



RP 229

Methodology for Prioritizing Appropriate Mitigation Actions to Reduce Wildlife-Vehicle Collisions on Idaho Highways



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16. Abstract Vehicle collisions with large wild animals are a safety issue for motorists and an ecological concern for wildlife populations. The objective of this research was to advance the efficacy of Idaho Transportation Department's (ITD's) project planning to reduce vehicle collisions with wildlife and to provide wildlife connectivity options across and under roads. A Wildlife-Vehicle Collision (WVC) Prioritization Process was developed through lessons learned from other U.S. States and Ontario Canada's efforts, and GIS modeling of data and maps already available in Idaho. The GIS maps were based on WVC crash and carcass data, Wildlife Highway Linkages maps, and species' habitat maps. The resulting maps of WVC priority areas statewide and within ITD districts were the first of a 13 step process developed for the project. Users of this process further identify priority areas in ITD Districts based on other data such as: Idaho Fish and Game (IDFG) knowledge of wildlife populations, transportation plans, land ownership, field surveys of existing structures, options such as fencing, bridges, and culvert, and their cost-effectiveness. This WVC Prioritization Process was a step along a series of actions which ITD has undertaken and will continue to take to reduce risks associated with WVC and provide wildlife connectivity along Idaho roads.			
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APPROXIMATE CONVERSIONS TO SI UNITS					APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol	Symbol	When You Know	Multiply By	To Find	Symbol
<u>LENGTH</u>					<u>LENGTH</u>				
in	inches	25.4	mm	mm	millimeters	0.039	inches	in	
ft	feet	0.3048	m	m	meters	3.28	feet	ft	
yd	yards	0.914	m	m	meters	1.09	yards	yd	
mi	Miles (statute)	1.61	km	km	kilometers	0.621	Miles (statute)	mi	
<u>AREA</u>					<u>AREA</u>				
in ²	square inches	645.2	millimeters squared	cm ²	mm ²	millimeters squared	0.0016	square inches	in ²
ft ²	square feet	0.0929	meters squared	m ²	m ²	meters squared	10.764	square feet	ft ²
yd ²	square yards	0.836	meters squared	m ²	km ²	kilometers squared	0.39	square miles	mi ²
mi ²	square miles	2.59	kilometers squared	km ²	ha	hectares (10,000 m ²)	2.471	acres	ac
ac	acres	0.4046	hectares	ha					
<u>MASS (weight)</u>					<u>MASS (weight)</u>				
oz	Ounces (avdp)	28.35	grams	g	g	grams	0.0353	Ounces (avdp)	oz
lb	Pounds (avdp)	0.454	kilograms	kg	kg	kilograms	2.205	Pounds (avdp)	lb
T	Short tons (2000 lb)	0.907	megagrams	mg	mg	megagrams (1000 kg)	1.103	short tons	T
<u>VOLUME</u>					<u>VOLUME</u>				
fl oz	fluid ounces (US)	29.57	milliliters	mL	mL	milliliters	0.034	fluid ounces (US)	fl oz
gal	Gallons (liq)	3.785	liters	liters	liters	liters	0.264	Gallons (liq)	gal
ft ³	cubic feet	0.0283	meters cubed	m ³	m ³	meters cubed	35.315	cubic feet	ft ³
yd ³	cubic yards	0.765	meters cubed	m ³	m ³	meters cubed	1.308	cubic yards	yd ³
Note: Volumes greater than 1000 L shall be shown in m ³									
<u>TEMPERATURE (exact)</u>					<u>TEMPERATURE (exact)</u>				
°F	Fahrenheit temperature	5/9 (°F-32)	Celsius temperature	°C	°C	Celsius temperature	9/5 °C+32	Fahrenheit temperature	°F
<u>ILLUMINATION</u>					<u>ILLUMINATION</u>				
fc	Foot-candles	10.76	lux	lx	lx	lux	0.0929	foot-candles	fc
fl	foot-lamberts	3.426	candela/m ²	cd/cm ²	cd/c m ²	candela/m ²	0.2919	foot-lamberts	fl
<u>FORCE and PRESSURE or <u>STRESS</u></u>					<u>FORCE and PRESSURE or <u>STRESS</u></u>				
lbf	pound-force	4.45	newtons	N	N	newtons	0.225	pound-force	lbf
psi	pound-force per square inch	6.89	kilopascals	kPa	kPa	kilopascals	0.145	pound-force per square inch	psi

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Foreword

This research project was sponsored by the Idaho Transportation Department's (ITD) Office of Highway Safety to answer highway safety concerns regarding wildlife-vehicle collisions (WVC) in Idaho. Over the years, data regarding WVC has been gathered independently by ITD and the Idaho Department of Fish and Game (IDFG) in an effort to determine the magnitude of the WVC problem on the ITD highway system. This project was focused on harnessing, organizing and combining these data on a corridor basis to determine where the impacts from WVC are located. By merging highway safety data from ITD with wildlife linkage data and habitat data from IDFG, the project team has attempted to paint a balanced picture of the true WVC problem. From an ecological perspective, this project will help prioritize the needs of wildlife and from a highway safety planning standpoint, it will aid in programming for the different treatment options to help prevent WVC.

Prior to this research project, there was no statewide perspective on where funds could best be put to use. The goal of this project was not to be the "end all" answer to where WVC occur or where mitigation projects might be built. Rather, this project was a step down a pathway with our partners at IDFG to better understand the data we have and how that data can inform us about where our problem areas are. This project also aids in educating interest groups and executive decision makers regarding the WVC problem.

There is still a lot of work to be done. ITD and IDFG regions will have to take the methodology that Dr. Cramer and her team have prepared and use it to determine local priorities based on local, specific constraints. In addition, ITD now has the education and data needed to work to include WVC metrics in planning and prioritization of WVC projects for the Highway Safety Improvement Program. The point is that this is the beginning and what we have learned from this research has helped to move us along this pathway and towards a safer highway system.

Sincerely,

Brent Jennings, P.E.
Highway Safety Manager
Idaho Transportation Department

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List of Acronyms

AADT	Average Annual Daily Traffic
AVC	Animal-Vehicle Collisions, typically refer to wildlife and domestic animal collisions
GIS	Geographic Information Systems – map making and viewing software in computers
GPS	Global Positioning Systems – gives an exact reference to a location, based on latitude and longitude
Hotspot	Is a section of road where numerous wildlife-vehicle collision carcasses have been collected and reported. These hotspots do not have a specific number, or length as reporting thresholds, rather they appear with more data points on maps than neighboring road sections.
IDFG	Idaho Department of Fish and Game
IFWIS	Idaho Fish and Wildlife Information System
IPLAN	A collaborative information portal available on the Internet that allows Idaho Transportation Department personnel and partners to publish geospatial data that assists in planning.
ITD	Idaho Transportation Department
ITIP	Idaho Transportation Investment Program , a five year planning document for both ITD and Metropolitan Planning Organizations in Idaho.
KDA	Kernel Density Analysis, a statistical application to group data points in time or space or both.
KDE	Kernel Density Estimate, a statistical application to group data points in time or space or both. Estimates look at how data is clumped.
Linkage Area	A wildlife linkage zone (a travel or migration corridor) associated with Idaho state and federal highways across all of Idaho. These were identified by agency personnel during workshops and reviews.
MP	Milepost
MXD	A file format in which maps created in the software ArcGIS are stored, with details on symbols, projections, links and other aspects of the maps stored for future users.
PDO	Property Damage Only, a term used for estimating costs of vehicle crashes.
SRMA	Special Recreation Management Area

STIP	State Transportation Improvement Plan
TAC	Technical Advisory Committee
TAMS	Transportation Asset Management Systems. Consists of ITD Maintenance and Pavement information. A database used by ITD maintenance personnel to inventory hours worked and topic areas worked in.
UPLAN	An interactive mapping platform on the internet that supports Utah Department of Transportation to help visualize data in maps, track assets and help with planning.
USU	Utah State University, Logan, Utah
WGA	Western Governors' Association
WGA-CHAT	Western Governors' Association Crucial Habitat Assessment Tool, a GIS software tool available on-line to map wildlife habitat in Idaho and other western states.
WVC	Wildlife-Vehicle Collisions

Scientific Names of Animals in Report

Black Bear - *Ursus americanus*

Bighorn Sheep - *Ovis canadensis canadensis*

Elk - *Cervus canadensis*

Grizzly Bear - *Ursus arctos*

Moose - *Alces americanus*

Mule Deer - *Odocoileus hemionus*

Pronghorn Antelope - *Antilocapra americana*

White-Tailed Deer - *Odocoileus virginianus*

Wolf - *Canis lupus*

Executive Summary

Problem Statement

Vehicle collisions with large wild animals are a safety issue for motorists and an ecological concern for wildlife populations. Ungulate (large wild herbivores such as deer, elk, moose, and pronghorn antelope) and bear wildlife-vehicle collisions (WVC) are a significant problem in Idaho. These WVC annually result in an average of 1,076 reported crashes, 13 human fatalities and serious injuries, thousands of crashes with property damage, and thousands of reported individual wild animals killed. The goal of this research was to advance the Idaho Transportation Department's (ITD) understanding of wildlife-vehicle collision problem in Idaho, improve project planning to reduce vehicle collisions and to provide wildlife connectivity options across and under roads.

Prior to this project, Idaho established several related databases and conducted several studies to address this issue. These included identification of wildlife linkages, and a database to record WVC carcasses. In 2009 ITD funded the Idaho Wildlife Linkages workshops. This collaborative effort with Idaho Department of Fish and Game (IDFG) focused on data collection and mapping workshops to create a database of wildlife habitat [linkage](#) areas along state highways. These were based on the pool of knowledge of state maintenance personnel, environmental planners, IDFG biologists and conservation officers, and non-governmental organizations.

The [Idaho Wildlife Linkage](#) project was awarded a 2009 Federal Highway Administration Exemplary Ecosystem Initiative Award.

ITD and IDFG developed an online database that allows agency staff and the public to record roadside wildlife carcass observations. This interactive website is part of the IDFG website. This database also includes ITD carcass data collected by ITD maintenance personnel, which were uploaded several times a year.

