. Ninety were distributed in May of 2015. Software was developed to collect all of maintenance activities, including carcass collection, they need to just press buttons on the I-pad. The software still asks users to put in the road and mile post to the 1/10th of a mile. Every time the maintenance workers return to the office to sync up the data, it gets delivered up to headquarters shared drive. Approximately 3,000 deer and 85 elk carcasses are reported along Washington roads each year (Meyers et al. 2008).

WSDOT Environmental Biologist, Marion Carey produces posters annually that go out to Maintenance offices to show how the data the maintenance staff collected addresses various efforts within WSDOT. They present pie charts, graphs, and stories of wildlife crossings, or fencing projects where the data were used. The environmental staff also sends the maintenance workers self addressed envelopes with the data collection forms, to be mailed back to headquarters, and they do everything they can to show the maintenance staff that data collection is still important to WSDOT environmental staff.

WVC Carcass or Crash Mapping

The carcass data doesn't automatically get mapped. All of WSDOT staff has access to the data through the intra-agency Environmental Workbench. Staff has to do some processing to get it into ArcGIS; ArcMap is used to map. The carcass data are available through 2014. By 2016 A WSDOT biologist believes the carcass data will be instantaneously available. Anyone within WSDOT can access that data and build it into that map they are making. They've been using it with Kernel Density and hotspot mapping. The WVC Crash data from State Patrol is loaded into WSDOT GIS workbench, and all personnel have access to the data to make maps.

A static map was produced by K. McAllister for WSDOT and is presented in Figure 23, below.

Wildlife Linkage Mapping

There is the Statewide Wildlife Connectivity Analysis: http://waconnected.org/statewide-analysis/, which has maps that are used across the state for identifying wildlife linkages. The website supports the GIS use of these maps with HCA Toolkit and Linkage Mapper. WSDOT personnel also use data layers are in Data Basin. This site has a huge accumulation of geographic and environmental data. Washington Wildlife Linkages project layers are in there. Data Basin, http://databasin.org/, is a science based data analysis and mapping platform available to anyone.

Planning and Prioritization Process

The Habitat Connectivity Investment Priorities Method was developed by Kelly McAllister of WSDOT in 2013. This method uses: crash data, carcass data, roads, wildlife linkages maps, and federally and state listed "species of concern" habitat maps. The process is intended to develop two priorities: the Ecological Stewardship Rank and the Safety Rank Priorities. The Ecological Stewardship Rank looks at listed species, things that DOT's have to look at habitat for threatened and endangered species, from connectivity modeling for linkages that can connect the best habitat. The Safety Rank is based on WVC crash and carcass data on larger animals more typically involved in injuries and fatalities to humans. This methodology is not yet very well integrated in WSDOT's practices across the state. The WSDOT environmental office is working hard to get offices across the state to consistently use this method. WSDOT staff also uses an intranet based Environmental Workbench to compare priority areas to long-term and up-coming transportation projects, identify potential areas where these roads cross high priority areas, conduct a field visit to those areas, and conduct an evaluation using the Passage

Assessment System (PAS) (Kintsch and Cramer 2011) to determine if existing structures could be retrofit for target species' movement. Final plans for mitigation are based on upcoming projects, including many bridge and culvert replacements.

Figure 23. Washington State WVC Priority Road Segments, from K. McAllister, personal communication 2014. Red segments are of high WVC priority, orange segments medium, blue segments low, and gray segments of no priority for WVC.

Wyoming

WVC Carcass Collection Method

Wyoming Department of Transportation (WYDOT) maintenance crews collect WVC carcass data. They record the location's highway and milepost to the nearest one-tenth mile, species, sex, age class, etc. The reports are submitted to Highway Safety to be entered into the carcass database. Some WYDOT Maintenance crews are still filling out the older paper data sheets, but the agency is progressing to electronic data entry. There is variability in maintenance crew compliance with reporting.

WVC Carcass or Crash Mapping

The WYDOT Highway Safety Program does produce maps of statewide crash hotspots. They can also produce carcass hotspot maps.

Wildlife Linkage Mapping

Wyoming does not have linkage maps in the same sense that other states do such as Arizona, and California. Wyoming started down the road of wildlife linkage mapping and even brought a consultant on board to do the work. However, after taking a look at what was already existing for Wyoming and the data that were regularly used and had easy access from various sources, Wyoming decided not to move forward and spend money on a big linkage study when most of the data were already available. WYDOT regularly uses various existing data sources such as WISDOM (Wyoming Interagency Spatial Database and Online Management System), Wyoming Migration Initiative, and Wyoming Game and Fish Department's (WYGFD) internal WISDOM (more detailed information than the public version).

Planning and Prioritization Process

WYDOT uses data and maps produced internally along with data and maps from Wyoming Game and Fish, USFWS, land management agencies, and the biological consultants they contract with for projects. WYDOT works very closely with WYGFD, especially regarding WVC mitigation and protecting and enhancing wildlife migration corridors. Fortunately, WGFD and the University of Wyoming have a lot of good data for wildlife migrations that, when combined with WYDOT WVC crash and carcass data, make it much easier to identify suitable locations for WVC mitigation.

Appendix A Part II - WVC Occurrence and Distribution Models

A second goal of Task 2 was to report "the application of wildlife habitat and ecosystems and WVC occurrence and distribution models" in best practices for WVC reporting, analyses, and mitigation. In order to best understand how these models are developed to inform transportation planning, the state of the science of habitat modeling is presented in two parts. First, a basic understanding is given on wildlife habitat fragmentation by roads, followed by how the science of wildlife connectivity informs modeling efforts. Secondly, the section ends with examples of how connectivity models have been and could be applied to help determine priority areas where WVC mitigation is needed.

Wildlife Habitat Fragmentation

Habitat fragmentation and loss due to roadways, urban development, agriculture, and resource extraction are some of the greatest threats to biodiversity (Wilcove et al. 1998). The ability of a species to move about among habitat areas of varying quality is central to populations surviving across their range (Hanski 1998). Pimm et al. (2001) demonstrated that isolation of sub-populations due to habitat fragmentation can lead to small populations that face increased risk of extinction through inbreeding depression and chance catastrophes. Ultimately, increasing fragmentation results in reduction of species distribution and population size. Landscape connectivity is defined as the degree to which the landscape facilitates or blocks wildlife movement among and within habitat types (Taylor et al. 1993). Connectivity has emerged as a key component of wildlife conservation. Wildlife movement and behavior have emerged as critical components of connectivity modeling and mitigation in complex landscapes. Mitigation for fragmentation effects of roads includes constructing crossing structures over or under highways to facilitate wildlife passage. However, structure use can vary with taxonomic group and the characteristics of the structure (reviewed in Kintsch and Cramer 2011).

Species Distribution

Wildlife species are distributed in natural and artificial (e.g., farmlands) landscapes according to their habitat preferences, the availability of habitat, demographic changes (e.g., decrease or increase in reproduction), their tolerance of disturbance, presence of prey and predators, and legacies of past distributions. Species distribution modeling is usually carried out to determine attributes such as historic distribution, current distributions, and potential causes of limited or reduced distribution. There are two primary ways of determining species distributions: 1) spatial modeling based on past or current known occurrences of the species and 2) probabilistic/spatial modeling based on habitat preferences of the species. Often the type 2 model is validated using species occurrence information so there is some overlap between the approaches. Wildlife move around in their habitat and in areas that are not typically their habitat, but which they briefly tolerate in order to meet daily, seasonal, and generational needs. These needs include feeding, finding cover, seasonal migration, finding mates, and juvenile dispersal.

The types of spatial data needed to assess wildlife occurrence and distribution in transportation planning include: habitat type (e.g., grasslands), habitat structure, locations of human activities and structures, locations of live wildlife populations, and locations of WVC. Locations of live animals and WVC are both useful in estimating distribution and potential movement of individual species and populations. Locations of WVC are useful for estimating where direct conflict between traffic and wildlife is occurring. Because wildlife species may have varying sensitivities to traffic and roadways, the absence of WVC does not mean that particular species do not occur in an area. They may be avoiding the roadways, or they may be safely crossing.

Habitat and Wildlife Movement

WVC are a result of wildlife moving from their habitat onto a road or highway and getting hit by a vehicle. Carcasses resulting from WVC are therefore evidence of wildlife distribution and movement. Select U.S. state wildlife agencies and DOTs use WVC information and other evidence of wildlife movement (e.g., GPS-collared deer) to locate appropriate sites for mitigation. Many state wildlife action plans now include the terms “corridor,” “connectivity,” and “linkage,” which are usually defined as continuous areas of low-disturbance habitat allowing wildlife movement. Connectivity maps can be modeled for a landscape by measuring habitat quality and disturbance (which impedes wildlife movement). Hypothetical corridors and linkages are typically modeled based on a combination of connectivity maps and assumed starting and ending habitat patches. State agencies and conservation scientists have treated linkage models in GIS as a source of prioritization information; however, these models have not been appropriately treated and tested as hypotheses, despite nearly a decade of critique in the ecological literature (e.g., Boitani et al. 2007). These models are usually based on delineation of pathways (e.g., corridors, linkages, or connective habitats) that take advantage of no or low disturbance from human activities and natural barriers to connect low-disturbance “habitat patches.” This approach reflects the idea that wildlife movement choices for seasonal, dispersal, or daily imperatives is based on both disturbance and habitat suitability and quality and that individuals only move among patches of habitat. However, species may move in more complex patterns and in most landscapes there may be many species moving around according to their habitat preferences and tolerances. As discussed below, this second case is more common and may be the most appropriate way to include habitat connectivity in planning for wildlife movement.

Connectivity & Linkage Model Assumptions

Connectivity for wildlife and natural processes is considered by many to be essential for maintaining ecological communities in the face of current disturbances (Morrison and Boyce 2009) and the effects of climate change (Heller and Zavaleta 2009, Crooks and Sanjayan, 2009). However, the way this is implemented matters and habitat quality and connectivity has generally been proposed as the target for conservation, rather than hypothetical linkages (Hodgson et al. 2009). Evaluating wildlife and habitat connectivity at a statewide and regional level and providing mapping in GIS is considered a source of useful information for integrating wildlife connectivity needs into traffic modeling analyses for future growth and anticipated infrastructure needs. Providing detailed, multi-scale analysis of the potential movement paths of specific focal species and broader habitat connectivity analysis is usually considered useful for decision makers to identify priority areas and hypothetical linkages that are irreplaceable and/or vulnerable. This mapping is also often used to identify areas where there may be safety concerns to the public, for example where there may be a high concentration of wildlife-related vehicle accidents where wildlife are crossing a roadway.

Developing and Testing Habitat Connectivity Models

Corridor/linkage models have been tested and developed using animal movement behavior. LaPoint et al. (2013) critically evaluated the development of corridor/linkage models and discussed common weaknesses among these type of models: i) generalization of habitat selection information, assumption that animals have complete knowledge of landscapes, or completely naïve experience with landscapes, ii) modelers do not base models on animal movement information, and iii) very few model predictions have been tested with animal movement data. LaPoint et al. (2013) further demonstrated that fisher movement in a partially-developed landscape was not well-predicted by typical linkage approaches (least-cost path and circuit theory-based models), but functional connectivity could be mapped using the behavior of the fishers themselves. One interesting suggestion of theirs was that corridor use by fishers was an adaptation to a fragmented landscape and that fishers used suboptimal habitat (e.g., cropland) to move among preferred areas and therefore these areas should not be discounted in models. This implies that for moving wildlife, corridors and linkages are not natural ecological occurrences, but rather can be responses to fragmentation. In addition, even if one area is used for movement during a given year, in following years, different areas may be used, resulting in different locations along a highway where traffic and wildlife may collide (Shilling and Waetjen

2015). Using wildlife movement to determine the locations of movement paths has been carried out for a wide range of taxa, suggesting that new approaches to connectivity modeling are already possible (Janin et al. 2009, Cushman et al. 2009).