This research project brought together these previous databases along with new data to help identify problem WVC areas in Idaho.

Research Objectives

1. Create a comprehensive GIS database from ITD and IDFG data related to wild ungulates and bear WVC that can be used to identify WVC problem transportation corridors.
2. Develop a methodology that ITD staff, working with IDFG and other groups, can use to identify and prioritize actions to reduce WVC.

The methodology developed through this project is expected to help support requests to include mitigation projects in the [ITIP](#).

Methods

The research team worked in coordination with Utah State University and partnered with the ITD Technical Advisory Committee (TAC) which included engineers, traffic safety analysts, Geographic Information Systems (GIS) personnel, and wildlife ecologists. ITD and IDFG GIS specialists provided data to incorporate into the research, and helped design future data downloads to the shared websites. Biologically trained professionals provided input on wildlife movements and habitat and how the products of this research would be used. Traffic safety analysts provided crash data and input on future data sharing. Engineers gave input on the safety and engineering cost concerns for measures to reduce WVC. GIS map modeling efforts for the final WVC Priorities map included several different iterations of map creation with different rankings and values of input data layers until a map that the TAC agreed was most representative of the situation on the ground, was finalized. Every effort was made to conduct this research in a manner that was consistent with ITD's vision of the final product, the Statewide WVC Mitigation Actions Prioritization Process.

Research Tasks

This research was the first step in ITD's effort to develop a statewide WVC Mitigation Actions Prioritization Process. The research team completed the following tasks.

- Task 1. A review was conducted of applicable literature and practices to identify management protocols used in other states to identify and prioritize problem areas for WVC.
- Task 2. A comprehensive GIS database was developed in collaboration with IDFG and ITD that is both standalone and compatible with [IPLAN](#) to identify and help prioritize problem areas for WVC on Idaho's state roads.
- Task 3. The WVC Prioritization Process (short for Statewide WVC Mitigation Actions Prioritization Process) was developed so ITD staff, working with IDFG and other interested parties could identify priority WVC problem road segments, and identify cost-effective feasible actions to reduce WVC in those locations.
- Task 4. The WVC Prioritization Process was applied in a pilot test to identify high WVC "hotspot" areas in ITD Districts 5 and 6, to recommend actions to reduce WVC in those districts, and to identify parts of the process that were improved.
- Task 5. Findings were delivered to ITD with this final report as well as a GIS database.

Results

The four tasks were carried out to inform and shape the Idaho WVC Prioritization Process.

The literature review and research on 10 states and 1 Canadian province practices to identify priority areas and actions for WVC hotspots found areas of commonality. There were six steps that all the state DOT WVC identification and prioritization processes had in common which were also critical to the Idaho process:

1. Examine all WVC crash data and bring that data into the process.
2. Collect WVC carcass data and place them in a geo-referenced database.
3. Map WVC carcass data points to view problem areas.
4. Include Average Annual Daily Traffic (AADT) data for all roads.
5. Include maps of different target species' habitat.
6. Include maps of potential [wildlife linkage](#) areas in the evaluation process.

The research also identified a variety of wildlife mitigation approaches relevant to ITD, from temporary variable message boards and slower speed zones, to wildlife exclusion fencing with wildlife crossing structures. These mitigation approaches are also referred to as treatment options, treatment actions, and WVC mitigation actions. These terms all refer to the actions that are undertaken to make a road safer for motorists by keeping wildlife off the road while also providing connectivity options for animal movement.

The GIS team created a comprehensive GIS database in collaboration with IDFG and ITD. This database can be used as a stand-alone product (a MXD file for ArcGIS) or in conjunction with other planning tools. The GIS data was also modeled to create maps to identify and prioritize problem areas for WVC within ITD districts and across the state based on geo-referenced data. This was the first step in the WVC Prioritization Process.

The research for Task 3 resulted in a GIS hotspot WVC map for the state and ITD districts, a gathering of all the data used in the mapping process, and a WVC Prioritization Process. This WVC Prioritization Process was developed to allow ITD staff, working with IDFG and other interested parties to identify priority WVC problem segments of roads for future mitigation projects, and cost-effective feasible actions to reduce WVC in those locations. The initial step in this process was the creation of a statewide map (Figure 1) with the top 15 WVC hotspots. The top 10 areas are within maroon circles on the map. The top 11 to 15 WVC areas were displayed within pink circles, which often contained clusters of WVC priority areas. These top 15 priority road segments are presented in Table 1. This initial step in the prioritization process was based solely on data from the above six listed sources that all other WVC Prioritization Processes have in common.

Table 1. Top 15 Wildlife-Vehicle Collision Priority Areas in Idaho
All Scored 74 Points or Higher

Ranking	Top Score Out of 100	Road	Milepost	ITD Maintenance District	Name
1	92	US-95	469	1	US-95 Cocolalla/Westmond/Algoma
2	90	SH-75	118 - 120 & 125 – 127	4	SH-75 Ketchum/Big Wood River
3	85	US-95	516 – 521	1	US-95 Indian Reservation/Kootenai River
4	84	US-95	488 – 493	1	US-95 Pack River/Elmira
5	84	SH-21	10 – 20	3	SH-21 Lucky Peak/Boise
6	83	I-90	37 - 44 & 47	1	I-90 Kingston
7	83	I-15	58 - 63	5	I-15 North Inkom/Portneuf
8	81	US-95	451 – 453	1	US-95 Granite/Cocolalla
9	81	I-84	176 – 179	4	I-84 Snake River Rim Special Recreation Management Area (SRMA)
10	79	US-95	193 – 194	2	US-95 Riggins North/Salmon River
11	77	US-95	208 - 218 & 220 – 223	2	US-95 Lucille/White Bird/Salmon River
12	75	US-30 & SH-34	US-30: 386 - 387 US-30: 399 – 400* ID-34: 50	5	US-30 & SH-34 Soda Springs
13	75	US-2	76 – 77	1	US-2 Idaho-Montana Border
14	75	US-95	460	1	US-95 Careywood
15	74	US-95	422	1	US-95 South Coeur d’Alene

*Note: ITD mapped US-30 MP 388 to 399 with just 1 foot between mileposts.

The WVC Prioritization Process begins with the Figure 1 map. The process then instructs users through a series of 13 steps that involve gathering data and consensus among ITD and IDFG partners to find the top priority WVC hotspot areas in need of mitigation that are also the most feasible to mitigate in the near future at the ITD District level. The steps instruct users to consider and quantify:

- Step 1. Perform modeling to create a Statewide Priorities Map.
- Step 2. Identify priority areas within an ITD district based *Needs Assessment* document created in conjunction with IDFG.
- Step 3. State objectives of the proposed mitigation actions that can be quantified and monitored.
- Step 4. Examine land ownership maps for feasibility of creating wildlife treatment actions or mitigations in protected areas
- Step 5. Compare WVC priorities with future ITD transportation projects for potential opportunities of including mitigation options.
- Step 6. Analyze existing infrastructure for retrofits.
- Step 7. Build consensus with public and private partners through field visits.
- Step 8. Select wildlife mitigation actions based on short-term and long-term possible solutions.
- Step 9. Evaluate how cost-effective these wildlife treatment options are projected to be over the long-term.
- Step 10. Identify potential funding partners.

- Step 11. Establish performance measures, state constraints and estimate likelihood of success.
- Step 12. Annually select projects at ITD District levels, and state level.
- Step 13. Announce state and district level priorities, begin building wildlife mitigation.

The WVC Prioritization Process delivers to ITD a consistent objective method to identify and plan for the most urgent, feasible, and cost effective wildlife treatment mitigation at both the district level and across the state.

Future Use of This Research

This research provided a standard prioritization process for identifying WVC hotspots and prioritizing actions to reduce the WVC problem areas across Idaho. The research to develop this WVC Prioritization Process was a step in a series of actions which ITD has undertaken to reduce risks associated with WVC and provide wildlife connectivity along Idaho roads. Future recommendations include:

- ITD and IDFG should form an “Interagency Wildlife Connectivity Committee” that oversees statewide efforts and guides the development of processes and methods, raises support, locates and encourages funding partners, and educates the public on the reduction of WVC and wildlife mitigation efforts. IDFG and ITD need to build partnerships that will result in regular meetings, common goals for wildlife mitigation along ITD roads, and a community of trust.
- ITD WVC carcass collection should be more consistently collected and reported across the state. This action specifically in ITD District 6 would help to identify WVC hotspots worthy of state ranking within the district. New technologies connected with “smart” phones that allow users to use a phone app to report carcasses are available from other states, such as Utah.
- Wildlife treatment actions should be monitored to evaluate their efficacy at meeting performance measures stated before the infrastructure was created.
- ITD personnel will need to be trained in the use of the WVC Prioritization Process.
- GIS mapping models will need to be improved. Most importantly, IDFG should create more accurate maps of wildlife habitats based on empirical field data and use those maps in the future prioritization process.
- ITD and IDFG need to develop an agreed upon Needs Assessment Template document that each ITD district in conjunction with IDFG regions develops for those jurisdictions that details high priority road and wildlife areas in need of transportation mitigation efforts to prevent WVC and promote wildlife connectivity.
- IDFG and ITD need to come to an agreement on values and methods used to conduct benefit-cost analyses.

This research project provided ITD a planning tool that when applied collaboratively with consistency and followed through with wildlife mitigation treatments, will meaningfully reduce WVCs and their associated damages to wildlife and humans in Idaho. Through implementation of the WVC Prioritization Process, ITD will improve road safety for motorists and enhance economic opportunity through wise stewardship of Idaho natural resources.