Connectivity Modeling Examples

In California, as in many other states, there have been several regional and state scale GIS-modeling exercises to map potential corridors and linkages for wildlife movement. Regional scale analyses include: the South Coast Missing Linkages Project (Beier et al. 2006), Sierra Nevada Reserve and Connectivity Design project (Shilling et al. 2002, Shilling and Girvetz 2007), Central Coast Reserve and Connectivity Design (Thorne et al. 2002), and the Klamath-Siskiyou Region (Zielinski et al. 2006). So far, there has been one statewide connectivity analysis in California (Spencer et al. 2010). None of these analyses were validated using animal movement data. One of the authors of this report (Shilling) tested 1 statewide and 2 regional corridor/linkage and cost-surface/disturbance models for their prediction of wildlife movement, where WVC occurrences were used as evidence of wildlife movement. Evidence was provided in a paper (Shilling 2015) that state agencies should treat linkage model outputs as hypothetical until proven otherwise using wildlife-occupancy or movement observations. For each highway tested, the highway was split into 0.5-mile long segments and the number of WVC was calculated for segments that overlapped >50 percent with linkages and for an equal number segments of the same highway adjacent to and on either side of the linkage, Figure 24. The number of WVC per segment within the linkage was compared to the number per segment outside the linkage using a 2-tailed t-test. A Chi-square test was used to compare WVC frequencies of birds, reptiles, and/or mammals (large, medium and small) within and outside linkages.

In contrast to the findings for the 2 linkage models, the connectivity maps used as the basis for the linkages may be more useful in predicting relative rates of wildlife movement, or at least of WVC. The connectivity maps underlying the statewide model (Spencer et al. 2010) was based on a combination of habitat and disturbance mapping. There was a weak relationship between WVC/highway segment and corresponding habitat-disturbance values. This finding is consistent with the observation that many species perceive landscapes as gradations of connectivity, rather than a binary (+ or -) presence or absence of suitability and linkages/paths (Fischer et al. 2004, Fischer and Lindenmayer 2006). In addition, Stoddard (2010) demonstrated that population-simulations were dramatically affected by the description of landscapes as binary conditions (e.g., core + linkage habitat vs. non-habitat) vs. continuous surfaces of habitat-disturbance. This means that maps of combinations of habitat and sources of disturbance may be more useful for predicting

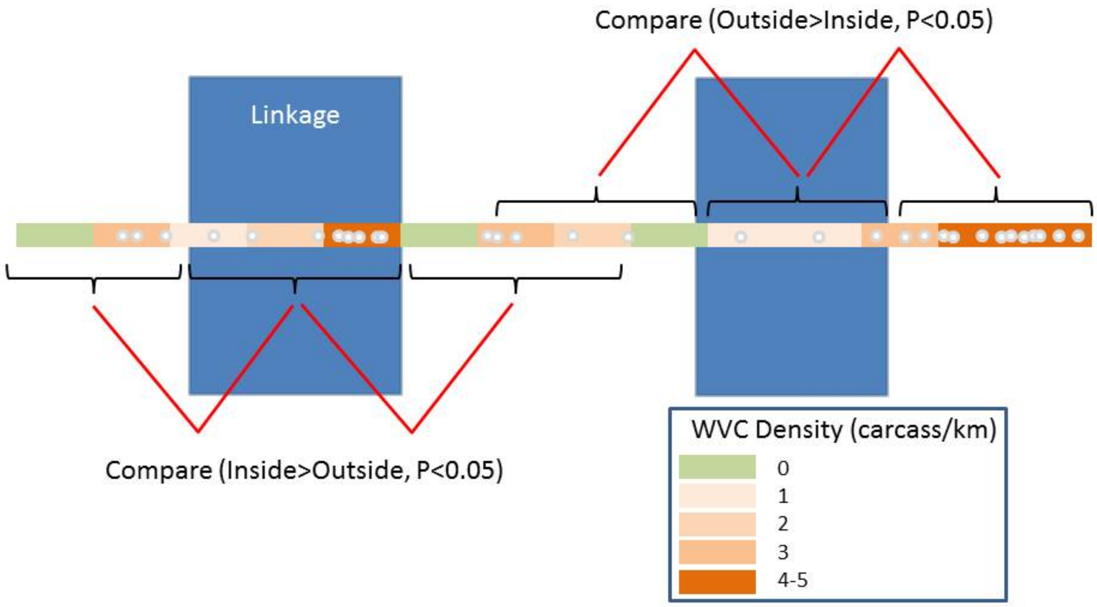

Figure 24. Using WVC occurrences to test predictive value of linkages for wildlife movement. The density of WVC (# carcasses/highway length) within hypothetical linkages is compared with the density outside.

Application of Connectivity Models

Data on wildlife that is project- and species-specific benefits planning for wildlife mitigation designs. Species-specific research is important because roads impact species and populations differently, and no single mitigation strategy works for all species or even among populations of a single species. Project-specific data specify wildlife habitats and activity relative to roads and, in conjunction with WVC data, contribute to predictive occurrence models on roads. These methods work well for species or species groups that show patterns in their occupancy of habitat, (Patrick et al. 2012, Gunson et al. 2012), such as South Dakota's bighorn sheep population. Predictive models may integrate both road-related, and landscape related explanatory factors that influence occurrence of WVC (Gunson and Teixeira 2015).

Once a rigorous model is developed and the factors related to WVC hotspots are fleshed out, the model may be extrapolated to other roads where WVC data do not exist. This is especially valid where data are minimal because a species is rare or data are not routinely collected for the species. Extrapolation of models should only be done on roads in ecoregions similar to where the model was developed. In addition, model extrapolation can only be conducted where the explanatory variables can be measured in both the region where the model was developed as well as where the model is being extrapolated to.

For this research project, the team explored the availability of project specific data for various target species, in addition to identifying improvements to WVC crash and carcass data that are needed in order to perform this type of species-specific occupancy modeling that is useful for informing regional mitigation planning. Ultimately, site-specific mitigation strategy development depends on site-specific assessments that consider the full suite of species at a defined hotspot.

Appendix B: Types of Wildlife Mitigation

Overview of Wildlife Mitigation Strategies to Reduce WVC (Adapted from Cramer et al. 2014).

Measure	Difficulty in Effort and Time to Deployment	Effectiveness	Use Across U.S	Cost
1. Actions that Target Wildlife				
1.a. Assess Infrastructure for Retrofits				
Use the Passage Assessment System for evaluating existing structures and fencing for changes that could benefit wildlife	Low	Medium	Medium	Low
1.b. Detract Roadside Value for Wildlife				
Supplemental feeding away from road to draw animals from road	Low	Unknown	Low	Low
Vegetation Management	Low	Low-Medium	Medium & Unknown	Low
1.c. Deter Wildlife from Roadway				
Wildlife deterrent devices mounted on roadside posts that produce noise & reflect light	Medium	Low	Low	Medium
Reflectors, Whistles	Low	Low	High	Low
1.d. Exclude Wildlife from Road and Provide Below- or Above-Grade Crossings				
Fencing	Low	Medium to High	High	Medium
Wildlife fencing with wildlife or double cattle guards & escape ramps	Medium	High	High	Medium to High
Wildlife crossing structures with wildlife fencing, escape ramps & guards	High	High	High	High

Measure	Difficulty in Effort and Time to Deployment	Effectiveness	Use Across U.S	Cost
1.e. Reduce Wildlife Populations				
Sharpshooting deer in suburban areas to reduce population	Low-Medium	Medium-High	Medium	Low
2. Actions that Target Drivers				
2.a. Public Education and Awareness				
Public awareness campaigns	Medium	Largely Unknown	High	Low
2.b. Signage				
Static driver warning signs	Low	Low	High	Low
Variable message boards	Low	Low-Medium	High	Low
2.c. Speed Reduction				
Wildlife crossing zones with reduced motorist speed limit	Low	Low-Medium	Low	Low
2.d. Driver Warning Systems				
Thermographic cameras to detect wildlife on or near road – used in vehicle or along road with driver warning system	High	Medium (Experimental)	Low	High, Future
Animal detection systems with driver warning signs	High	Low-Medium	Low	High
2.e. Road Treatments to Improve Driver Sight Lines				
Vegetation Management	Low	Low-Medium	Medium	Low
Roadway Lighting	High	Low-Medium	Low	Low

Actions That Target Wildlife

Assess for Retrofits - Using the Passage Assessment System (PAS)

Objective: Many existing culverts and bridges may allow wildlife to pass beneath roads with small modifications at a lower cost and on shorter time frames than needed for new wildlife crossings. The Passage Assessment System (PAS) is a tool for evaluating existing transportation infrastructure for its ability to facilitate wildlife movement from one side of a roadway to the other. The system allows users to assess a structure and fencing for species with varying abilities to move under the road at those sites.
Application: The PAS has been used at any location with an existing bridge or culvert to determine its potential to function as a wildlife crossing, and has been used in multiple locations across the United States.
More Information: The PAS was originally developed in a research project for the Washington Department of Transportation. The full report is available at:
http://www.wsdot.wa.gov/research/reports/fullreports/777.1.pdf
For an updated version of the PAS, contact Julia Kintsch at ECO-resolutions LLC, julia@eco-resolutions.com; or Patricia Cramer, cramerwildlife@gmail.com.

Detract Roadside Value for Wildlife

Objective: Draw wildlife away from roads and roadside habitat using a variety of techniques, such as:

- Provide supplemental feeding (intercept feeding) and salt-mineral sources at locations away from road.
- Use road de-icing agents that don't attract wildlife and/or reduce the use or sodium chloride roadway salt and magnesium chloride liquid deicer.
- Plant right-of-way with native vegetation that is unpalatable and of low nutritional value to wildlife.
- Remove roadkill carcasses promptly to avoid attracting eagles and other scavengers.

Application: Detraction techniques are suitable for implementation along all roadways and may become standard operating procedures for transportation departments; however it should be noted that these techniques at best can serve only to decrease the likelihood of wildlife activity along roadsides and cannot eliminate WVC. Detraction techniques may offer only short-term benefits or may need to be repeated, for example, planting the right-of-way with low nutritional species may be helpful in the short-term, but over the long-term, other species are likely to colonize the right-of-way on their own.

More Information: Little research has been conducted on the effectiveness of these detraction techniques in reducing WVCs; In general, it is recommended that any of these measures be combined with other countermeasures to increase the overall effectiveness towards reducing WVCs. A suggested 'deer-resistant' seed list is available at http://www.deercrash.org/Toolbox/CMToolboxVegetationManagement.pdf, although actual resistance depends on the availability of other more desirable browse.

Deter Wildlife from Entering Roadway

Objective: Deter wildlife near roads from entering the roadway. These techniques include:

- Mounting visual or acoustic repellants on poles along the right-of-way to deflect animal entry.
- Mounting whistles on vehicles.

Application: Visual or acoustic stimuli designed to elicit a flight response are generally considered ineffective (Mastro et al. 2008), although some studies have produced conflicting or uncertain results. Techniques that are not recommended include roadside reflectors, deer flagging, and acoustic deterrents – none of these methods have conclusively prevented deer from entering the road or produced a decrease in WVC.

More Information: Deer-Vehicle Crash Information Clearinghouse http://www.deercrash.org/Toolbox/CMToolboxDeerFlagging.pdf and http://www.deercrash.org/Toolbox/CMToolboxReflectorsMirrors.pdf

Exclude Wildlife from Road and Provide Below- or Above-Grade Crossings

Objective: Wildlife exclusion fencing prevents wildlife from entering the right-of-way and guides animals to wildlife crossing structures, such as bridges, culverts, or overpasses. Wildlife fencing with crossing structures have been shown to substantially decrease WVCs in multiple locations, particularly when multiple safe crossing opportunities are installed and connected with wildlife fencing over a longer road segment (Nichols et al. 2014).

Installing fencing, either typical wire fencing, 8 feet (1.4 meters) high, or boulder fencing which is a wide stretch of riprap boulders extending out parallel to the pavement that cannot be traversed by hooved animals; most often used at the end of a segment of wildlife exclusion fencing to prevent animals from entering the fenced right-of-way. The use of boulder fencing is limited and poorly studied, however, it does appear to offer an effective mechanism for preventing ungulates from entering the right-of-way at a specific location. Fencing is not recommended as a standalone measure or over an extended stretch of roadway, and may increase the barrier effect for many species, and present a potential safety hazard for drivers

Application: Wildlife crossing structures, in conjunction with wildlife exclusion fencing, double cattle guards (deer guards) and escape ramps have proven to be the most effective means of preventing WVCs and providing safe passages for wildlife. Wildlife crossing structures in conjunction with wildlife fencing have been installed in a number of locations across the United States and around the world. For maximum effectiveness and cost efficiency, wildlife crossing structures and associated fencing should be carefully designed for the target species or suite of species. Where a dedicated wildlife crossing is not feasible, a mixed wildlife-human use structure may be considered.

More Information:

The Wildlife Crossing Guilds (Kintsch et al. in review) provide guidance for determining structure type, size and other characteristics for different types of wildlife.

Planning for wildlife and resources to help design wildlife crossing structures can be found at www.wildlifeandroads.org.

For guidance on designing crossing structures and associated fencing, guards and escape ramps, refer to the Wildlife Crossing Structures Handbook (Clevenger and Huijser 2011).

Reduce Deer Populations

Objective: Reduce deer population sizes in areas near roads with high incidence of WVC to reduce the likelihood of deer-vehicle collisions.

Application: Local entities such as cities and towns engage sharpshooters to cull deer resident populations in suburban areas, or increase hunter tags in hunting units with high wildlife populations near roads. Hunting is recognized as an effective means or reducing a deer population; however, the subsequent impacts on WVC is uncertain, particularly in rural areas, although at least one study documented a decrease in deer-vehicle collisions following deer population culling, targeting reproductive-age females (Muller et al. 2014). The impacts of culling on population size are temporary and increased harvesting must be implemented annually for long-term impacts to population size. Targeted harvesting to control population size is best done in conjunction with public education and outreach, particularly where population management is being conducted near suburban areas.

More Information:

Deer-Vehicle Crash Information Clearinghouse
http://www.deercrash.org/Toolbox/CMToolboxHuntingHerdReduction.pdf

Actions That Affect Drivers

Public Education and Awareness Campaigns

Objective: Public education and awareness campaigns are used to alert the public and, in particular, the driving public, about the potential hazard of WVC and, in some cases the countermeasures being implemented to reduce the likelihood of WVC.
Application: Public education and awareness campaigns typically communicate the scope of the WVC problem and the impacts to wildlife and ecosystems; and may provide driver safety tips for avoiding WVCs. These types of public outreach efforts have been conducted across the country and may target a particular timeframe (rut or migration) or species, or may provide more general awareness.
More Information:
Colorado Wildlife on the Move annual press releases
https://www.codot.gov/programs/environmental/wildlife/wildlifeonthemove

Signage

Objective: Driver warnings and caution signs are used to alert drivers to the potential for wildlife on the road in areas with high WVC rates. Signage includes:
- Static signs
- Seasonal or temporary signs
- Variable message boards.

Application: Typical, non-location specific warning signs have been widely (over-)used across the county and are recognized as having no impact on driver speeds and their ability to respond to an animal in the roadway. Feature that add to a signs distinctiveness (e.g., flashing lights, animation, unique graphics) attract more attention from drivers and may perform better at reducing vehicle speeds and brake reaction times (e.g., Grace et al. 2015), however their effect on reducing WVCs remains inconclusive. Similarly, signage that is posted only seasonally when wildlife is most active or that indicate caution over a limited distance elicit a greater response from drivers and influence vehicle speed more than signs that are posted year-round. Variable message signs offer an opportunity to communicate wildlife warnings during specific timeframes, and have proven to reduce vehicle speeds with respect to high incidence of wildlife on the road (Hardy et al. 2006). In several cases, dynamic signage has been used to tally the number of WVCS in a specific road segment since the beginning of the year. Signage may be most effective when used in conjunction with other mitigation measures.

More Information:

- Deer-Vehicle Crash Information Clearinghouse http://www.deercrash.org/Toolbox/CMToolboxDeerCrossingSigns.pdf
- WVC and Crossing Mitigation Measures: A Toolbox for the Montana Department of Transportation (Huijser et al. 2007).

Speed Reduction Zones

Objective: Speed reduction zones are road segments with reduced speed limits (e.g., seasonal or night-time reductions) or with physical traffic calming measures (e.g., narrower lane widths or apparent lane widths via wider striping) to reduce vehicle speeds in areas with high WVC rates. Other traffic calming measures (e.g., speed bumps, bulb-outs, round-abouts) must be implemented on low volume, low speed roads, typically in more urban or suburban areas.

Figure 25. Seasonal wildlife crossing zone sign installed in Colorado that may be folded in half to be concealed. CDOT Photo.

Application: Research is inconclusive on the effectiveness of speed reduction zones in reducing WVCs. Although it is generally recognized that drivers are better able to avoid WVCs at slower vehicle speeds, speeds would have to be reduced to 45 mph or less to achieve a notable reduction in WVCs (Nichols et al. 2014). A test of seasonal and/or nighttime wildlife crossing zones in Colorado determined them to be ineffective at reducing WVCs, although no concurrent population studies were conducted (https://www.codot.gov/programs/environmental/wildlife/wildlifeonthemove/data-and-charts/wildlife-zones-hb-1238-final-101014.pdf). Roadway design may have a greater influence on vehicle operating speed than the posted speed limit.

More Information: WVC and Crossing Mitigation Measures: A Toolbox for the Montana Department of Transportation (Huijser et al. 2007).

Driver Warning Systems

Objective: Animal detection systems consist of sensors along either side of a road segment that detect wildlife movement when crossed and send a signal to flashing warning signs alerting drivers that an animal is currently present within the right-of way. These systems may use infrared light beams, radar beams, or electromagnetic fields to sense wildlife activity. In-vehicle sensors and warning systems are also becoming and and may ultimately provide a reliable, targeted driver warning system as their development continues; however, widespread deployment and use may take several generations.
Application: Animal detection systems, when operating reliably and trusted by the driver public can have a positive impact on reducing vehicle speeds when the signs are flashing; however, these systems may also be plagued by false positives resulting in flashing lights when no animals are present. An untested and unreliable system has little effect on drivers or WVC rates. Animal detection systems may be installed over a long road segment (e.g., 1+ miles, 1.6 km) or at a gap or fence end in a road segment with wildlife exclusion fencing (Dodd et al. 2010). It is recommended that animal detection systems be deployed in conjunction with public awareness campaigns to engage drivers and advise them on how the system works.
More Information: Various types of animal detection systems have been implemented in multiple western states (e.g., Washington, Montana, Idaho, Colorado, Wyoming, Arizona), as well as other locations around the world. Animal Vehicle Crash Mitigation Using Advanced Technology (Huijser et al. 2006).The Reliability and Effectiveness of an Electromagnetic Animal Detection and Driver Warning System (Huijser et al. 2012).

Road Treatments to Improve Driver Sight Lines

Objective: Road treatments include strategies such vegetation management in the right-of-way (e.g., increased mowing frequency) and roadway lighting to increase the visibility of animals on or approaching the roadway.
Application: The effectiveness of road treatments to improve sight-lines for drivers with a resulting decrease WVCs are difficult to quantify and inconclusive. Freshly cut vegetation may be more appealing to deer, resulting in the unintended consequence of attracting deer to the roadside, fall regrowth may be less palatable than spring regrowth, and cuttings can be timed accordingly. In addition, vegetation clearing may increase the barrier effect of the roadway for some species. Meisingset et al. (2014) recommend targeting vegetation clearing to short WVC hotspot segments in the late fall when vegetation regrowth has ceased. Targeted clearings may be most effective when used in conjunction with seasonal speed limit reductions through these hotspot segments. Roadway lighting should be downward pointing to minimize light pollution, and limited to specific locations (e.g., fence ends) to avoid broad impacts to wildlife movement patterns.

More Information: The SDDOT Pierre Area has experimented with double cutting (i.e., mowing a wider swath along the right-of-way) during the fall months to provide better sight lines for drivers, which coincided with lower WVC rates, although a direct correlation cannot be confirmed.

Appendix C. Agency Personnel Interviewed

Contact	Affiliation	Title/Role
Nathan Baker	SDGFP Region 2 (central)	Regional Manager
Mike Carlson	SDDOT Rapid City Area	Engineer
Kris Cudmore	SDGFP Region 1 (western)	Resource Biologist (administers SDGFP Region 1 carcass contract)
Julie DeJong	SDGFP Region 3 (southeast)	Regional Manager
Sarah Ellis	SDDOT Pierre Area	Administrative Assistant
Terry Erickson	SDDOT	Transportation inventory Management (GIS)
Jacquie Ermer	SDGFP Region 4 (northeast)	Regional Manager
Colleen Farley	SDDOT Winner Area	Administrative Assistant
Keith Fisk	SDGFP HQ	Statewide Wildlife Damage Program Administrator
Ruth Howell	SDDPT	Environmental Commitments Coordinator
Corey Huxoll	SDGFP	Game harvest Surveys coordinator
John Kanta	SDGFP Region 1 (western)	Regional Manager
Silka Kempema	Natural Heritage Program	Wildlife Biologist
Mark King	SDDOT Operations	Maintenance and Construction Management (Statewide administrator for WVC carcass pickup contracts)
Chelsea Krause	SDGFP	GIS Coordinator
Chad Lehman	SDGFP Black Hills/Custer SP	Wildlife Biologist
Andy Lindbloom	SDGFP	Senior Big Game Biologist
Chris Moeller	Carcass contractor	for SDGFP and SDDOT, Black Hills/Rapid City area
Leslie Murphy	SDGFP	Biologist
Matt (Rip) Rippentrop	SDDOT	Custer District Project Engineer
Kevin Robling	SDGFP	Big Game Biologist
Jenny Serbousek	SDDPS	Senior Statistician, Accident Records
Andy Vandel	SDDOT	Statewide Safety Engineer (analyzes WVC crash data for project scopes)
Dean Vandewiele	SDDOT Pierre Area	Engineer

Contact	Affiliation	Title/Role
Steve Wiege	SDDOT Rapid City Area	Administers Area carcass contract
Tribal Contacts		
Narcisse Russeau	Cheyenne River Sioux Tribe	Director, Game Fish, and Parks
Dakota Longbrake	Cheyenne River Sioux Tribe	Director of Transportation
Wayne Big Eagle	Crow Creek Sioux Tribe	Fish and Wildlife
Carol Robinson	Flandreau Santee Sioux Tribe	Economic Development
Ben Janis	Lower Brule Sioux Tribe	Director, Dept. of Fish, Wildlife and Recreation
Audrey Martinez	Oglala Sioux Tribe	Department of Public Safety
Harold Salway	Oglala Sioux Tribe	Director, Oglala Sioux Parks and Recreation (OSPRA)
Frank Vander Walker	Rosebud Sioux Tribe	Director, Game, Fish and Parks
LaJuanda Stands and Looks Back	Rosebud Sioux Tribe	MAP 21 Program
Charlene Miller,	Sisseton Wahpeton Oyate	Manager, Fish and Wildlife Program
Jeff Kelly	Standing Rock Sioux Tribe	Director, Game, Fish and Wildlife
Glen Bahm	Standing Rock Sioux Tribe	Public Transit
Greg Conoyer	Yankton Sioux Tribe	Game Warden, Fish and Wildlife Dept.
Lou Golus Jr.	Yankton Sioux Tribe	Safety Director

Appendix D: Example Forms to Report WVC Carcass Pickups in South Dakota

DEAD DEER PICK UP AND DISPOSAL

DATE	COUNTY	HIGHWAY	MRM	EASTING/ LATITUDE	NORTHING/ LONGITUDE	SPECIES WHITETAIL / MULEY	SEX BUCK / DOE
1-5-15	Brown	281	W.S. 189.7	45.23.632	98.30.947	W	D
1-5-15	Brown	281	W.S. 189.7	45.23.632	98.30.947	W	D
1-5-15	Brown	281	E.S. 192.4	45.25.992	98.30.918	W	D
1-5-15	Brown	12	ES. 293.9	45.27.536	98.24.990	W	B
1-5-15	Brown	12	SS 311.9	45.26.223	98.03.358	W	D
1-13-15	Brown	10	SS 270	45.43.296	98.42.555	W	B
1-13-15	Brown	10	SS 270	45.43.296	98.42.555	W	D
1-13-15	Brown	281	E.S. 224.8	45.52.405	98.31.059	W	D
1-13-15	Brown	281	W.S 216.7	45.45.251	98.31.068	W	D
1-13-15	Brown	281	W.S. 216.7	45.45.251	98.31.068	W	D
1-13-15	Brown	281	E.S. 214.9	45.43.843	98.31.056	W	D
1-13-15	Brown	281	W.S. 212.9	45.42.263	98.31.087	W	B
1-13-15	Brown	281	W.S. 191.3	45.25.063	98.30.948	W	D
1-13-15	Brown	281	W.S. 191.1	45.24.859	98.30.952	W	D
1-13-15	Brown	281	E.S 191.7	45.25.372	98.30.918	W	B

96 - Total Deer

(15)