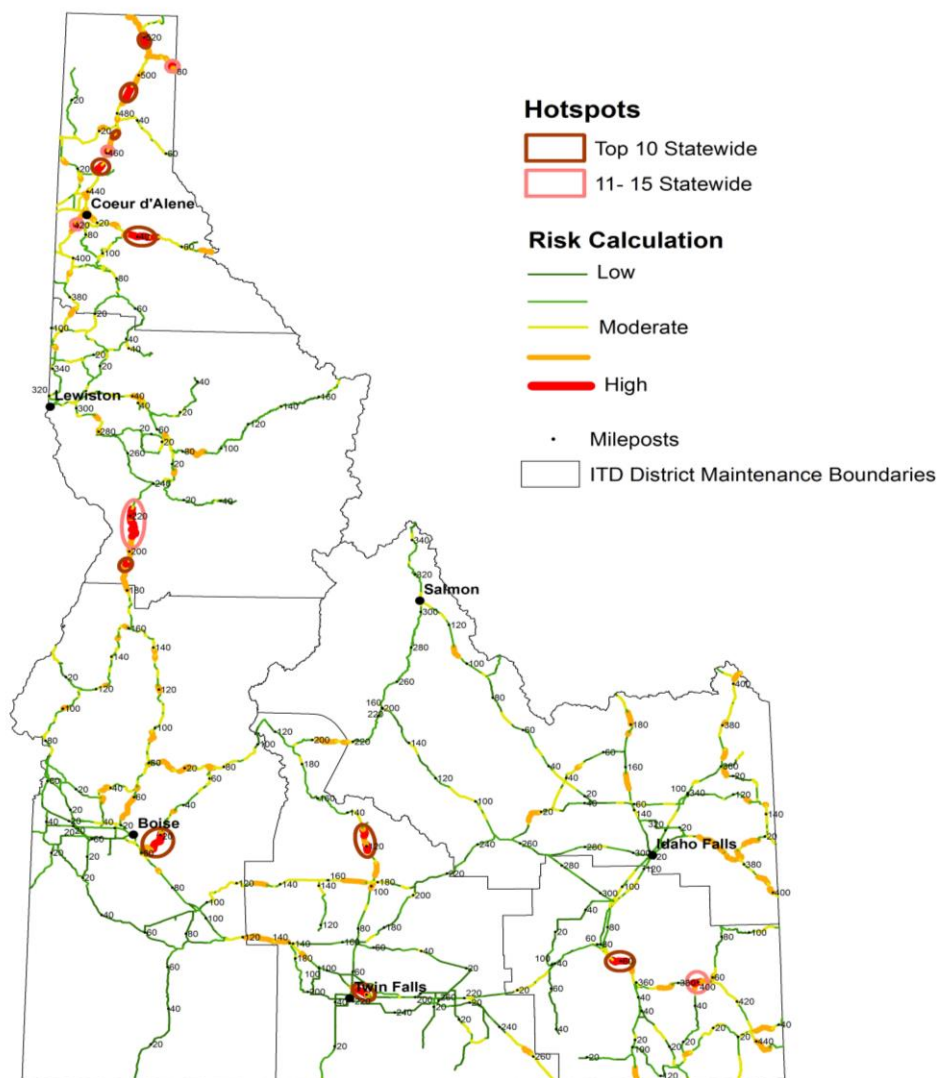


Figure 1. Idaho Statewide 2013 Wildlife-Vehicle Collision Top Priority Road Segments Based Solely on GIS Data, January 1, 2014

Note: The lack of priority hotspots in ITD District 6 was due in part to low carcass reporting by ITD

Chapter 1

Research Methods and Overall Results

Introduction

Vehicle collisions with large wild animals are a safety issue for motorists and an ecological concern for wildlife populations. Ungulate (large wild herbivores such as deer, elk, moose, and pronghorn antelope) and bear wildlife-vehicle collisions (WVC) are a significant problem in Idaho. This research provides the initial step in the development of a Statewide Wildlife Vehicle Collision (WVC) Mitigation Action Process for Idaho.

The research conducted in this project was a step in Idaho's effort to mitigate WVC. Idaho established several related databases and conducted several studies to address this issue. Since 1997 ITD's online crash database, [WebCARS](#), contains information regarding reported WVC crashes. ITD funded the 2009 Idaho Wildlife Linkages Workshops and Website. This collaborative effort with Idaho Department of Fish and Game (IDFG) focused on data collection and mapping workshops to create a database of wildlife habitat linkage areas along state highways. These were based on the pool of knowledge of state maintenance personnel, environmental planners, IDFG biologists and conservation officers, and non-governmental organizations. ITD District 6 also conducted a [Wildlife Linkage Analysis](#) in 2005. The resulting website is used by state resource and transportation agency personnel to identify wildlife habitat areas in transportation corridor planning and early project development and to determine areas in need of further study. The database won a [2009 Federal Highway Administration Exemplary Ecosystem Initiative Award](#).

A second project developed an online database that ITD, IDFG, and others can use to document and monitor wildlife mortality caused by vehicles. This database allows users to report [roadside wildlife carcasses](#). The website, which also includes the Transportation Asset Management Systems (TAMS) data on carcasses collected by ITD, is managed by IDFG and can be accessed by anyone.

While these efforts were outstanding in some ITD districts, prior to this research there was no uniform prioritization methodology to identify where WVC were most prevalent in districts or the state and how to go about creating mitigation solutions. There was a need for a statewide process that was systematic, data driven and repeatable across Idaho. ITD could use this process to analyze where there was the greatest need to mitigate roads for wildlife, and thus reduce WVC.

These mitigation approaches are also referred to as treatment options, treatment actions, and WVC mitigation actions. These terms all refer to the actions that are undertaken to make a road safer for motorists by keeping wildlife off the road while also providing connectivity options for animal movement.

The research was conducted between two teams: the GIS research team at Utah State University (USU) and the research team of transportation ecology experts across North America. The GIS experts at USU included Chris McGinty, Ben Crabb, and Suzanne Gifford, who worked in the laboratory of Dr. Douglas Ramsey, a USU Wildland Department professor. The outside researchers who brought considerable knowledge of the science and practice of transportation ecology into the project were: Julia Kintsch of ECO-resolutions, Kari Gunson of Eco-Kare International, Fraser Shilling of University of California at Davis Road Ecology Center, and Sandra Jacobson of the U.S. Forest Service. Dr. Patricia Cramer of USU was the Principal Investigator (PI). Both teams conducted tasks in an iterative manner with continued input from ITD personnel and members of the Technical Advisory Committee (TAC).

During the completion of Task 1 the researchers learned of the mitigation methods and prioritization processes used in 10 states and 1 Canadian province to identify problem WVC areas and create mitigation actions. In the second task the researchers, in consultation with the TAC, created a comprehensive Geographic Information Systems (GIS) database to be incorporated into the [IPLAN](#) portal for transportation planning. This database will begin to identify problem areas for large herbivore and bear WVC. In the third task a methodology or process was created to assist ITD and IDFG in defining priority locations where mitigation efforts are needed to reduce WVC. TAC members gave input into the development of the initial map developed as the first step in this process. The TAC helped develop the remaining steps to the WVC prioritization process. This research project overall was a step in an ongoing process of identifying areas in Idaho that need wildlife mitigation actions. This resulting report and GIS project should be considered a living document that will be and should be continually updated from ITD and IDFG databases and relevant new information.

This report is organized into three chapters and nine appendices. Chapter 1 reviews the methods and results of the tasks completed in this research. Greater details for each task are provided in the Appendices. Chapter 2 reviews the prioritization process in detail. Chapter 3 provides guidance on follow-up issues, the next steps for this research, and conclusions and future recommendations. Appendix A presents results from Task 1, with data, websites, figures, and overall presentations on how various states map wildlife linkages, with a presentation on GIS mapping techniques. Information and websites on how select states and the Canadian Province of Ontario prioritize WVC areas for future actions and an overview of a prioritization process in California are presented in Appendix B. Appendix C presents various wildlife mitigation actions to prevent WVC. The details of the GIS process for creating the priority maps in Step 1 of the WVC Prioritization Process are shown in Appendix D. Appendix E includes maps of various species of reported carcasses along Idaho roadways. Appendix F is a series of forms from the Washington State DOT Passage Assessment System to evaluate existing structures for future retrofits. Appendix G details the results of Task 4 when the prioritization process was applied to sites in ITD Districts 5 and 6. Appendix H is a table of all known wildlife crossing structures in Idaho with select photos of structures. Appendix I present the maps of the research, in larger format paper for printing.

Task 1. Processes Used to Prioritize WVC Hotspot Areas and Wildlife Mitigation Strategies

Objectives

For Task 1 the research team reviewed applicable literature in order to:

1. Identify management processes used to distinguish and prioritize problem areas for big game (large herbivores and bear) wildlife-vehicle collisions in states like Idaho.
2. Develop a matrix of successful solutions for large herbivore and bear species present in Idaho.

The research in this task:

- Synthesized information from relevant studies.
- Performed all work on this project using the most up to date and current methods and information.

Methods

The research team members were all involved in WVC prioritization processes in their home states in the U.S. and Canadian province. Each member wrote a description of how their state or province was progressing on developing a process. The PI emailed and called leaders in transportation-wildlife issues in each western state not represented by the team members to learn of how they prioritized WVC hotspots. This informal survey was also combined with Internet searches, including those of the Transportation Research Board (TRB) current and past research projects, and attendance at both the 2013 International Conference on Ecology and Transportation in Phoenix, Arizona, and the American Association of Transportation Officials Environmental Conference in Virginia Beach, Virginia. The PI and other researchers also stayed current with new wildlife mitigation methods and new technologies in order to create the best matrix of successful solutions.

Results

Task 1 research results can be categorized into three types of data that were used to inform the WVC Prioritization Process:

- Prioritization methods used by various western states and the Canadian province of Ontario.
- Common major inputs into prioritization processes.
- Types of WVC mitigation strategies.

The most pertinent data inputs for a prioritization process are presented below, and additional information is presented in appendices as referred to in the text.