Appendix E. Results of Surveys and Meetings with Tribal Representatives

Tribe	Department	WVC Data Collection Yes/No	Carcass Pick up	Areas of High Incidence/Hot Spots for WVC	Survey/GIS Info on wildlife habitat/ populations	Mitigation Recommendations
Cheyenne River Sioux Tribe	Game, Fish and Parks PO Box 590 Eagle Butte, SD 57625 605-964-7812	No response provided.	No response provided.	Rural Areas	Big Game Surveys	Post more signs on reservation.
Crow Creek Sioux Tribe	Fish and Wildlife PO Box 50 Ft. Thompson, SD 605-245-2221	No. They would be willing to do so in the future.	No response provided.		Tribe does some surveys.	Eliminate blind spots. Bigger culverts to allow wildlife to pass through.
Flandreau Santee Sioux Tribe	Economic Development PO Box 283 Flandreau, SD 57028 605-997-3891	No. They obtain information from the State.	Assume State picks up carcasses.		No response.	No recommendations.
Lower Brule Sioux Tribe	Department of Fish, Wildlife and Recreation PO Box 246 Lower Brule, SD 57548 605-473-5666	No	Tribe picks up carcasses.		Deer Surveys	No recommendations.
Oglala Sioux Tribe	Oglala Sioux Parks and Recreation (OSPRA) PO Box 570 Kyle, SD 57752 605-455-2530 Public Safety Records Department PO Box 300 Pine Ridge, SD 57770 605-867-5141 Ext. 8113	Yes	No carcass pickup unless it is a protected species (bald eagle).		Biology department does area surveys. (Robert Goodman 605-685-9389)	No recommendations.
Rosebud Sioux Tribe	Game, Fish and Parks PO Box 300 Rosebud, SD 57570 605-747-2289	Yes; police department collects information;	State picks up Carcasses.		Elk and Deer Surveys. Wildlife areas identified near Grass	Provide assistance in tracking data

Tribe	Department	WVC Data Collection Yes/No	Carcass Pick up	Areas of High Incidence/Hot Spots for WVC	Survey/GIS Info on wildlife habitat/ populations	Mitigation Recommendations
		Marlin Eno.			Mountain, Upper Cut Meat, and along Solider Creek	
Sisseton Wahpeton Oyate	Fish and Wildlife Program PO Box 509 Agency Village, SD 57262 605-698-3911	No longer collect data.	Tribe picks up carcasses (salvaged if fresh). Have good working relationship with State Conservation Officers.		Annual aerial surveys available upon request from Fish and Wildlife Program.	No recommendations.
Standing Rock Sioux Tribe	Game, Fish and Wildlife PO Box 549 Ft. Yates, ND 58538 701-854-7236	No.	No response.	More problems on North Dakota side of Reservation.	Big Game Surveys	No recommendations.
Yankton Sioux Tribe	Fish and Wildlife Dept. PO Box 1153 Wagner, SD 57380 605-384-3641	No. Safety Director hopes to do so in the future.	No.	Safety is new program within the Tribe.	Unknown	No recommendations.

Results of Tribal Member Input on WVC Hotspot Areas as Indicated During 2015 Tribal Transportation Safety Summit.

Cheyenne River Sioux Tribe				
Route	**Mileposts**	**Species**	**Location**	**Notes**
US 212	136	White-tailed; some mule deer in open areas	Dupree	Wildlife populations noted
US 212	138-139	White-tailed; some mule deer in open areas	Dupree	Wildlife populations noted
US 212	166	White-tailed; some mule deer in open areas	10 miles east of Eagle Butte (Lesmeister residence)	Wildlife populations noted (tree belts/houses)
US 212	171-172	White-tailed; some mule deer in open areas	5 miles east of intersection with BIA 19 (or 15 miles east of Eagle Butte)	Wildlife populations noted (sunflower/farmland)
SD Hwy 63	145-147	White-tailed; some mule deer in open areas	North of Cheyenne River (near intersection of 63 and BIA 12)	Wildlife populations noted
SD Hwy 63	201	White-tailed; some mule deer in open areas	4 miles south of Firesteel	Wildlife populations noted (tree belts)
SD Hwy 65	169-170	White-tailed; some mule deer in open areas	North of Dupree	Wildlife populations noted
SD Hwy 65	175-178	White-tailed; some mule deer in open areas	North of Moreau River crossing	Wildlife populations noted
BIA 2/BIA 4	Not available	White-tailed; some mule deer in open areas	Section from Green Grass to Promise	Heavy wildlife populations noted (highway runs parallel to Moreau River)
Thunder Butte Road	Not available	White-tailed; some mule deer in open areas	Area where road crosses Moreau River	Wildlife populations noted
Crow Creek Sioux Tribe				

Route	Mileposts	Species	Location	Notes
SD Hwy 34	Inside county line	White-tailed deer	No mapping information provided	2014 – 25 white-tailed; 1 mule deer; no specific map information provided
Flandreau Santee Sioux Tribe				
Route	**Mileposts**	**Species**	**Location**	**Notes**
SD Hwy 13	109	White-tailed deer	North of Flandreau Indian School	WVC noted on Hwy 13 North of Flandreau Indian School
SD Hwy 13	110 (bridge)	White-tailed deer	North of Flandreau Indian School	WVC noted on Hwy 13 at bridge near Pow Wow grounds (Big Sioux River area)
Lower Brule Sioux Tribe				
Route	**Mileposts**	**Species**	**Location**	**Notes**
SD Hwy 47	81-83; 85-87	White-tailed; some mule deer	South of Big Bend Dam	Hot spots noted
SD Hwy 1806	144-148	White-tailed; some mule deer	Near intersection with Cedar Creek Road (along Missouri River)	Hot spots noted
BIA 10	Not available	White-tailed; some mule deer	East of Olsonville	Hot spots noted
Little Bend Road	Not available	White-tailed; some mule deer	2 miles north of Lower Brule	Hot spots noted
Little Bend Road		White-tailed; some mule deer	3 miles south of Lower Brule	Hot spots noted
329th Avenue		White-tailed; some mule deer	1 mile south of intersection with Little Bend Road and 233rd Street	Hot spots noted
Oglala Sioux Tribe				
Route	**Mileposts**	**Species**		**Notes**
US 18	86	White-tailed deer	East of Oglala	Wildlife vehicle collision
US 18	92-93	White-tailed deer	Dearly Bridge, South of Oglala	Wildlife vehicle collision
US 18	113-116	White-tailed deer	Denby	Wildlife vehicle collision

US 18	161	White-tailed deer	Vetal	Wildlife vehicle collision
US 18	104 -128	White-tailed deer, mule deer, and other	Section from Pine Ridge to Batesland	Other wildlife noted: fox, coyote, pheasants, skunk, porcupine, raccoon, badger, turtles, owls wolf, mountain lion
SD Hwy 44	149 – 155	White-tailed and/or mule deer	Wanblee to intersection of Hwy 73	Populations noted
SD Hwy 73	Not available; 038 – 064	White-tailed and/or mule deer	from intersection of US 18 to northern boundary of Reservation near the White River	Populations noted
BIA 2	Not available	Bob cat	near Potato Creek	Population noted
BIA 4	Not available	White-tailed deer	S Curve 12 miles north of Allen	Wildlife vehicle collision
Intersection of BIA 27 and BIA 23	Not available	Mountain lion	Porcupine community	Mountain lion observed
BIA 28	Not available	White-tailed and /or mule deer	Wounded Knee to Manderson/White Horse Creek	Wildlife populations noted
BIA 33	Not Available	White-tailed and/or mule deer	Manderson to northern boundary of Reservation	Other wildlife populations along this stretch include turkey, mountain lion
BIA 41	Not available	White-tailed deer	2.5 miles and 4 miles N of Loneman School	Wildlife vehicle collision
BIA 41 and BIA 32	Not available	Elk	West of Pine Ridge	Elk located in this area
BIA 41	Not available	White-tailed and/or mule deer	Stretch between Oglala to Red Shirt	Noted for populations of white-tailed and mule deer. Mountain Lion observed near Oglala.

Route 107	Not available	White-tailed deer	Yellow Bear Road south of Kyle	Populations noted
Rosebud Sioux Tribe				
Route	**Mileposts**	**Species**	**Location**	**Notes**
US 18	177 – 187	White-tailed and/or mule deer	West of intersection of BIA 7 and US 18 (West of Parmelee)	Area known as Upper Cut Meat; lots of wildlife in the area.
US 18	194-200	White-tailed and/or mule deer	East of intersection of BIA 7 and US 18 (East of Parmelee)	Soldier Creek crosses Highway 18 at MM 197
US 18	208-209	Turtles	Near Mission	Turtle Crossing Road (Todd Creek)
US 18	216-225	White-tailed and/or mule deer	Between White Horse and Okreek	Lots of Trees/Drainages
SD Hwy 63 North of US 18	27 -28	White-tailed and/or mule deer	North of Parmelee	Dry creek bed crossing
BIA 1	Ranch Road Intersection	White-tailed and/or mule deer	Northeast of Rosebud	Dry creek bed crossing
BIA 5	Not available	White-tailed and/or mule deer	Spring Creek to Intersection of BIA 7. North of St. Francis	Grass Mountain area lots of wildlife in the area.
BIA 7	Not available	White-tailed and/or mule deer	Area north of Intersection with BIA 5. North of Two Strike and Rosebud	BIA 5 follows Little White River
BIA 30/Iron Shell Lane	Along Little White River	White-tailed and/or mule deer	West of Spring Creek	BIA
Sisseton Wahpeton Oyate				
Route	**Mileposts**	**Species**	**Location**	**Notes**
I-29 (US 81)	215-224	White-tailed and/or mule deer	South of Reever	Deer movement from coulees to croplands
Unknown Lake Road	Not available	White-tailed and/or mule deer	Road runs alongside Lake Traverse	Wild life populations located along Cottonwood Lake and Lake Bde-Sake,

				Lake south to Lake Traverse.
117th Street	Not available	White-tailed and/or mule deer	Near Sisseton	Wildlife population in this area (coulees and croplands; heavy tree area)
Standing Rock Sioux Tribe				
Route	**Mileposts**	**Species**	**Location**	**Notes**
US 12 and SD Hwy 73	113 – 120	White-tailed and/or mule deer	Section between Morristown and Watauga	Prairie Creek Area/Bridge
US 12 and SD Hwy 73	133-143	White-tailed and/or mule deer	Section east of McIntosh to intersection of 251st Avenue	Farmland area
SD Hwy 63	239-242	White-tailed and/or mule deer	South of Little Eagle	Valley and draws located in this area
SD Hwy 65	199-200	White-tailed and/or mule deer	North of intersection of Hwy 65 and Hwy 20 (southern border of Reservation)	Hunting Lodge in the area; drainages
113th Street	Not Available	White-tailed and/or mule deer	East of Bullhead to intersection of 260th Avenue	Farmland south of road
Yankton Sioux Tribe				
Route	**Mileposts**	**Species**	**Location**	**Notes**
SD Hwy 49	Not available	White-tailed deer	Section between US Highway 18 to intersection of 298th Street. West of Pickstown	
SD Hwy 50	Not available	White-tailed deer	Section between 379th Avenue and 381st Avenue. West of Lake Andes	Populations noted Tributary to Lake Andes runs parallel to highway

Appendix F. Example of Carcass Removal Contractor Contract

This part of a contract was created by Utah Department of Transportation and was found in the Section on Requirements for Reporting Carcasses Using Smart Phones.

Attachment B
Scope of Work
Animal Carcass Removal Services Region One
AllStar Advantage Services

6. Patrols shall be made on every Monday and Thursday unless changes are pre-approved by the Region/District Engineer.

7. The Contractor patrols shall be performed during daylight hours. The Contractor shall provide multiple vehicles and equipment as needed to ensure that all animals on all routes are picked up during the patrol times each week. If the vehicle reaches capacity then the Contractor shall be required to dispose of the load and return to the same site where he/she left off and resume the patrol. Extra payment for dumping and returning shall not be paid as extra mileage.

8. On interstate highways, or where the lanes are divided, patrols shall be made in alternating directions so both lanes of the interstate will be patrolled. Removal shall be performed in both directions of travel. On non-interstate highways, or where the lanes are adjacent, the patrol will be made for both directions in a single pass.

9. The Contractor shall provide all labor and equipment necessary to patrol the roadway, pickup and dispose of the remains

10. The contractor shall collect carcass location and data as required by the Utah Department of Natural Resources (DNR) using the Wildlife Vehicle Collision Reporting application provided by DNR using a "smart phone" or similar device. Invoices will not be paid until the "Wildlife Vehicle Collision Reporting" data is uploaded to the DNR database. Each entry shall contain, in addition to the required fields, the geographic location of the carcass before pick up, displayed in degree–minute-second (DMS) format, DDD.MM.SSS.ssss. The Wildlife Vehicle Collision Reporting application shall be installed and run on a "smart phone" or similar device that has the following characteristics:

Operating System	Minimum Version required
Android	2.1
iOS Safari	3.2
Chrome	10.0

The device make and model, service plan, data plan, internet service, or other necessary hardware, software, or third party service shall be obtained by the vendor without separate payment by UDOT.