Prioritization Processes

Most western U.S. states have begun prioritizing areas along their state and federal roads that have high WVC. In fact, 2013 could be considered the year of the prioritization process. Washington State DOT (WSDOT) developed a prioritization process, Arizona DOT (AZDOT) proposed a future prioritization process, New Mexico lawmakers mandated a statewide effort to prioritize WVC areas across the state during this year, Wyoming DOT (WYDOT) funded a study to identify WVC hotspots, Utah began using UPLAN GIS software and a new smart phone application to prioritize WVC hotspots within different Utah Department of Transportation (UDOT) regions, and Ontario Canada began a study to create a prioritization method for the province WVC hotspots. Details of these efforts and other states' prioritization plans are presented in Appendix A and Appendix B. All of these state and provincial efforts have the following components in common:

1. Examine all WVC crash data and bring that data into the process.
2. Collect WVC carcass data and place them in a geo-referenced database.
3. Map WVC carcass data points to view problem areas (See Appendix C for examples).
4. Include Average Annual Daily Traffic (AADT) data for all roads.
5. Include maps of different target species' habitat.
6. Include maps of potential wildlife linkage areas in the evaluation process (See Appendix A for publicly available software for these analyses).

These common components to prioritization processes are discussed under Task 3, in the development of the WVC Prioritization Process. State and provincial efforts to create these prioritization processes are continually updated and changed over time to best reflect new developments in wildlife concerns and the technologies that can bring large amounts of data together. The processes are described in greater detail in Appendix B.

Mitigation Strategies for Large Herbivores and Bear

Mitigation strategies that have been used or experimented with to deter large herbivores and bear from entering roads and to help them find ways under and over roads are presented in Table 2. These measures are listed from those that take the least effort and are inexpensive, to the more expensive, long-term solutions of creating wildlife crossing structures. Each one of these approaches is detailed in Appendix C.

Table 2. Mitigation Option for Wildlife and Transportation: Low, Medium, and High Values of Difficulty in Deployment, Effectiveness, and Use across the U.S., and Cost

Measure	Difficulty in Effort and Time to Deployment	Effectiveness at Reducing WVC	Use Across the U.S.	Cost
Public Awareness Campaigns	Medium	Largely Unknown	High	Low
Wildlife Crossing Zones with Reduced Motorist Speed	Low	Low - Medium	Low	Low
Static Driver Warning Signs	Low	Low	High	Low
Vegetation Management	Low	Low - Medium	Medium & Unknown	Low
Supplemental Feeding Away From Road to Draw Animals From Road	Low	Unknown	Low	Low
Variable Message Board for Drivers	Low	Low - Medium	High	Low
Reflectors, Whistles	Low	Low	High	Low
Wildlife Deterrent Devices Mounted on Roadside Posts That Produce Noise & Reflect Light	Medium	Low	Low	Medium
Boulder Fencing at Fence Ends	Low	Medium	Low	Low
Thermographic Cameras to Detect Wildlife on or Near Road - Used in Vehicle or Along Road with Driver Warning System	High	Medium - 1 Study - Experimental	Low ITD Districts 1 & 6	High, Future
Wildlife Fencing With Wildlife or Double Cattle Guards & Escape Ramps <i>*Note: High Negative Impacts to Wildlife Connectivity</i>	Medium	High	High	Medium to High
Animal Detection Systems with Driver Warning Signs	High	Low - Medium	Low	High
Wildlife Crossing Structures With Wildlife Fencing, Escape Ramps & Guards	High	High	High	High

Recommendations

Idaho was poised at the start of this research to make great strides in the practice and science of transportation ecology related to large herbivores and bear. This report has dozens of recommendations for ITD and IDFG for future actions to be taken to help reduce WVC in Idaho. Efforts toward further developing this prioritization process will need to continue on the part of both ITD and IDFG, and future agency, non-profit, and public partners. These include:

- Wildlife monitoring research of all mitigation efforts in the state to better evaluate effectiveness and wildlife preferences in Idaho.
- Personnel within ITD and IDFG receive regular (minimum of annually) training in using this process. This training would cover:

- a. How to use the prioritization process and new incoming data.
- b. How to work collaboratively to use data to make informed decisions on where and what type of mitigation is necessary in “hotspots.”
- c. How to work proactively in defining and mitigating problem WVC areas across Idaho.

The training opportunities would be decided upon by ITD and IDFG. Later in this report there is a recommendation to create a Wildlife Connectivity Committee. This committee could decide on who would conduct the training, such as ITD environmental planners with experience in creating wildlife and road mitigation projects, safety engineers who can stress the needs and constraints of this division within ITD, and IDFG wildlife professionals knowledgeable about wildlife movements in the presence of roads.

Task 2. GIS Database Development

Objectives

The deliverable for Task 2 was the development of a comprehensive database that can be used to identify and prioritize problem areas for big game animal-vehicle collisions on Idaho’s state road system. The research team:

- Collaborated with IDFG and ITD personnel in order to gather previously defined corridors, road kill data, and crash data.
- Collected, consolidated, and analyzed these data, within the limits of its availability and quality, to identify and validate problem corridors.
- Utilized GIS software to create and analyze data layers in order to visually represent crash data, road kill data, migration corridors, the highway system and other areas of interest. The team synthesized information from relevant studies and applied relevant methods.
- Coordinated with IDFG personnel to further what has already been accomplished regarding this task and to deliver data and data outcomes to the web.
- Made recommendations on how to maintain the developed database up-to-date and relevant after the research is complete.

Methods

USU GIS researchers and the Project PI worked with ITD and IDFG to obtain multiple layers of GIS maps to incorporate into the project’s final file. These GIS maps were brought into a single MXD file, and projections, symbology, etc. were standardized to match the objectives of this research and to match the [IPLAN](#) format.

Results

The GIS research team spent over 4 months compiling needed GIS data and adapting it for this project. The road carcass data collected through ITD's Transportation Assessment Management System (TAMS) (an inventory system for hours worked and areas worked in) was also brought together and analyzed. The team worked to help ITD personnel understand data downloads from ITD to IDFG. Several additional data layers were unavailable at the time of the research, and are noted in Table 3, which describes all data layers used. In future iterations of these GIS layers, the missing layers can be incorporated into the final MXD file, Figure 2.

Recommendations

Three recommendations are provided concerning GIS data:

1. The ITD maintenance personnel in every ITD maintenance district will need to consistently collect carcass data over all ITD roads.
2. ITD will need to automatically upload carcass data from maintenance crews to the IDFG WVC carcass website, preferably on a daily basis.
3. IDFG will need to improve its wildlife habitat data layers used in this research, based on empirical data.

The carcass data for each ITD road are critical to understanding WVC. How these data are collected, and how uniform the collection efforts are across the state and over time are critical to understanding the significance of the problem. An important development in these efforts was achieved in this project. The GIS research team mapped carcass data across the state coded by which source the data came from: either the IDFG interactive website for agency personnel and the public, or by ITD maintenance personnel carcass records. This allowed for a new understanding between ITD and IDFG on how the data on carcasses collected by ITD maintenance crews are uploaded to IDFG websites, and how this could be improved. Project Manager Caleb Lakey took the information developed from this process and spoke with maintenance personnel about data collection efforts. Improvements to this process were by far the most important recommendations from this task.

The third recommendation, for IDFG to improve the wildlife data layers used in this research by creating GIS maps of wildlife habitat based on empirical data from wildlife studies would greatly improve the accuracy of the MXD files and the final WVC priorities map. These data layers would represent where different wildlife species are known to reside and what seasons they use those areas and migratory pathways between. These data layers can be added to the final MXD file from this research, or updated into the [IPLAN](#) planning platform.

Table 3. Maps Included in the MXD File

Data Map	Data Type	Data Source	Notes
Base Map - Terrain	Basemap	ArcGIS Online	
Base Map - Places & Boundaries	Basemap	ArcGIS Online	
Base Map - Hillshade	Basemap	ArcGIS Online	
Base Map - Imagery	Basemap	ArcGIS Online	
Base Map - Streets	Basemap	ArcGIS Online	
Base Map - Topo	Basemap	ArcGIS Online	
IDFG Administrative Boundaries	Polygons	https://fishandgame.idaho.gov/ifwis/portal/opendata	
ITD Districts (Administrative & Maintenance)	Polygons	ITD - Tom Marks	
Idaho Highway Wildlife Linkage	Lines	https://fishandgame.idaho.gov/ifwis/portal/category/tags/corridor	Updated with District 6 priorities
Land Cover	Raster	National Land Cover Dataset	
Land Ownership	Polygons	http://sagemap.wr.usgs.gov/ftp/regional/usgs/westUS_own.htm	Metadata available at http://sagemap.wr.usgs.gov/ftp/regional/usgs/westUS_own.htm
Mileposts	Service/ Points	BIO-WEST	
Mileposts	Points	http://inside.uidaho.edu/	
Mule Deer Seasonal Habitat	Polygons	https://fishandgame.idaho.gov/ifwis/portal/opendata	
Elk Seasonal Habitat	Polygons	https://fishandgame.idaho.gov/ifwis/portal/opendata	
Game Distributions	Polygons	https://fishandgame.idaho.gov/ifwis/portal/opendata	
Idaho Bighorn Sheep Distribution	Polygons	https://fishandgame.idaho.gov/ifwis/portal/opendata	
Bridges – Local	Points	ITD - Tom Marks	2,388 records
Bridges	Points	ITD - Tom Marks	1,831 records
Culverts	Points	ITD - Tom Marks	Not available for the entire state
Average Annual Daily Traffic 1999 - 2011	Lines	http://inside.uidaho.edu/	
Average Annual Daily Traffic 2012	Lines	ITD -Tom Marks	
ITD Wild Animal Crashes 1999 - 2012	Table	ITD - Steve Rich	Need to turn 2007 & earlier records into point shape files using road & milepost info (no latitude/longitudes).
ITD Wild Animal Crashes 1987 - 1998	Table	ITD - Kelly Campbell	
Idaho State Highways	Lines	ITD - Tom Marks	

Table 3 (cont.) Maps Included in the MXD File

Data Map	Data Type	Data Source	Notes
Federal Aid (Roads)	Lines	ITD - Tom Marks	
All Paved Roads in Idaho, Right-of-Ways			Data was unavailable.
Landscape Connectivity Areas ID'd by CHAT - Critical Habitat Assessment Tool		Western Governors' Association	Data was not finished product during development in late 2013. Data Layers are now available.
TAMS - ITD Carcass Records 2011 - 2013	Table	ITD TAMS Coordinator	
TAMS - ITD Carcass Records Pre-2011		ITD TAMS Coordinator	
IDFG Roadkill Carcasses 4/2013 - Present	Web/Table	https://fishandgame.idaho.gov/species/roadkill/list	These data would be updated & added to MXD file at later dates.
IDFG Roadkill Carcasses Pre-4/2013	Web/Table	https://fishandgame.idaho.gov/ifwis/core/view/roadkills/list	These data were included.