The cost of obtaining, operating, and uploading required data to the DNR database shall be included in the unit price bid. Failure to comply with this requirement will result in termination of the contract and/or only partial payment of outstanding invoices.

Page 3 of 4

Appendix G. Rapid City Region WVC Priority Areas Mapped in Expert Opinion Workshop

WVC Workshop, Rapid City, June 1, 2015

Shaded rows were also hotspots for WVC as mapped from crash data and displayed in Figure 7.

Blue shading indicates 6 - 8 WVC per km, per 10 years:

Peach shading = 9 – 17 WVC per km, per 10 years:

Orange shading = 17 – 35 WVC per km, per 10 years

Deep Orange = Over 35 WVC per km, per 10 years

CUSTER AREA				
Route	**Mileposts**	**Species**	**Location**	**Notes**
US 16	0-11	Elk	WY state line - Custer	Heavy truck traffic; Elk migrate north/south through segment. Wheat fields along MP 4-5.
US 16	9	White-tailed deer	WY state line - Custer	White-tailed deer are reluctant to go into Hell Canyon, cross to east
US 16	12-15	Bighorn sheep	WY state line - Custer	
US 16	15-18	Elk, white-tailed deer	WY state line - Custer	Heavy truck traffic; Elk migrate north/south through segment WVC crash data: 6.7 deer per 10 years, per km
US 16	25-26	White-tailed deer	Custer	WVC crash data: 6.7 deer per km, 10 years
US 16	37-40	White-tailed deer	South of Hill City	WVC crash data: 7 deer per km, per 10 years
US 16	42-45	White-tailed deer	North of Hill City	WVC crash data: MP 45, 22.6 WVC per km, per 10 years
US 16	45-46	Bighorn sheep	North of Hill City	WVC crash data: MP 45, 22.6 WVC per km, per 10 years + WVC crash data: MP 45 – 49, 6.5 WVC per km, per 10 years = 29.1 WVC per km per 10 years
US 18	15-20	Elk	Edgemont - Hot Springs	
US 18	22-31	Elk & mule deer	Edgemont - Hot Springs	High hits for both species

CUSTER AREA				
Route	**Mileposts**	**Species**	**Location**	**Notes**
US 18	33	Elk & mule deer	West of Hot Springs	
US 18	38 - 39	WVC Crash data		WVC crash data: MP 38 -39, 7 WVC per km, per 10 years
US 18	45-47	White-tailed deer	East of Hot Springs	Cheyenne river
US 385	6-8	White-tailed deer	NE state line - Oelrichs	River crossing
US 385	43	Bison	Hot Springs - Pringle	Wildlife exclusion fencing through segment (length?). Recommendation to move bison guard from MP 38 to 40; improve sight distances. WVC crash data, MP 43, 7.5 WVC per km, per year
US 385	49	Bison	Hot Springs - Pringle	West of Wind Cave N.P.
US 385	56-59	White-tailed deer	North of Pringle	Hay fields along west side of highway
US 385	64-66	White-tailed deer	South of Custer	WVC crash data, MP 45 – 66.8, 8 WVC per km, per 10 years
US 385	88-90	White-tailed deer	North of Hill City	
US 385	91-93	Bighorn sheep	Hill City - Merritt	
US 385	94-96	Elk, deer	Pactola Reservoir	Scenic area with lots of crashes
US 385	100-105	White-tailed deer	Lawrence-Pennington county line	
SH 36	24	White-tailed deer	1.5 miles east of Cuter High School	
SH 79	40-44	Bison	North of Buffalo Gap	Bison warning signs WVC Crash data, MP 44 – not sure, 18 WVC per km, per 10 years
SH 79	41	Elk	North of Buffalo Gap	
SH 79	59-60	White-tailed deer	Hermosa	Battle Creek crossing WVC crash data: MP 60, 14 WVC per km, per

CUSTER AREA				
Route	**Mileposts**	**Species**	**Location**	**Notes**
				10 years
SH 89	35	Mule Deer	South of Pringle	
SH 89	35-38	Livestock	South of Pringle	
SH 89	38	Elk	South of Pringle	
SH 89	41-43	Elk	South of Pringle	Zeimet Ranch
C308	Hill City to Deerfield Lake	Elk, white-tailed deer	West of Hill City	Deerfield Road (county) – recreational access

RAPID CITY AREA				
Route	**Mileposts**	**Species**	**Location**	**Notes**
I-90	2-6	White-tailed deer	West of Spearfish	Seasonal movements WVC crash data: Eastbound MP 0 -10 (11 WVC) + Westbound MP 0 -10 (10.5 WVC) = 21.5 WVC per km per 10 years
I-90	8-14	White-tailed deer	Spearfish	WVC crash data: **WORST SPOT IN SOUTH DAKOTA** MP 9.9 – 11.1 = 127.5 WVC per THIS SECITON, per 10 years,
I-90	17	Elk	East of Spearfish	WVC crash data: MP 17.8 - 18.5 Eastbound (8 WVC) + Westbound (7 WVC) = 15 WVC per km per 10 years
I-90	20-25	White-tailed deer, mule deer	Whitewood	Hotspot around bridge (~MM20) WVC crash data: MP 23-24 Eastbound (18.6 WVC) + MP 23-24 Westbound (17 WVC) = 35.6 WVC per km per 10 years
I-90	28-30	Mountain lion	North of Sturgis	Regular lion crossings

RAPID CITY AREA				
Route	Mileposts	Species	Location	Notes
				WVC crash data: MP 24 – 30 Eastbound (11 WVC) + Westbound MP 24 – 30 (11.5 WVC) + MP 30 (8.8 WVC) = 31.3
I-90	34-36	Mountain lion	South of Sturgis	
I-90	37-40	Elk, white-tailed deer	Sturgis – Rapid City	Seasonal elk movements
I-90	44-46	White-tailed deer	North of Rapid City	
I-90	95-110	Mule deer, white-tailed deer, elk	Wasta – Wall	Segment includes Cheyenne River crossing
US 14-ALT	43-46	White-tailed deer, mountain lion	Sturgis - Deadwood	Pillar Peak
US 14-ALT	47-49	White-tailed deer	Sturgis – Deadwood	Golf course to south
US 14-ALT	~51.5	Mountain lion	Sturgis – Deadwood	Mountain lion hit
US 16	57-59	White-tailed deer, some mule deer	South of Rapid City	
US 85	6-8	Elk	Wyoming state line	Church camp
US 85	~30	Bighorn sheep	North of Deadwood	Stagecoach crossing – retrofit opportunity? WVC crash data: MP 20 – 34, 12 WVC per km per 10 years
US 85	34-35	White-tailed deer	Deadwood – I-90	WVC crash data: MP 20 – 34, 12 WVC per km, per year
US 385	122-119	Bighorn sheep	Junction US 85/Strawberry Hill	26 animals released 2/2015 on adjacent BLM lands to northeast
US 385	120	Mule deer	Strawberry Hill	
SH 44	31-33	White-tailed deer	Johnson Siding	Residential area, residents feeding wildlife WVC crash data: MP 30 – 39, 7 WVC per km, per 10 years
SH 44	40	Bighorn sheep	West of Rapid City	Warning signs present WVC crash data: MP 39-41.5, 8 WVC per km,

RAPID CITY AREA				
Route	**Mileposts**	**Species**	**Location**	**Notes**
				per year
SH 44	50-54	White-tailed deer	East of Rapid City	WVC crash data: MP 50 (8.7 WVC) + MP 50 - 54.5 (8.8 WVC) = 17.5
SH 44	63-66	White-tailed deer	East of Rapid City	
SH 79	67-69	White-tailed deer	Hermosa - Rapid City	Spring Creek crossing WVC crash data: MP 67 – 6, 9 WVC per km, per 10 years
SH 79/ Bus. I-90	I-90 Junction to Rapid City limit	White-tailed deer	Northwest side of Rapid City	WVC crash data: at intersection at Maverick Junction: MP 44 +, 18 WVC per km, per 10 years
Sheridan Lake Rd	Rapid City limit to USFS boundary	White-tailed deer, some mule deer	Southwest of Rapid City	County road
Nemo Road	~ Red Deer Road	White-tailed deer, turkey	West of Rapid City	County road

BELLE FOURCHE AREA				
Route	**Mileposts**	**Species**	**Location**	**Notes**
US 85	45-47	White-tailed deer	North of Spearfish	WVC crash data: MP45 – 53, 7 WVC per km, per 10 years
US 85	50-52.5	Elk, white-tailed deer	Belle Fourche – Spearfish	Redwater River crossing WVC crash data: MP 45 – 53, 8.7 WVC per km, per year
US 85	64-79	Mule deer, white-tailed deer	North of Belle Fourche	
US 85	90-92	Mule deer	Junction SH 168	Moreau River crossing; heavy oil industry traffic

BELLE FOURCHE AREA				
Route	**Mileposts**	**Species**	**Location**	**Notes**
US 85	~110-130	Mule deer, some pronghorn	Buffalo	Heavy oil traffic corridor; pronghorn movement mostly north-south along west side of highway.
US 212	15-20	White-tailed deer	East of Belle Fourche	Seasonal movements WVC crash data: MP 14 – 21, 9 WVC per km, per 10 years
US 212	27-28	White-tailed deer	Nisland	
US 212	30-34	White-tailed deer	Nisland	
US 212	36	WVC Crash Data		WVC Crash Data: MP 36, 19 WVC per 10 years
SH 34	4-5	Elk, white-tailed deer	West of Belle Fourche	
SH 34	11-13	White-tailed deer	Jolly	WVC Crash data: MP 10 – 15, 40.6 WVC per km per 10 years
SH 34	19-20	White-tailed deer	St. Onge	
SH 34	25-2 8	White-tailed deer	North of Whitewood	
SH 79	44 – not sure			WVC Crash data: MP 44 - ? 18 WVC per km, per year, will verify
SH 79	112	White-tailed deer	Bear Butte Creek	Creek crossing
SH 79	116	White-tailed deer	Bear Butte State Park	Spring Creek crossing
SH 79	120	White-tailed deer	Bear Butte – Vale	
SH 79	127-128	White-tailed deer	North of Vale	Belle Fourche River crossing
SH 79	130-133	Mule deer, white-tailed deer	South of Newell	Horse Creek crossing through this segment
SH 79	185-189	White-tailed deer, some mule deer	South of Reva	

PIERRE AREA (Haakon and Jackson Counties)				
Route	**Mileposts**	**Species**	**Location**	**Notes**
US 14	115-146	White-tailed deer, some mule deer	Quinn – Philip Airport	

Appendix H: Benefit-Cost Analysis of WVC Hotspot Areas in the Rapid City Region

Cost-benefit is the framework for analyzing a range of benefits and costs in monetary terms (Federal Highway Administration 2014). Below is guidance for performing benefit-cost analysis to assess the cost of WVC in a given area relative to the costs and benefits of mitigating the WVC problem in that area. Benefit-cost analysis involves the following steps, using data available from SDDOT and SDGF:

1. Estimate costs of WVC from WVC crash data.
2. Estimate cost of WVC on wildlife populations estimated from WVC carcass data.
3. Estimate the percentage decrease in WVC crashes the mitigation is expected to provide.
4. Estimate life span of the mitigation.
5. Estimate cost of the mitigation plus its maintenance over time.
6. Input values into a Benefit-Cost equation to find the value of the project.
7. Determine how long would it take for project to pay for itself.

These values are created when the mitigation is to be placed on an existing road with data on WVC, and the mitigation option has a known cost. When the mitigation is on a new road, or the user wants to only evaluate how expensive a mitigation could be in order to pay for itself, the steps are slightly different and further described in the next section.

The Benefit – Cost equation is presented below. The reader may be familiar with the term Cost-Benefit which is used more often than Benefit-Cost. Cost-Benefit is described by the Federal Highway Administration as the framework for considering a range of benefits and costs. The correct term for the analysis itself is Benefit-Cost, which comes in the order of the equation, and is used by the U.S. Federal Highway Administration (Federal Highway Administration 2014).

$$\text{Benefit/Cost Ratio} = \frac{\text{Annual Benefits x Numb. Years the Mitigation is Expected to Last}}{\text{Estimated Project Cost}}$$

1. Estimate Cost of WVC From Reported Crashes

The user gathers data on the reported WVC crashes in area of concern. This includes the severity of each crash and the numbers of reported crashes for each severity type. Users will query WVC crash database for the exact road and nearby mileposts (to be decided how far, but on average 5 miles, 8 km), to see how many WVC crashes have been reported in past 5 years. For a new road such as the Sioux Falls SR 100, the reader will need to query the WVC crash database for records on nearby roads, in the same way as above for the exact road.