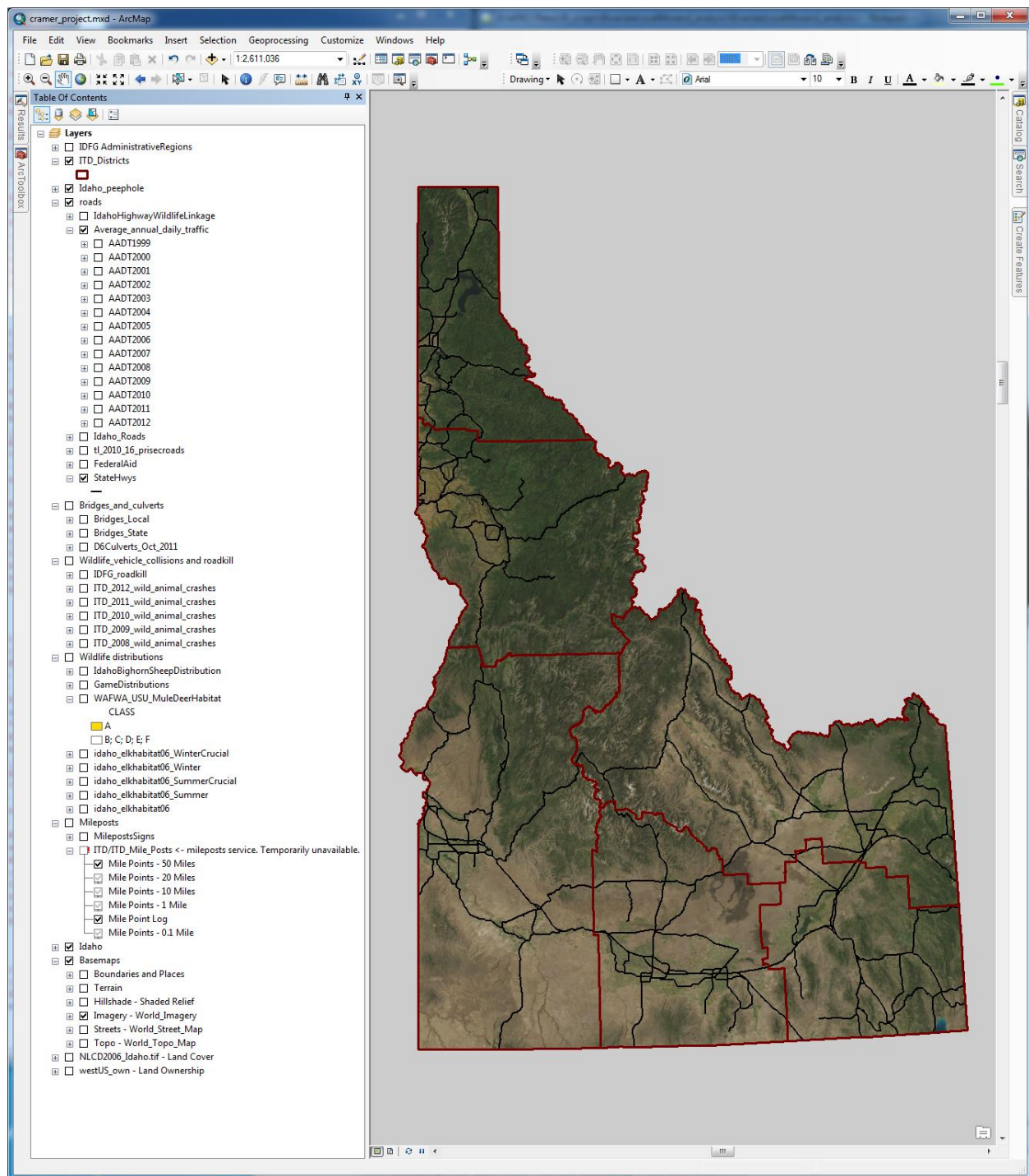


Figure 2. Screen Shot of MXD File Displayed in ArcGIS

Task 3. Development of the ITD WVC Prioritization Process

Objective

The research performed for Task 3 developed a methodology that ITD staff working with IDFG and other interested parties can use to identify problem corridors for WVC, determine priorities for mitigation measures, and identify cost-effective mitigation methods. The researchers gained an understanding of ITD's current project selection process and developed a methodology or process that ITD staff, working with IDFG and other agencies, can use to:

- Identify problem areas for large ungulates and bear WVC.
- Estimate the cost (medical cost of injuries, property damage and sportsman's animal value) of WVC at these locations.
- Identify cost effective mitigations measures.
- Perform a cost benefit analysis for the proposed mitigation measures.
- Establish priorities for mitigation efforts.

Methods

Development of this task involved geospatial data (in a GIS), and prioritization methods similar to methods developing in other states. Quantification of GIS layers was conducted to assess high WVC areas based on the geospatial data, and reviews/discussions with members of the TAC and several western state DOT personnel aided in the development of the majority of additional steps defining the prioritization process.

The geospatial data was used first to help identify and prioritize highway segments with highest priority WVC based solely on GIS data. This process first created a safety map and an ecological map. The two maps were then combined to create a statewide WVC priority areas map (Figure 3).

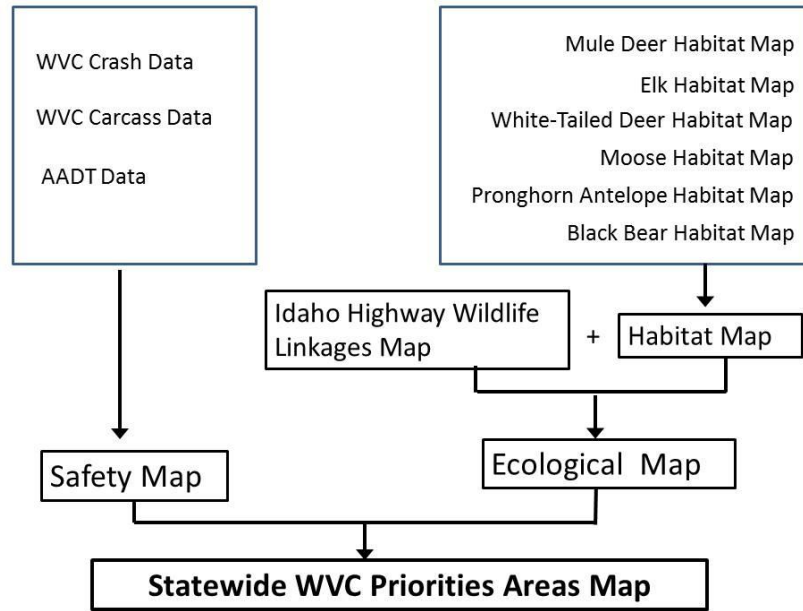


Figure 3. GIS Mapping Process to Create State Wildlife-Vehicle Collisions Priorities Area Map

Within the data of the map layers, each mile segment of every ITD administered road received points for safety and ecological data, for a total of 100 points. Statewide thresholds were created to identify the top 10, and then the top 15 WVC priority areas in Idaho. These were based on segments of road where every mile was evaluated in relation to other segments within five miles. When this was applied to the data for the top 15 priorities, the score criteria increased the lengths of 7 of the top 10 segments. The final score for such segments with multiple mile scores was the single highest score of individual miles. Appendix D goes into greater detail on how these rankings were created.

A second set of analyses then changed the threshold values for the points for each ITD district to find the top 4 priorities for each individual ITD district. This allowed every ITD district to view their top priorities in relation to the district without the rankings being overcome by high ranking areas in other districts, which is what occurred with the state map. Those differences in rankings are discussed below. Those district priorities were cross-referenced with the two district environmental planners on the TAC, Scott Rudel (ITD-D3) and Tim Cramer (ITD-D6), to help validate the process and find what could be improved about the final map output. Greater details are presented in Appendix D. TAC members gave input throughout this process.

Concurrent with the GIS data task for the prioritization process, the additional steps in the process were developed based in part on how other western states, most notably California DOT (Caltrans, and described by Research team member Sandra Jacobson in Appendix B), Arizona (AZDOT's Norris Dodd), Washington (WSDOT's Kelly McAllister), and Colorado DOT (CODOT, as described by Research team member Julia Kintsch in Appendix B) prioritized their WVC areas for mitigation. These steps were presented to the TAC and members gave input as those steps were finalized (Table 6). Full details on the

GIS methods are presented in Appendix D, and the prioritization process is presented more fully in Chapter 2.

Results

The processes in Step 1 developed a state-wide map with the top 15 (Table 4) WVC areas in need of mitigation based on geospatial data (Figures 4 and 5, and Appendix D). A second part to Step 1 was to create maps of all 6 ITD districts' priorities (Table 5 and see Appendix I for maps of each District. This was done to allow districts to see their individual top WVC sites based on similar rankings without the district sites becoming "overcome" by areas with higher reported WVC carcasses in other parts of the state. The name of each segment was created based on the following standard: Road Number-Nearest Town or Towns -Nearest Body of Water.

These maps were just an initial step in the WVC Prioritization Process. The user of this process would then proceed with the following steps presented in Table 6, and in greater detail in Chapter 2.