The user can use the WVC crash database from SDDPS and query the columns for the road number and MRM where the potential mitigation is to be placed. The locations of reported WVC crashes on the map created in this study are a secondary manner to to estimate the number of collisions in a stretch, but this method could prove to be time consumptive. Alternatively, the locations of the reported crashes can be mapped and the number of crashes in the area of concern can be analyzed visually.

Estimate Costs of WVC Reported Crashes for Each Road Segment.
The Federal Highway Administration costs for each crash type were provided by Andy Vandel, SDDOT Traffic Safety Engineer (Table 8, below). The cost of a fatal crash was obtained from a Federal Highway Administration memorandum, URL: http://www.dot.gov/sites/dot.dev/files/docs/VSL%20Guidance%202013.pdf. SDDOT takes an average value for all fatal, and serious, visible, and possible injury crashes, see below.

Table 8. Crash and Injury Type and 2015 Average Cost Estimates Based On U.S Department of Transportation (2013).

Injury Type	US DOT 2013 Cost Estimates (US Dollars)	SDDOT Average Estimates Used for Dollar Values in 2015
Fatal	$ 9,395,247	$ 370,800*
Serious	$ 506,217	$ 370,800*
Visible	$ 185,144	$ 370,800*
Possible	$ 105,228	$ 370,800*
Property Damage Only (PDO)	$ 17,343	$ 17,343

* SDDOT average estimates used in 2015 to place monetary values on these crash types.

The user can use the values in Table 8 for each crash type, and multiply the number of WVC crashes of each crash type estimate the costs of the reported WVC crashes for each road segment, for total of five years. Obtain an annual average for each crash type by dividing by the number of years used.

2. Estimate Cost of WVC on Wildlife Populations Estimated from Carcass Data

There are South Dakota estimates for the values of individual wild animals in the case of the state prosecuting poachers. These values can be used to estimate the value of the wildlife lost to WVC. There are two methods for estimating the number of wild animals killed in WVC; one method is to take the number from carcasses collected in a stretch of road under scrutiny, and the second, if these data are lacking, to estimate the number of animals killed from the WVC crash data. We are only giving a value to the animal lost to the public of South Dakota. Values of different wildlife species for South Dakota were taken from: The South Dakota Department Game and Fish Statute 41-1-5.1; Source: SL 1969, ch 104; SL 1985, ch 321, § 2; SL 1998, ch 254, § 1; SL 1999, ch 209, § 2; SL 2001, ch 227, § 1; SL 2010, ch 206, § 3. These statutes give the following values for different wildlife species individuals in cases of penalties for poaching (Table 9).

Table 9. Value of Individual Animals of Different Wildlife Species, Taken from South Dakota Legislature (2015).

Species	Typical Animal Value	Trophy Animal Value
Mule Deer	$ 1,000	$ 2,000 - $ 5,000
White-Tailed Deer	$ 1,000	$ 2,000 - $ 5,000
Elk	$ 5,000	$ 6,000 - $10,000
Pronghorn Antelope	$ 1,000	$ 2,000 - $ 5,000
Bighorn Sheep	$10,000	Not given
Mountain Goat	$10,000	Not given
Bison	$ 5,000	Not given
Mountain Lion	$ 5,000	Not applicable
Bobcat	$ 1,000	Not applicable

Data on WVC carcasses in South Dakota are not presented in the official SDGFP carcass database with Mile Post and road number. This then makes it impossible to obtain carcass data from this database unless a qualified person can merge the carcass database with the SDDOT mile post GIS layer and extract roads and mile posts for each entry, then create value of carcasses per mile for the data. At this time, in the fall of 2015, this step is not possible to conduct because the database is populated by carcass collector entries that lack accuracy.

There is one alternative to this lack of accurate carcass data. Olson (2013) found there were 5.26 times more carcasses of mule deer along Utah roads than reported in WVC crash records. Since Utah is an arid western state somewhat typical of South Dakota, the user can take this value and multiply it to the WVC crash values to a stretch of road to get an estimate of the number of carcasses that may occur.

When the carcass database and GIS merges are accurate, the user can tally the number of each species' carcasses per year for the five-mile section of interest.

The user can assume five percent of the ungulates killed were trophy animals, because often wildlife agencies set a goal for males to compose 15 percent of the population and Olson et al. (2014b) found mule deer bucks to be more highly represented in the carcass data than in the estimates of the population. For example, for every 10 white-tailed deer killed, 9.5 of the individual carcasses will be valued at $1,000, and 0.5 of the animals valued at $2,000 to $5,000. Calculate both a low value and high value for the trophy animals:
10 white-tailed deer carcasses equate to a value range of:
9.5 deer worth $1,000 each = $9,500
0.5 deer worth $2,000 each = $1,000
0.5 deer worth $5,000 each = $2,500.
The total value of 10 white-tailed deer = $10,500 - $12,000.

Combine the values of the different species of carcasses for the stretch of road under scrutiny if there are other wildlife species' carcasses other than deer. Since in this example for 2015 the animal type involved is not known from crash data, it has to be assumed that the animals were all deer in general.

Add the cost of the reported WVC crashes and the cost of the reported or estimated carcasses for the years of time under scrutiny and the stretch of road under consideration, and divide by the years of data to get an annual average cost of WVC in that stretch. This is the annual value of wildlife lost to WVC in South Dakota for that stretch of road. This is the benefit to be brought into the numerator.

3. Estimate the Percentage Decrease in WVC Crashes

There are typically three different levels of expected reductions in WVC from mitigation:

1. 50 percent as used by Oregon DOT (ODOT) in the Lave Butte Project near Bend, Oregon as derived from their benefit-cost analysis.
2. 75 percent which is the typical portion estimated for most WVC mitigation.
3. Or as much as 90 percent, which was the actual amount of WVC reduced in a project in Utah. Huijser et al. (2009) analyzed 10 wildlife mitigation studies and their reductions in WVC and found an average of an 86 percent reduction in either WVC crashes or carcasses.

The analysis can be performed with three different equations, each one with a different level of reduction of WVC crashes (.50, .75, and .90 reductions), or if wildlife crossing structures and fencing are to be placed, the 90 percent reduction is appropriate. These different equations can then be instrumental in helping to decide how much WVC reduction is needed for the treatment to be considered effective.

4. Estimate the Lifespan of the Mitigation

Structures such as bridges and culverts are built to last at least 50 years. Fencing may have a shorter lifespan if the quality is not among the best. Fifty years is an acceptable lifespan.

5. Estimate Cost of the Mitigation

The cost of mitigation should include how much extra the wildlife mitigation is adding to an existing project, or cost of a standalone project. For example, if a culvert is enlarged to accommodate wildlife, the difference in cost from a culvert that would have been installed for other needs is subtracted from the cost of a larger culvert that is built to accommodate wildlife. Costs of fencing, escape ramps, and wildlife guards or double cattle guards also need to be brought into the cost estimates. In addition, cost for maintenance of the structure or fencing needs to be incorporated into the final cost over the lifetime of the structure.

6. Input Values into Benefit-Cost Equation to Find the Value of the Project

Multiply the percent reduction in WVC to the average annual cost of WVC in the stretch of road. This value is the average annual cost saved from the mitigation if it reduces the WVC by that percentage chosen.

Multiply this annual savings by the expected life span of the treatment. The final monetary value over these years becomes the benefit portion of the benefit-cost equation.

7. Determine How Long Would It Take for Project to Pay for Itself

To evaluate if a mitigation structure will be cost-effective, the benefits over time are divided by the costs. The resulting quotient is then reflective of the predicted cost-effectiveness. If the value is 1 or greater, the project is predicted to pay for itself.

The project can also be analyzed by the expected amount of time it would take to pay for itself. The value of reduced WVC averaged each year is divided into the expected cost to see how many years of savings would add up to the total cost.

Examples of Benefit-Cost Analyses

Two different areas were selected to conduct an analysis of potential retrofits and new construction for wildlife mitigation to help reduce WVC at these sites. For each site a benefit-cost analysis was performed for each action to evaluate if the proposed mitigation would pay for itself over 50 years.

The two areas of interest were selected in collaboration with SDGFP biologists, and SDDOT engineers.

1. US 18 Edgemont Hills Bridge Mile Post 19 Fencing Retrofit
2. US 16 Hells Canyon - Jewel Cave – Overpass

Work Sheet

	# IN PAST 10 YEARS	Average per year	Average Cost in $	Average No. x Average cost
Number of Property Damage Only	0	0	$17,343	
Number of Possible Injury	0	0	$ 370,800	
Number of Visible	0	0	$ 370,800	
Number of Serious	0	0	$ 370,800	
Number of Fatal	0	0	$ 370,800	
Sum = Total average annual cost				

US 18 Edgemont Hill Bridge MP 20

Along US 18 the Edgemont Bridge may be a place where SDDOT could funnel elk to move beneath the highway with the addition of wildlife exclusion fencing. This bridge is in an area where elk cross the highway frequently. This bridge is high (greater than 20 feet, 6 meters high) over a ravine. The PI on this project took two field trips to the site with SDDOT Custer Area Project Engineer, Matt (Rip) Rippentrop to evaluate if elk could use the existing bridges at MP 20 ad 18. The field analysis and later camera data from wildlife cameras placed on the MP 20 bridge verified elk could use and one was verified using the area beneath the MP 20 bridge. See Figures 26 and 27 below for locations.

There were no elk carcasses from the local carcass collector's data, but the route the individual drives is north of this area, therefor no carcass data have been recorded even if there were carcasses. Therefore, crash data are the only means to help establish the cost of the past five years of WVC.

The field analysis of the site resulted in Dr. Cramer and Mr. Rippentrop estimating that a four-mile (6.4 kilometers) fencing project on both sides of the highway could help direct mule deer, elk, and other wildlife to two existing bridges at MP 18 and MP 20, and would end north of these site on a steep embankment fill where animals would have to come up to the highway and jump a cable barrier, which is less likely than a flatter area.

Crash data revealed that between MP 18-22 there were 18 reported WVC crashes in 10 years (we used 10 years of data because it was available. Five years of data are the minimum). The annual average WVC was then 1.8 WVC.

Figure 26. Location of US 18 Edgemont Hill Bridge in Southwest South Dakota.

Figure 27. Location of Edgemont Hill Road Bridge from Aerial angle, near Edgemont, SD.

1. Estimate cost of WVC from WVC crash data

	No. in Past 10 Years	Average per Year	Average Cost in $	Average No. x Average cost = Annual Cost
Number of Property Damage Only	18	1.8	$17,343	$31,217
Number of Possible Injury	0	0	$ 370,800	
Number of Visible	0	0	$ 370,800	
Number of Serious	0	0	$ 370,800	
Number of Fatal	0	0	$ 370,800	
Sum = Total average annual cost				$31,217

1. Estimated average annual cost of WVC crashes = $31,217

2. Estimate cost of WVC to wildlife populations from WVC carcass data

No carcass data was available at time of analysis. The 1.8 WVC per year x 5.26 deer potentially killed equals 9.47 deer annually killed. If 95 percent were typical deer, and 0.5 percent were trophy deer, then the equation becomes: (.95 x 9.47 x $1,000) + (.05 x 9.47 x $2,000, and then x $5,000) = $8,996 + $947 = $9,943. Highest value at $5,000 for trophy bucks killed = $8,996 +$2,367 = $11,363. The range of values for deer lost annually = $9,943 - $11,363.

3. Estimate the percentage decrease in WVC the mitigation is expected to provide

Low-estimate cost savings: 90 percent decrease in WVC would equal: 1.8 x .9 = 1.6 crashes prevented. This would equal an annual savings of 1.6 x $17,343 = $27,749 for prevented crashes alone.

Mid-estimate and high estimate cost savings: 90 percent decrease in values of animals lost = $8,948 to $10,226. These are the values of animals saved from being killed on road.

Total cost savings with crash savings and wildlife savings estimates range from ($27,749 + $8,948) = $36,697 to ($27,749 + $10,226) = $37,975 annually.

4. Estimate life span of the mitigation

If we select fencing to place to existing bridge, if it is highly valuable fence, could last 50 years.

5. Estimate cost savings over life of mitigation:

Lowest estimate with only crashes valued: 50 years x $27,749 = $1,387,450 saved in 2015 dollars. Over $1.3 million saved in the lifespan of 50 years.

Mid-estimate with crashes plus lower value of trophy buck deer= 50 x $36,697 = $1,834,850.

High-estimate with crashes plus upper value of trophy buck deer = 50 x $37,975 = $1,898,750. Estimates of cost savings over 50 years range from 1.3 million to 1.9 million.

6. Estimate cost of the mitigation and maintenance:
If it is estimated that it costs $100,000 per mile for fencing and escape ramps, then x 4 miles (6.4 km) = $400,000 for project. This value can be lower if the terrain is more flat and open without trees, or more expensive if terrain is very rocky, rolling, and with vegetation.
This is a gross generalization of the cost.

Maintaining the fence each year is also considered a cost. It is not known what the maintenance costs would be annually, but this analysis will add a maintenance cost placeholder of $2,000 a year. In 50 years this equates to $100,000.

Total cost for fencing and yearly maintenance for 50 years = $500,000.

7. Set up Benefit-Cost equation to find the value of the project in terms of benefit cost ratio.
Low-estimate cost savings: Benefit = $1,387,450 / Cost = $500,000 = Benefit cost ratio = 2.77
Mid-estimate cost savings: Benefit = $ 1,834,850 / cost = $500,000 = Benefit cost ratio = 3.67
High-estimate cost savings: Benefit = $ 1,898,750 / cost = $500,000 = Benefit cost ratio = 3.80
The benefit-cost ratio ranges from 2.77 to 3.80. The project would pay for itself over its lifetime.

How long would it take for project to pay for itself?
Low-estimate for cost savings: $500,000 total cost $27,749 saved per year = 18 years the mitigation could be expected to pay for itself.
Mid-estimate cost savings: $500,000/$36,697 saved per year = 13.2 years
High-estimate cost savings: $500,000/$37,975 saved per year = 13.1 years.

Bottom line: The project is predicted to pay for itself in 13 to 18 years in costs saved from prevented crashes and lost wildlife.

US 16 Hells Canyon - Jewel Cave Overpass MP 11

US 16 from it's start in the west from the Wyoming border, to MP 12 in the east near Jewel Cave National Monument has been chosen among attendees of the June 1 SDDOT and SDGFP meeting as a hotspot area with problems of elk on the road and involved in WVC. The terrain is hilly and the north side of the road in the segment near MP 11 is above the highway, see figures below. This may make the placement of a wildlife overpass more cost-effective than a wildlife crossing bridge. A culvert would not be an option for the elk in the area, since elk are documented in many western states as being hesitant to use culverts.

Figure 28. US 16 Jewel Cave Hells Canyon Road Stretch for Potential Mitigation.

Figure 29. US 16 From Approximately MP 9 to the West, to MP 13 in East. Hells Canyon is on The Right, Under US 16 at Loop to the North.

1. Estimate cost of WVC from WVC crash data

WORK SHEET

	# IN PAST 10 YEARS	Average per year	Average Cost in $	Average No. x Average cost
Number of Property Damage Only	40	4	$17,343	$69,372
Number of Possible Injury	0	0	$ 370,800	0
Number of Visible	0	0	$ 370,800	0
Number of Serious	0	0	$ 370,800	0
Number of Fatal	0	0	$ 370,800	0
Sum = Total average annual cost				$69,372

1. Estimated average annual cost of WVC crashes = $69,372

2. Estimate cost of WVC from WVC carcass data

No carcass data were available for this region, so the crash data were used to base an estimate of the number of animals killed on the road. Even though elk are the primary driver for mitigation ideas, the monetary values of deer will be used to keep the benefit-cost analysis consistent.

Each year there is an average of four reported WVC crashes. This value is multiplied by 5.26 for an estimate of the number of wild animals killed and not reported. There are an estimated 21 animals killed on this road each year. If 95 percent of these animals are considered to be typical deer, valued at $1,000 each, then their annual value equals $9,950. If the trophy bucks represented five percent of the total animals killed, and their value was estimated at $2,000, then their total value of lost animals yearly equals $2,100. If the bucks killed were valued at $5,000, the monetary value of bucks lost would be $5,250 annually.
Summing these totals, we arrive at two values:
Annual Value of animals lost, low estimate = 19,950 + $2,100 = $22,050
Annual Value of animals lost, high estimate – 19,950 + 5,250 = $25,200.

3. Estimate the percentage decrease in WVC the mitigation is expected to provide
The area has elk, which are difficult to encourage to use structures, so estimate the reduction in WVC will be 75 percent. This would be a high expectation for elk, but on the lower end of expectations for wildlife mitigation in general. This expectation may be re-visited in time. Calculate the value of WVC saved from this mitigation.
Crash only value of reduced WVC = $69,372 x .75 = $52,029 in reduced costs each year.

Mid-estimate = value of reduced WVC plus lover value of wildlife lost = ($69,372 + $22,050) x .75 = $68,566
High-estimate = value of reduced WVC plus higher value of wildlife lost = ($69,372 + $25,200) x .75 = $70,929.

A 75 percent reduction in WVC is expected to save from $52,029 to $68,566 annually.

4. Estimate life span of the mitigation
50 years for fence and overpass

5. Estimate cost savings over life of mitigation:
Low-estimate of savings, WVC crashes prevented only: 50 years x $52,029 = $2,601,450 ~ $2.6 million
Mid-estimate of savings, with low estimate of wildlife savings: 50 years x $ 68,566 = $3,428,300 ~ $ 3.4 million
High-estimate of savings, with high estimate of wildlife savings: 50 years x $70,929 = $3,546,450 ~$ 3.5 million

6. Estimate cost of the mitigation
Fencing
If 10 miles (16 km) of fencing at $100,000 per mile = $1 million for fencing on both sides of the road
Overpass
If an over pass over a 2 lane highway ~ $2 million for structure
Maintenance
The fencing and overpass maintenance was not known at the time of this calculation, but was estimated to be $2,000 per year. Over 50 years, this equates to $100,000 in maintenance.

Total rough estimate of over pass and 10 miles of fencing = $ 3.1 million

7. Set up Benefit-Cost equation to find the value of the project in terms of benefit cost ratio.
Low-estimate cost savings: Benefit = $2,601,450 / Cost = $3,100,000 = 0.84
Mid-estimate cost savings: Benefit = $3,428,300/ Cost = $3,100,000 = 1.1
High-estimate cost savings: Benefit = $3,546,450/ Cost = $3,100,000 = 1.1

Low-estimate cost savings: Based solely on crash data and values for 2015 costs, the project would NOT pay for itself in 50 years.
Mid and high-estimate cost savings: When the value of the deer lost to WVC are added to the cost of WVC, the project is predicted to pay for itself.

How long would it take for project to pay for itself?
Low-estimate for cost savings: $3.1 million total cost / $52,029 saved per year = 60 years the mitigation could be expected to pay for itself.
Mid-estimate for cost savings: $3.1 million total cost / $68,566 saved per year = 45 years the mitigation could be expected to pay for itself.
High-estimate for cost savings: $3.1 million total cost / $70,929 saved per year = 44 years the mitigation could be expected to pay for itself.

If the 10 miles (16 km) of fencing was too high a cost, and too long a stretch of road without multiple wildlife crossings, which it is ecologically, the fencing can be reduced to a five mile total. This would reduce the cost by $500,000. This would also reduce the efficacy of the mitigation as elk and other animals moved around the fence end. Research in western U.S. states has shown that over three years' time, mule deer and elk adapt to new appropriate structures and reduce their end of fence runs at mitigation sites (Cramer 2015). This exercise in fencing length is an example of how wildlife professionals would be needed to evaluate the exact specifications of the mitigation.

Another change in the benefit-cost analysis would be to estimate the number of elk killed on the road, and bring in the cost of their lives lost. The elk are valued from $5,000 to $10,000 each. These numbers would increase the value of the benefits of the mitigation.

These examples can help SDDOT planners evaluate how much money to attribute to a mitigation strategy in order for it to pay for itself. By changing the fencing from 10 miles (16 km) to 5 miles (8 kilometers), the estimated savings of $500,000 made the project more cost-effective. But it should be cautioned that changing the length of fencing to five miles would potentially decrease the effectiveness of the crossing structure, as elk move to the fence ends to cross the road with greater ease than if they were more motivated to use the overpass structure.

Appendix I. Idaho Memorandum of Understanding for WVC Collaboration

PURPOSE: MEMORANDUM OF UNDERSTANDING
Between THE IDAHO TRANSPORTATION DEPARTMENT
And
THE IDAHO DEPARTMENT OF FISH AND GAME

This MEMORANDUM OF UNDERSTANDING (MOU) is hereby made and entered into by and between the Idaho Transportation Department, (hereinafter "ITD"), and the Idaho Department of Fish and Game, (hereinafter "IDFG"), collectively referred to as the "parties." Both parties acknowledge that:

1. The collaboration and processes outlined in this MOU are designed to enhance the efforts of the agencies within their ordinary regulatory and statutory obligations.

2. Traditional project-by-project evaluation and coordination limit the effectiveness for the signatory agencies in achieving their missions.

3. Enabling safe wildlife passage, reducing road kill, and increasing public safety at the earliest opportunities, particularly in locations where regulatory processes do not require wildlife mitigation or conservation measures, will require financial support from both the agencies and other partners.

4. Resources devoted to regulatory consultation and documentation on a project-by project basis, in many cases, would be better spent on combining and streamlining processes and data for multiple projects, plans, and programs over an extended timeframe. This economy of scale would allow a coordinated program to address habitat fragmentation, wildlife viability, and transportation planning and development at the statewide level.

BACKGROUND:
The ITD's mission is to promote safety, mobility, and economic opportunity for users of Idaho's transportation system. The IDFG's mission is to preserve, protect, perpetuate and manage the fish and wildlife populations of the State. It is for the economic, social, cultural, and recreational benefit of Idaho's citizens and visitors that IDFG and ITD collaborate for the common purpose of maintaining and improving Idaho's transportation systems while simultaneously protecting and managing the Idaho's fish and wildlife resources and their associated habitats. This MOU embodies the idea that "we cannot sacrifice transportation for wildlife and we cannot sacrifice our wildlife for transportation" and so establishes a program of cooperation between the agencies.

AUTHORITY:
This MOU is entered into pursuant to the authority of Idaho Code, Chapter 23, Title 67, Sections 2326 through 2333 and 2339 (Joint action by public agencies), and 40-309 (Transportation Board powers and duties). This MOU supersedes the previous MOUs signed in March 1987, January 1993, and April 2004, but does not invalidate MOUs written between ITD districts and IDFG regions.

SPECIFIC AREAS OF COLLABORATION:
Data Access and Information Systems

ITD SHALL:

1. Automatically, on no less than a monthly basis, export all road kill data from TAMS to IDFG for incorporation into their road kill and observations database.

2. Automatically, on no less than a monthly basis, export all law enforcement reported wildlife vehicle collisions to IDFG for incorporation into their road kill and observations database.

3. Respond to individual requests from IDFG for transportation system information within 2 weeks unless otherwise coordinated. For re-occurring requests, provide the data via the most effective means of electronic data transfer.

4. Annually update the wildlife vehicle collision risk map using the protocol and data identified in wildlife vehicle collision research in Methodology for Prioritizing Appropriate Mitigation to reduce Big Game Animal-Vehicle Collisions on Idaho Highways (P. Cramer et al 2014) or the most recently accepted protocol.

IDFG SHALL:

1. Maintain and develop databases, applications, and web services or some other means of effective electronic data transfer for purposes of data exchange with ITD. This data shall be credible for transportation planning and project assessment purposes. Site specific knowledge and consultation as well as ongoing data collection will need to come from regional staff.

2. Provide real time access to updated fish and wildlife data including threatened, endangered, game, and species of greatest conservation need including wetlands, waters, priority areas, areas of connectivity, and other associated data that are pertinent to the planning and maintenance of the transportation system. Respond to individual request for information within two weeks unless otherwise coordinated.

3. Provide interpretation of IDFG data regarding its appropriate application, when requested or needed.

Both Parties SHALL:

Establish a Data Development Team by August 2015 as outlined in Exhibit A.

Professional Services

ITD SHALL:

Consider the expertise of the IDFG personnel for contract services related to federal requirements for biological assessments, designing and implementing monitoring and surveys, and providing consultation associated with state and federal highway projects within available resources and desired timelines. Development of professional service agreements on an annual basis are encouraged. See Exhibit B for a Cooperative Agreement template for single or multiple projects. ITD shall consider use of Best Management Practices recommended by IDFG within available resources.