Table 4. Top 15 Wildlife-Vehicle Collision Priority Areas in Idaho
*All Scored 74 Points or Higher, Segment Defined as Miles Within 5 Miles of Milepost,
 Using a Moving Window Application. Rank Based on Top Score within Segment*

Ranking	Top Score Out of 100	Road	Milepost	ITD Maintenance District	Name
1	92	US-95	469	1	US-95 Cocolalla/Westmond/Algoma
2	90	SH-75	118 - 120 & 125 - 127	4	SH-75 Ketchum/Big Wood River
3	85	US-95	516 - 521	1	US-95 Indian Reservation/Kootenai River
4	84	US-95	488 - 493	1	US-95 Pack River/Elmira
5	84	SH-21	10 - 20	3	SH-21 Lucky Peak/Boise
6	83	I-90	37 - 44 & 47	1	I-90 Kingston
7	83	I-15	58 - 63	5	I-15 North Inkom/Portneuf
8	81	US-95	451 - 453	1	US-95 Granite/Cocolalla
9	81	I-84	176 - 179	4	I-84 Snake River Rim Special Recreation Management Area
10	79	US-95	193 - 194	2	US-95 Riggins North/Salmon River
11	77	US-95	208 - 218 & 220 - 223	2	US-95 Lucille/White Bird/Salmon River
12	75	US-30 & SH-34	US-30 386 - 387 US-30 399 - 400 US-34 - 50	5	US-30/US-34 Soda Springs*
13	75	US-2	76 - 77	1	US-2 Idaho - Montana Border
14	75	US-95	460	1	US-94 Careywood
15	74	US-95	422	1	US-95 South Coeur d'Alene

**Note: ITD mapped US-30 MP 388 to 399 with just 1 foot between mileposts*

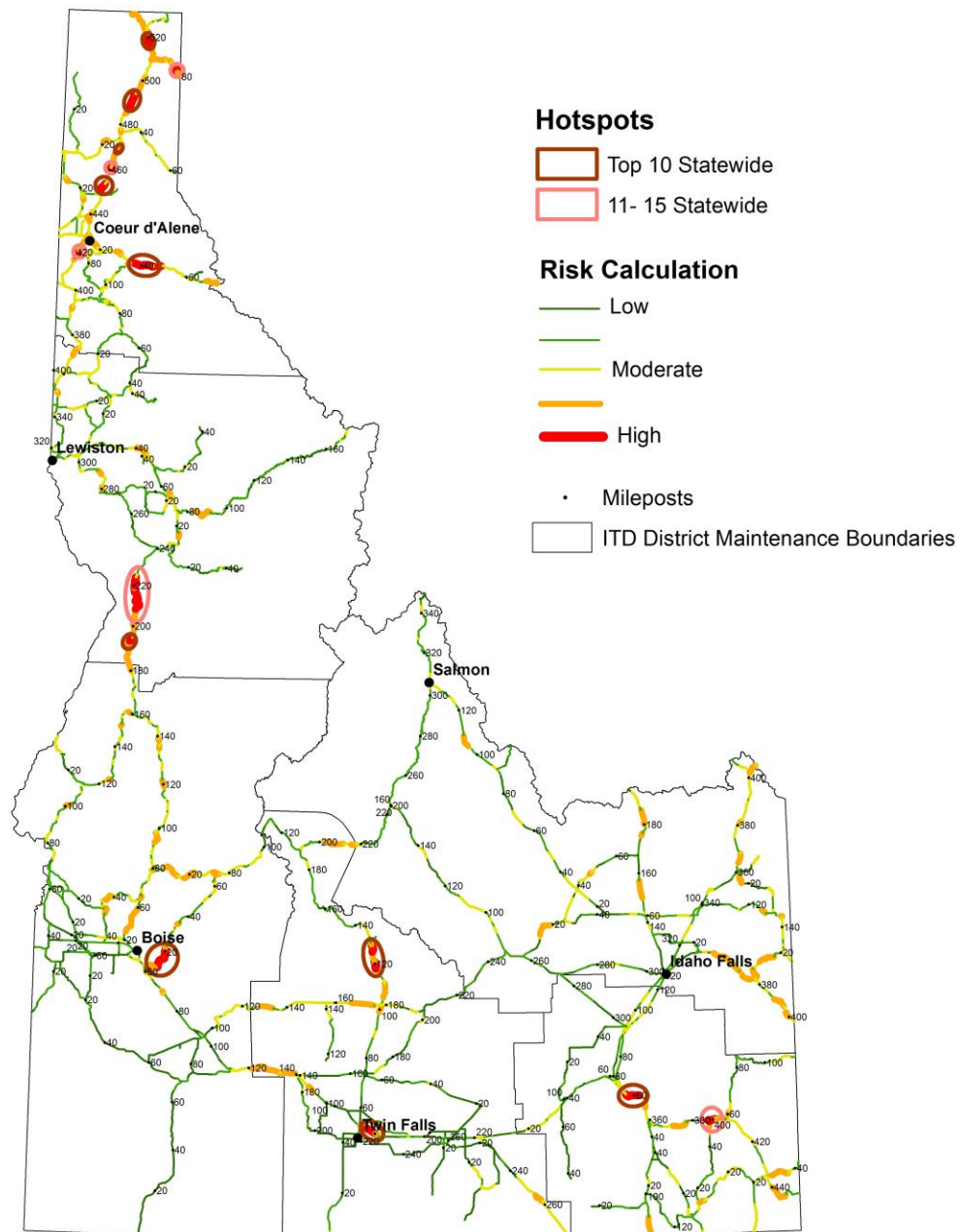


Figure 4. Highest State Priority Wildlife-Vehicle Collision Road Segments in Idaho Based on GIS Data

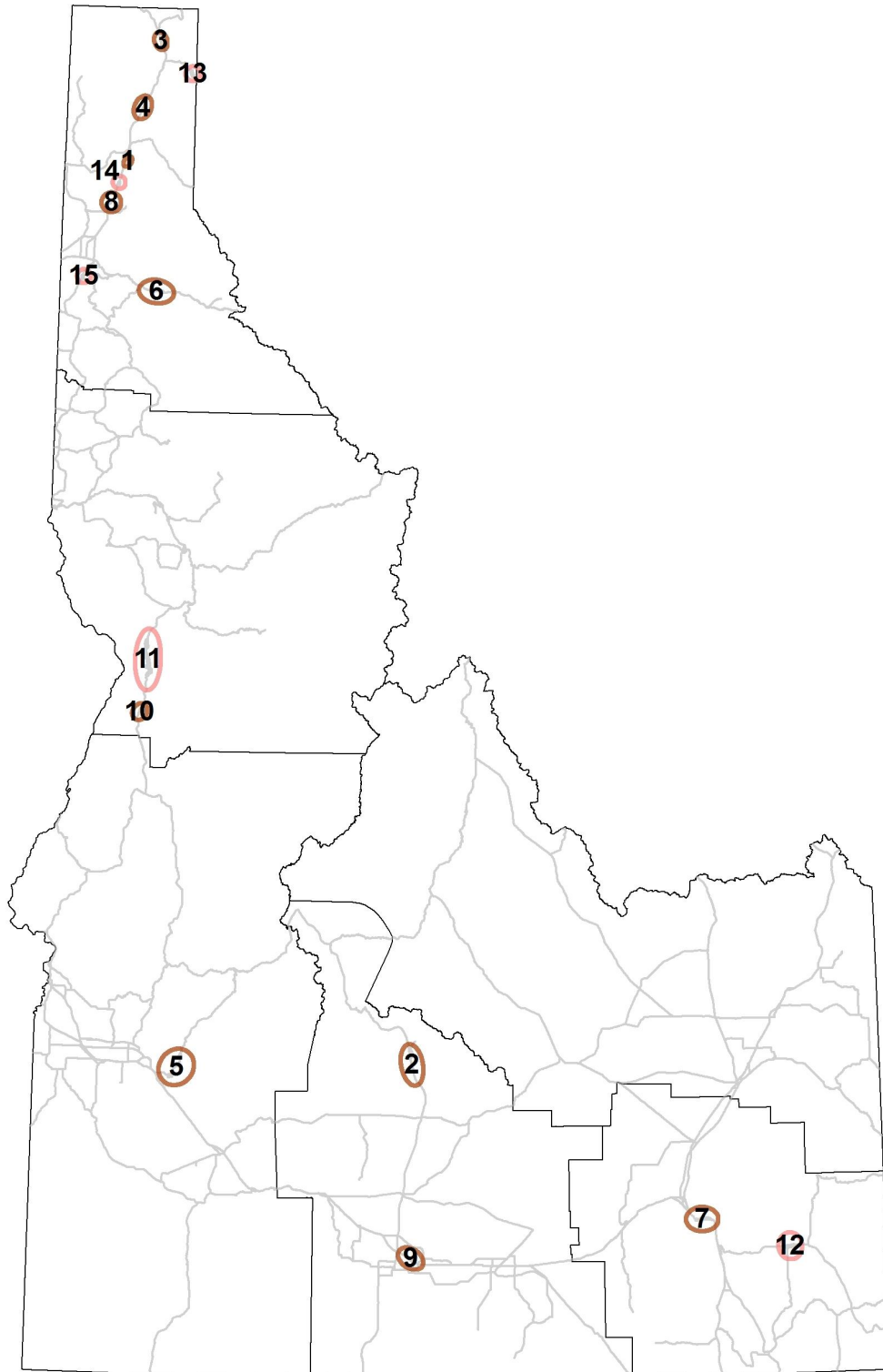


Figure 5. Top 15 Wildlife-Vehicle Collision Priority Road Segments in Idaho with Rankings Displayed

Table 5. Top Four Wildlife-Vehicle Collision Priority Areas within Each ITD District in Idaho

Ranking	Top Score Out of 100	Road	Milepost	Name
District 1 Score ≥ 82				
1	92	US-95	469	US-95 Cocolalla/Westmond/Algoma
2	85	US-95	516 – 518	US-95 Kootenai River/Indian Reservation
3	84	US-95	488 – 493	US-95 Pack River/Elmira
4	83	I-90	37 – 43	I-90 Kingston
District 2 Score ≥ 79				
1	79	US-95	191 – 194	US-95 Riggins-North/Salmon River
2	77	US-95	203 – 208	US-95 Lucille/White Bird/Salmon River
3	72	US-95	183 – 185	US-95 Pollock/Little Salmon River
4	70	US-95	198 – 199	US-95 Riggins/Lucille/Salmon River
District 3 Score ≥ 69				
1	84	SH-21	3 – 21	SH-21 Lucky Peak/Boise
2	70	SH-55	95 – 96	SH-55 Smiths Ferry
3	70	SH-55	135 & 138	SH-55 Lake Fork
4	69	SH-55	58	SH-55 Horseshoe Bend South
District 4 Score ≥ 70				
1	90	SH-75	118 - 120 & 125 – 129	SH-75 Obsidian, North & South
2	81	I-84	176 – 181	I-84 Snake River Rim Special Recreation Management Area
3	72	SH-75	108 – 110	SH-75 Ketchum
4	71	I-84	121 – 122	I-84 Twin Falls
District 5 Score ≥ 71				
1	83	I-15	58 – 63	I-15 North Inkom to Pocatello
2	75	US-30 & SH-34	US-30 386 - 387 US-30 399 - 400 US-34 50	US-30 & US-34 Soda Springs
3	72	US-30	371 - 372	US-30 Lava Hot Springs
4	71	US-30	444	US-30 Montpelier
District 6 Score ≥ 63				
1	70	US-20	381	US-20 Last Chance/Henry's Fork
2	67	SH-31	10 - 12	SH-31 Victor/Pine Creek
3	67	US-26	374 & 376	US-26 Swan Valley
4	63	US-26	357 - 360	US-26 Swan Valley/Birch Creek

Table 6. Wildlife-Vehicle Prioritization Process Steps
Maximum Score Potentials Described in WVC Prioritization Process

Step and Information Source	Evaluate	Maximum Score for This Step
Step 1. GIS Layers	Safety GIS Layer Total Maximum Points = 50	
	Idaho 2007 Wildlife Linkages Maximum Points = 30	
	Wildlife Habitat Maps Maximum Points = 20	
	Total Combined GIS Map Points (50 + 30 + 20) Maximum Score	100
Step 2. ITD-IDFG Needs Assessment ITD Districts	Work with IDFG to prioritize areas based on ecology not represented in Step 1 GIS analyses.	15
Step 3. State Objectives of the Proposed Actions	Clearly state objectives & performance measures of action.	No Points
Step 4. Land Ownership	Evaluate land ownership in the area for feasibility of creating mitigation in conjunction with protected lands.	5
Step 5. Evaluate Future Transportation Projects	Evaluate area in relation to projects listed in Long Range, STIP , Corridor Plans, & Projects. Look for potential opportunities to incorporate WVC mitigation actions.	5
Step 6. Look for Retrofit of Existing Structures	Analyze existing infrastructure for retrofits opportunities.	5
Step 7. Field Visit	Build consensus with public & private partners while visiting potential mitigation sites.	No Points
Step 8. Select Mitigation Type & Specifics	Choose mitigation in short-term & long-term based on WVC problem & possible solutions	No Points
Step 9. Conduct Benefit-Cost Analysis	Evaluate how cost-effective the mitigation is projected to be over life of infrastructure.	5
Step 10. Identify Potential Funding Partners	Work at district & state level to find public & private funders for mitigation	No Points
Step 11. Establish Performance Measures, State Constraints, Estimate Likelihood of Success	Define safety & ecological standards for success, estimate time, cost, cooperation constraints, & potential for success	No Points
Step 12. Annually Select District & State Priorities	ITD Districts select annual priority WVC priority segments for mitigation, Committee selects state priorities	No Points
Step 13. Announce State & District Level Priorities, Begin Mitigation Actions	Regular annual event where ITD-IDFG jointly issue press release on top projects to be constructed, & work schedules for completing projects.	No Points
Total Potential Points		135

Recommendations

Task 3 was the major accomplishment of this research project, and its accuracy largely relies on the accuracy of the GIS databases used to create the WVC priorities map. Future recommendations include:

- Fact checking by both ITD and IDFG to the validity of each GIS layer used.
- A new GIS-based and expert opinion “fact checked” wildlife linkages mapping effort based on empirical wildlife movement data and WVC carcass data that also standardizes the process for ranking wildlife linkages across the state.
- A continued dialogue among agency personnel that creates a continually updated prioritization process that adapts to the ever-changing data and technology available.
- The creation of performance measures that assist ITD in evaluating if this prioritization process was used at the State and District levels, and if it helped to create additional mitigation solutions to WVC across Idaho.
- ITD to develop a set of Best Management Practices (BMP) and guidelines for reducing WVC while promoting wildlife connectivity across or under roads. This would be a more formally developed set of guidelines that would be useful for planning and engineer teams. It would detail where different mitigation actions would work, where they should and shouldn’t be used and the pros and cons of each.

Greater detail on this task is presented in Chapter 2.

Task 4. Apply the Prioritization Process to Select Sites

Objective

The objective of this task was to apply the WVC prioritization process to select areas within Idaho to evaluate how well it could be applied in real world stations and to make changes to the process that would improve its performance.

For Task 4 we applied the proposed methodology to identify the high priority corridors for mitigation, to recommend mitigation measures at these sites, and improve the WVC Prioritization Process from lessons learned in this task. This task involved the following steps:

- Using available data developed in Task 2 and 3, problem corridors for big game WVC in ITD Districts 5 and 6 were selected and approved by ITD’s PM and TAC.
- Mitigation priorities based on the work performed were proposed. This included field verification of the sites with ITD and IDFG personnel.
- Based on this pilot test, gaps in the needed data and changes needed in the proposed methodology/process were identified.

Methods

High WVC sites identified in Task 3 were selected for this task through a conference call on November 25, 2013, with Patricia Cramer, Sue Sullivan, Caleb Lakey, and Brent Jennings. ITD District 6, based in Rigby, and ITD District 5 based in Pocatello were selected to visit several select district “hotspots” for WVC. This was due in part to the proximity of these locations to USU, and because District 6 priorities were under-represented in the statewide analyses; thus may have been overlooked if this task did not focus on some of those sites. The statewide analysis set a threshold of 79 points for sites to receive a high enough rating to be considered in the top 10 in the state. This was the number where 10 sites scored above, and the remaining sites were below. The bar was then lowered to a score of 74 points, to observe the top 15 sites. Again, this value was chosen when there were 15 sites that scored higher than this value. The top WVC priority sites were highly clustered in the northern panhandle of Idaho, ITD’s District 1. District 6 near the border of Yellowstone National Park had the least amount of sites in the state ranking. This was not for a lack of wildlife linkages identified there, or a lack of wildlife habitat. Rather, it was almost certainly due to the lack of reported WVC carcass data from ITD for that district combined with lower ranking of the wildlife linkages there because the wildlife linkage mapping process in District 6 was done prior to the statewide effort. Thus this task focused on areas in need of wildlife mitigation strategies that did not rank within the state prioritization but were tremendously important at local levels.

On December 2 and 3, 2013, Patricia Cramer worked with Tim Cramer, the ITD District 6 environmental planner to visit District 6 high priority sites along US-20, SH-87, and SH-31. On December 3, 2013 Patricia Cramer and Tim Cramer worked with ITD District 5 environmental planner Alissa Salmore in Pocatello ITD District 5, along with Becky Abel, Zack Lockyer and Don Jenkins of IDFG Southeast Region (Pocatello) to evaluate high WVC sites along I-15 south of Pocatello. The Passage Assessment System (PAS) evaluation sheets (Appendix F) were used along these stretches of road to evaluate how existing infrastructure could be retrofit for passage of large herbivores and bears, and to help make recommendations for future road projects to incorporate wildlife mitigation opportunities.⁽²⁾ Each road segment is presented in Appendix G. Throughout this task, the ITD PM and TAC members discussed the proposed process and provided feedback.

Results and Recommendations

Brief and specific recommendations for potential mitigation of each high WVC segment visited are presented in Appendix G. Several steps within the prioritization methodology were updated and improved after these field visits and input from the TAC. These include:

1. Users should examine carcass and crash data in early steps of this prioritization methodology, preferably in Step 2. Crash data will only identify if a wild animal was involved, not to the species. Carcass data can be identified to species and can help users determine the species most often involved in WVC, which in turn will help inform mitigation solutions.

2. After the user has identified the species most often involved in WVC in the road segment, they should work with IDFG and other natural resource agencies to learn if these animal movements are year round or seasonal. Seasonal and specific wildlife movements across roads could be partially mitigated for with driver warning systems, prior to adequate wildlife crossing structures built in future efforts.
3. Users of the WVC Prioritization Process will need to cross reference potential sites for wildlife crossing structures with land ownership records to capitalize on opportunities to protect critical wildlife passage areas. Knowledge of local land uses near these WVC priority areas is also critical in determining best mitigation strategies that may lie outside of standard practices and the prioritization process. As a result of this concern, the GIS team located a land ownership GIS layer that designates all land in Idaho according to private and public entities, and included it in the final MXD file for users. Further actions focused on land ownership could entail enlisting non-government organizations and local governments in helping to protect adjacent lands with conservation easements and land use zoning in wildlife crossing areas.
4. Estimating costs of mitigation efforts such as rip rap removal and placement of pathways under bridges, building new bridges, and building escape ramps, for example, can take a considerable amount of time. Users of this WVC Prioritization Process may not have access to professionals who have the time and ability to make cost estimates of these potential actions. As a result of the field work in this task and all the potential retrofits that were considered, the WVC Prioritization Process was altered to only classify potential mitigation costs into three categories, low, medium, and high, as estimated by the users.
5. Gaps in data that were identified during this research appear to be largely related to WVC carcass reporting and species habitat and movement maps. These data sources can be improved see Chapter 3 for details.