IDFGSHALL:

Consider the expertise of the ITD personnel for contract services related to engineering and traffic control functions associated with fish, wildlife, and administrative projects within available resources and desired timelines. Development of professional service agreements on an annual basis are encouraged. See Exhibit B for a Cooperative Agreement template.

Provide current and applicable Best Management Practices and designs for fish and wildlife treatments and modifications related to transportation systems at annual meetings or as part of normal project review. These treatments and designs will be the most current and accepted for transportation systems and will provide engineering specifications as available.

Both Parties Agree:

To evaluate the potential sharing of human resources and expertise for mutual benefit. Such human resources might include technical personnel, biologists, engineers, planners, and project specialists. Sharing might consist of either agency providing some or all of either a full-time employee or associated salary with a specific work plan and clearly outlined supervisory lines and work objectives.

Project Communication and Coordination

Both Parties SHALL:
I. District/Region: Meet annually, between March and June, to discuss issues of mutual concern. See Exhibit C for recommended attendees and typical agenda items. The designated ITD and IDFG meeting note keepers will copy the ITD Environmental Section Manager and IDFG Wildlife Program Coordinator, respectively.

2. Headquarters: Meet annually, between March and June, to discuss issues of mutual concern and assure the MOU is operationalized. Provide annual updates to their respective Director's offices on the implementation and success of this MOU.

3. Respond to information and input requests from the other agency within two weeks of the request unless otherwise notified.

4. Consider comments from the other agency when developing project scope and budget.

5. Continue with currently established and functional coordination meetings, as needed.

Public and Media Relations

Both Parties SHALL:

I. When issuing a press release which may impact or affect the other agency, the affected agency will be given advance notice and provided an opportunity to offer input on the draft press release, before it is released to the public.
2. Cooperate in the issuance and/or development of joint statements, press releases, website content, collaboration, and success stories when the issue or topic includes mutual areas of concern, interest, and investment.

3. When contacted by the media about an issue or topic that includes mutual areas of concern, interest, and investment, staff will take the following steps: 1) Inform superiors and make certain of messages to be conveyed before responding. 2) Insure adherence to agency media/public information policies. 3) Contact the other agency prior to or immediately after conducting a media interview and provide them the media contact information. 4) Suggest the media contact the other agency for their perspective on the given topic.

Road-killed Big Game animals:

ITD SHALL:

I. Report all road-killed big game animals to the nearest 1/1 oth of a mile in the TAMs database no less than bi-weekly.

2. In coordination with Regional IDFG Staff, encourage the reporting of road killed wildlife species other than big game, especially where road kill frequency or type may be indicating an important conservation or resource issue.

IDFG SHALL:

I. Report all road-killed big game animals observed to be reported to the nearest 1/10th of a mile in the IDFG road kill web application no less than bi-weekly. <https ://fishandgame.idaho. gov/species/roadkill>

2. Use road kill data for purposes of mapping and prioritizing wildlife crossings, linkages, and public safety concerns. Develop collaborative highway treatment plans and funding to reduce road kill, increase wildlife linkage/connectivity/corridors, and reduce hazards to drivers.

3. Communicate and develop road kill information for wildlife species and conservation priorities in relation to listed, greatest conservation need, and locally important species.

Both parties SHALL:

1. Develop a cooperative ITD District-IDFG Region Road Kill Removal and Disposal Protocol.

2. Remove big game or any road-killed species that presents a potential safety hazard from the roadway upon first encounter.

3. Dispose of Big Game road-killed animals in a manner that is consistent with public health and safety concerns.

4. Report any identified federally protected road-killed species to the U.S. Fish and Wildlife Service and/or IDFG. These may include eagles, grizzly bears, and lynx.

Signage and Public access

ITD SHALL:

1. Develop and deploy signage to clearly identify and delineate public recreation access.

2. Install and maintain authorized Wildlife Management Area (WMA) permanent wildlife management signs and other fish and game guide signs at IDFG expense.

3. Provide to IDFG a list of surplus properties that may be exchanged, sold, or donated to IDFG for the enhancement of public access and recreation.

IDFG SHALL:

1. Develop and deploy signage to clearly identify and delineate public recreation access.

2. Provide to ITD an inventory of surplus properties that may be exchanged, sold, or donated to ITD for the enhancement of transportation systems.

3. Provide to ITD an updated inventory of IDFG properties where public recreation and access may be developed and provided in cooperation with
ITD.

Both Parties SHALL:

1. Discuss the above in the context of district/region cooperation through their participation in and according to the identified structure in Exhibit C. Develop funding opportunities and cooperatively fund development and enhancement of public recreation and access opportunities.

2. Coordinate additional signage, as agreed.

LIMITATIONS:
Nothing in this MOU by and between ITD and IDFG shall be construed as limiting or expanding the statutory or regulatory responsibilities of either agency or any involved

individual acting on behalf of the agency or in performing functions granted to them by law; or as requiring either agency to expend any sum in excess of its respective appropriation. Each and every provision of this MOU is subject to the laws and regulations of the state of Idaho and of the United States.

Nothing in this MOU shall be construed as expanding the liability of either party. In the event of a liability claim, each party shall defend their own interests. Neither party shall be required to provide indemnification of the other party. This MOU does not in any way restrict any entity from participating in similar activities with other public or private agencies, organizations, and individuals.

EFFECTIVE DATE:
This MOU shall become effective upon signature of the Director of ITD and the Director of IDFG.

METHOD OF TERMINATION:
This MOU shall remain in force for five years from the date of the last signature unless it is mutually extended or formally terminated by either party after thirty (30) days written notice to the other party.

AMENDMENTS:
Amendments to this MOU shall become effective upon the date of mutual agreement and written approval by the Director of lTD and the Director of lDFG.

IDAHO TRANSPORTATION DEPARTMENT
Director

IDAHO DEPARTMENT OF FISH AND GAME
Director

Exhibit A

Data Development Team Agenda

Wildlife Program Coordinator

Recommended Frequency: Semi-annually. As needed follow up meetings, outside of this structure, should take place if issues and discussions arise.

Duration: Approximately 2 hours

Location: Alternate annually between ITD and IDFG HQ facilities

Responsible party for organization of meeting and agenda: IDFG Program Coordinator and ITD Environmental Services Manager

Considerations:

• Plan ahead - Schedule the meeting at least two months prior to proposed date to ensure participation from all parties

• Take good notes -consider designating a note taker

Topics to discuss:

• Identify a process for what new data will be collected, how it will be collected and the process for developing the tools

• Create a clause regarding the standard for acceptance of sister agencies' data

• Work towards 24/7 data access between agencies

• Provide for a project milestone "checklist" to ensure data sharing and resulting actions occur

• Address staffing issues

• Work towards data sharing online as much as possible, particularly with existing resources (e.g. ITD Planning Network (IPLAN), Crucial Habitat Assessment Tool (CHAT), etc.)

• Challenges associated with interpretation/explanation of data and any restrictions on its use

• Identify the lifespan of data

• Set a timeframe for providing official responses between agencies

Tracking Progress

• Send out notes to all participants and upper-level management

• IDFG Program Coordinator and Environmental Section Manager to follow up every quarter with attendees on action items, issues and questions related to the above topics.

Exhibit B

TEMPLATE COOPERATIVE AGREEMENT
FOR
IDAHO DEPARTMENT OF FISH AND GAME
IDAHO TRANSPORTATION DEPARTMENT

PROJECT NO. AO ---
(Project Name)
(Key No.)
THIS Cooperative Agreement is made and entered into this day of __________ , , by and between the Idaho Transportation Department, hereafter called ITD and the Idaho Department of Fish and Game, hereafter called the IDFG.

PURPOSE
The purpose of this agreement is to use the expertise of IDFG staff to complete biological evaluations needed for ITD project development.
The work covered by this Agreement for Project No_____ is_____, as shown on the attached Exhibit A, Scope of Work.
The Parties Agree As Follows:

The IDFG agrees to:
1. Provide an estimate of the approximate cost, time and schedule for the work noted on Exhibit A.
2. Bill the ITD for reimbursement of actual expenses. IDFG will maintain complete records and submit an itemized invoice of all manpower, materials and out-of-pocket expenses, and accomplish all record-keeping in accordance with the following procedures:
a. Individual time sheets will be maintained reflecting the total hours spent on the project. It is imperative that the hours be traceable to the project.
b. Material - Costs of new material utilized on the project shall be supported by copies of invoices.
c. Out-of-pocket expenses - All expenses shall be supported by copies of receipts.
d. The record system will be such that all costs can be traceable from all billings through the ledgers and the source document.
3. Conduct all services using qualified personnel.
4. Deliver a monthly progress report to ITD unless otherwise noted in Exhibit A. The progress report shall include the status of budget and schedule, complete, and any potential changes to the scope of work.
5. Deliver the product within the schedule and budget noted in Exhibit A.
6. Deliver documents in a format shown in Exhibit A.

The ITD agrees to:
1. Provide additional information requested by IDFG in a timely manner.
2. Make all appropriate payments to IDFG, based on quarterly billing requests.

TERM OF AGREEMENT

This Agreement shall become effective on the first date written above and remain in full force and effect
until amended, replaced upon the mutual consent of the ITD and IDFG or performance of the above conditions are not being met satisfactorily by any party. Either party may terminate this Agreement upon written notice to the other signatory agency.

EXECUTION

This Agreement is executed for the ITD by its District Engineer and executed for IDFG by the Chief of the Bureau of Administration.

IDAHO TRANSPORTATION DEPARTMENT

District Engineer

IDAHO DEPARTMENT OF FISH AND GAME

Chief of Administration

Exhibit C

(Sample) Annual ITD District/ITFG Region Coordination and Planning Meeting

Attendees:
Idaho Transportation Department Idaho Department of Fish and Game
District Senior Environmental Planner Regional Conservation Officer
District Senior Transportation Planner Regional Environmental Biologist
District Maintenance Engineer Regional Habitat Manager
District GIS Analyst
Responsible party for organization of meeting and agenda: ITD District Senior Environmental Planner unless otherwise mutually agreed.

Communication Best Practices:
- Plan ahead - at least two months prior to meeting date to ensure participation from all parties
- Consider designating a note taker or bringing someone in to transcribe notes for participants
- Field Trip of current and future project sites - to increase understanding of critical habitat and areas of concern before or after the regular meeting.

(Sample) Agenda items:
- Share and update district/region staffing flow charts with contact information and preferred method of contact
- Introduce any new staff and exchange contact information
- Review MOU and/or assign ITD/IDFG counterparts to review their relevant sections and ensure appropriate parties are adhering to the language of the MOU and providing listed resources and information.
- Check-in on MOU effectiveness. Where are good things happening? Where do we need improvement? Do any amendment suggestions need to be proposed?
- Review upcoming projects on the ITIP.
- Scoping of future projects not yet on the ITIP.
- Discuss opportunities for wildlife crossing improvements and inclusion with current highway construction projects
- Discuss and evaluate joint funding sources for wildlife crossings
- Discuss opportunities for staff sharing
- Report on road kill removal plans and progress
- Broad discussion on types of impacts transportation projects often have on habitat and wildlife
- Share successes and develop action items for jointly draft new releases and success stories.
- Identify and share grant and funding opportunities. Develop action items for follow up on grants and funding.
- Effectiveness of data sharing protocols and developments
- Discuss other Region/District specific concerns

Post-Meeting Items
Distribute notes, including action items and responsible parties.

Exhibit D

District/Region Road Kill Removal and Disposal Protocols

Participants:
Idaho Transportation Department Idaho Department of Fish and Game
District 0_Q_erations Engineer Regional Manager
District Maintenance Foremen Regional Conservation Officers
Sample of items to consider for protocols:
Removal:
- What types of road killed animals will be removed from the road prism?
- What is the protocol for handling wounded animals?
- How far does an animal need to be moved? Outside the fog line? Out of sight?
- Are scavenger species a concern with road kill?
- Does the removal protocol change based on the season and weather?

Disposal:
- What constitutes proper disposal?
- Who will pay for any disposal fees?
- Where are approved disposal locations?

Coordination:
- What is proper protocol for removal and handling of protected species?
- How do we minimize double counting between ITD personnel and IDFG personnel as well as the traveling public?
- How often will the plan be updated?
- How will the plan be disseminated to all personnel?
- Who is the point of contact at each agency regarding road kill?

Safety:
- What are the safety concerns with road kill removal?
- What can be done to minimize these concerns?