Chapter 2

The WVC Prioritization Process – A User’s Guide

Overview

The WVC prioritization process begins with the WVC priority “hotspot” map created in Step 1, and progresses with 12 additional steps. For a more detailed presentation of how the GIS maps were created and validated in Step 1, see Appendix D. Final maps are presented in Appendix I. This chapter presents details for users to progress through the next 12 steps after the map has been created and reviewed. In the mapping process it was found that each ITD district had different threshold values for the top four priorities. Therefore, a single threshold value for indicating a top priority road segment would not work across the state. Rather than setting a specific threshold value for a road segment to be considered a district priority, several road segments would have to be evaluated with this process in each ITD district. This combined evaluation helps to prioritize road segments in a transportation corridor, or among district WVC priority sites, or some other collection of road segments. In order to prioritize road segments in an area of concern, such as an ITD district, the WVC prioritization process needs to be conducted for more than one segment of road. Table 7 below gives an overview of how each step of the prioritization process is conducted during different phases of the transportation planning process. Table 8 can also be used as a future checklist for prioritization process users as they compare 3 or more road segments against one another for prioritization. The chapter ends with an example of how to apply the WVC Prioritization Process on three sample road segments.

Table 7. Prioritization Steps Maximum Points per Step, and In Relation to Transportation Planning Process Steps

Prioritization Step	Total Maximum Points	Long Range Planning 20 - 30 Years Ahead	Corridor or STIP Planning	Project Level Planning	Project Design	Maintenance & Operations
Step 1. Map Modeling of GIS Data from ITD & IDFG	100					
Step 2. Create Needs Assessment for ITD In Conjunction with IDFG	15					
Step 3. State Objectives of the Proposed Actions	0					
Step 4. Consult Land Ownership Maps	5					
Step 5. Evaluate Transportation Plans for Future Projects	5					
Step 6. Analyze Existing Structures for Retrofits	5					
Step 7. Build Consensus Through Field Visit	0					
Step 8. Select Mitigation Type	0					
Step 9. Conduct Benefit-Cost Analysis	5					
Step 10. Identify Potential Funding Partners	0					
Step 11. Establish Performance Measures, State Constraints, Estimate Likelihood of Success	0					
Step 12. Annually Select Projects at ITD & State Level	0					
Step 13. Announce State & District Level Priorities, Begin Mitigation Action Building	0					

Note: Table can act as a future checklist. Grey areas denote when the step would be applicable in the planning, operations and maintenance processes.

Table 8. Checklist for Evaluating Three Road Segments for Wildlife-Vehicle Collision Priority Ranking for Potential Action

Step	Definition	Point Value	Value Description	Candidate Site 1	Candidate Site 2	Candidate Site 3
Step 1. GIS Map Value	Take Numeric Value of Road Segment From Map	50 - 100	State Top 10: ≥ 79 Points			
			State Top 15: ≥ 74 Points			
			District Top 4 Priority: Variable Points			
Step 2. Needs Assessment	ITD In Conjunction with IDFG Give Points to Road Segment	0 - 3	No urgency, Low Rank			
		5 - 8	Some Urgency, Moderate Rank			
		10	Urgent & Moderate Rank			
		13 - 15	Urgent & High Priority			
Step 3. State Objectives	Objective of Mitigation for Each Road Segment	0				
Step 4. Land Ownership	Determine Public & Private Lands & Degree of Protection	0	Developed Private Land			
		3	Mix of Public/Private			
		5	Protected Public Land			
Step 5. Transportation Plans	Compare Location of Road Segment with Upcoming Projects	0	Segment is Not in Upcoming Projects			
		2	Segment is in Long Range Plan Future Projects			
		3	Segment is in Corridor Plan			
		5	Segment is in: STIP , ITIP , & Long Range Plans			
Step 6. Analyze Existing Structures for Retrofits	Evaluate Bridges, Culverts, Fences, & Terrain for Target Species' Movement	0	No Structures, & Topography Limited			
		2	No Structures & Terrain Suited for New Structures			
		4	Existing Structures &/or High Cost to Retrofit or Replace			
		5	Existing Structures Could Be Retrofit With Low Cost			
Step 7. Build Consensus	Invite Potential Partners to Site Visits	0				
Step 8. Select Mitigation	Select if It Will Be: Driver Warning, Fences, Crossing Structures, etc.	0				
Step 9. Benefit-Cost Analysis	Evaluate Potential for Reduction of WVC	0	Project Could Not Pay Off in 50 Years			
		3	Project Could Pay Off In 30 Years			
		5	Project Could Pay Off in 20 Years or Less			

Table 8 (cont.) Checklist for Evaluating Three Road Segments for Wildlife-Vehicle Collision Priority Ranking for Potential Action

Step	Definition	Point Value	Value Description	Candidate Site 1	Candidate Site 2	Candidate Site 3
Step 10. Identify Potential Funding Partners	Agencies, Non-Profits, Corporate, Citizens	0				
Step 11. Performance Measures, Constraints Likelihood of Success	Establish the Range of These Potentials	0				
Step 12. Annually Select Projects	At ITD & State Level	0				
Step 13. Announce State & District Level Priorities	Annually Make Selections & Begin Mitigation Action Building	0				

Step 1. Map Modeling to Create a Statewide Priorities Map

The processes used to develop the statewide priorities maps are presented in detail in Appendix D. This modeling exercise should be conducted annually to update the information and incorporate new data as they are developed. The future Interagency Wildlife Connectivity Committee would be the authority for initiating this effort, and for changes to the map modeling process.

During the development of Task 1, the research found commonalities among states in their mapping of WVC priority “hotspots.” These were incorporated into Idaho’s WVC Prioritization Process mapping step, and included:

1. WVC Crash Data.
2. WVC Carcass Data.
3. WVC Carcass Maps - See Appendix B for details and examples.
4. Average Annual Daily Traffic (AADT) Data.
5. Maps of Different Species’ Habitat (areas wildlife are known to reside).
6. Wildlife Linkage Maps. See Appendix A for publicly available software for these analyses and examples.

These map components are described in greater detail below to help the reader better understand the role of each data layer in the mapping process, and thus in the WVC Prioritization Process.

Wildlife-Vehicle Collision Crash Data

WVC crash data is collected under standard sets of conditions across a jurisdiction with little variation in collection effort, thus it is the most reliable source of data related to WVC. These standard conditions include the reporting of these data by safety officers of state highway patrols and other law enforcement, and typically mandate the WVC crash is recorded if the collision damage to the vehicle went over a monetary threshold for reporting, which is typically \$1,000 to \$2,000 U.S. dollars. These data are also helpful in judging monetary and human costs of WVC, because the extent of vehicle damage and human injury and death are also recorded with the crash location data.

Wildlife-Vehicle Collision Carcass Data Collection

To understand the magnitude and breadth of WVC it is necessary to collect carcass data in addition to WVC crash data. Virginia DOT (VDOT) found maintenance personnel reported over 9 times more white-tailed deer carcasses than traffic safety crash reports documented WVC on those roads.⁽¹⁾ Carcass data are typically collected by a department of transportation’s maintenance personnel, but can also be collected by outside contractors, wildlife agency personnel, and the public. Typically the species, age class, and gender are reported along with location. The accuracy of the data is partly dependent on how that location is recorded; the traditional method has been by recording the locations to the nearest 1/10th of a mile on paper sheets. New technologies are allowing these locations to be reported with Global Positioning System (GPS) coordinates that are taken with a GPS unit or even a smart phone.

The data are typically stored in the transportation agency's server, but some states have carcass mapping efforts outside of agencies.

Wildlife-Vehicle Collision Carcass Mapping

Mapping carcass data can be conducted as a single one-time effort with static maps, or with an "ongoing" dynamic mapping system that is defined by users. Research regarding ongoing-dynamic efforts conducted on websites found just 5 states where this was possible in 2013:

- University of California at Davis - Road Ecology Center Carcass Mapping Sites for California and Maine.
- Colorado's I-70 Public Carcass Reporting and Mapping Site.
- Utah's Smart Phone App That Immediately Uploads Carcass Data to a Protected Mapping Website.
- Idaho's Carcass Mapping Site.

See Appendix B for full details of all of the above. These sites allow users to define the spatial scale to view carcass data locations. In more advanced sites the data are clumped differently according to different scales. Other states have more locally driven mapping procedures that can be conducted by DOT personnel or the effort is conducted in a single project that produces one-time static maps, such as has been conducted in Oregon, Washington, and New Mexico (see Appendix B for map examples).

Average Annual Daily Traffic

The Average Annual Daily Traffic (AADT) is a representation of the barrier effect motor vehicles have in wildlife's ability to move over a road. While this can be mapped with specific numbers represented in different traffic classes, most transportation ecologists agree that it is not a direct relationship, and even low traffic volume roads can form barriers. At this time the Idaho AADT was mapped directly in different traffic volume classes, but in the future there may be a consensus on how AADT effects vary by road types.

Species Habitat Maps

Species habitat maps depend largely on what species a DOT is considering in its WVC prioritization process. In Ontario there are problems with smaller animals such as reptiles and amphibians killed on roads, so their mapping process involves animals other than those that pose a safety risk to motorists. Typically though, mapping concentrates on ungulates, especially deer, moose, and elk. Their habitat is typically mapped in large polygons representing seasonal ranges and the areas they need to migrate through to access those ranges. These data are typically very coarse and only general approximations. This is the case for the Idaho data on all species of importance to WVC. The species of greatest concern

for WVC receive higher rankings in a points system for their habitats. These data can be updated over the years as mapping procedures become more refined.

WVC prioritization processes in western U.S. states and Ontario were all funded or based within the departments of transportation. They were all part of ongoing processes that are continually updated and changed over time to best reflect new developments in wildlife concerns and the technologies that can bring large amounts of data together. The processes are described in greater detail in Appendix D.

Wildlife Linkage Maps

A third common feature in prioritization processes is the inclusion of maps portraying wildlife linkages. Most western states have created these maps through one or a combination of several processes. In the rapid assessment process, workshops of agency personnel and other concerned individuals were conducted to use expert opinions to help determine where sections of road were perceived to be a problem for different wildlife species' movements. In GIS modeling of maps, different software was used to find the theoretical linkages for target species. The publicly available software for these analyses are presented in Appendix A. Often map modeling through GIS is used in combination with expert review in a check and balance approach, which is similar to [Idaho's Wildlife Linkage](#) Maps (see the description of Colorado's approach for a more detailed review in Appendix B).

These databases and maps were brought together through GIS modeling to create the final WVC Priorities Map, Figure 6.

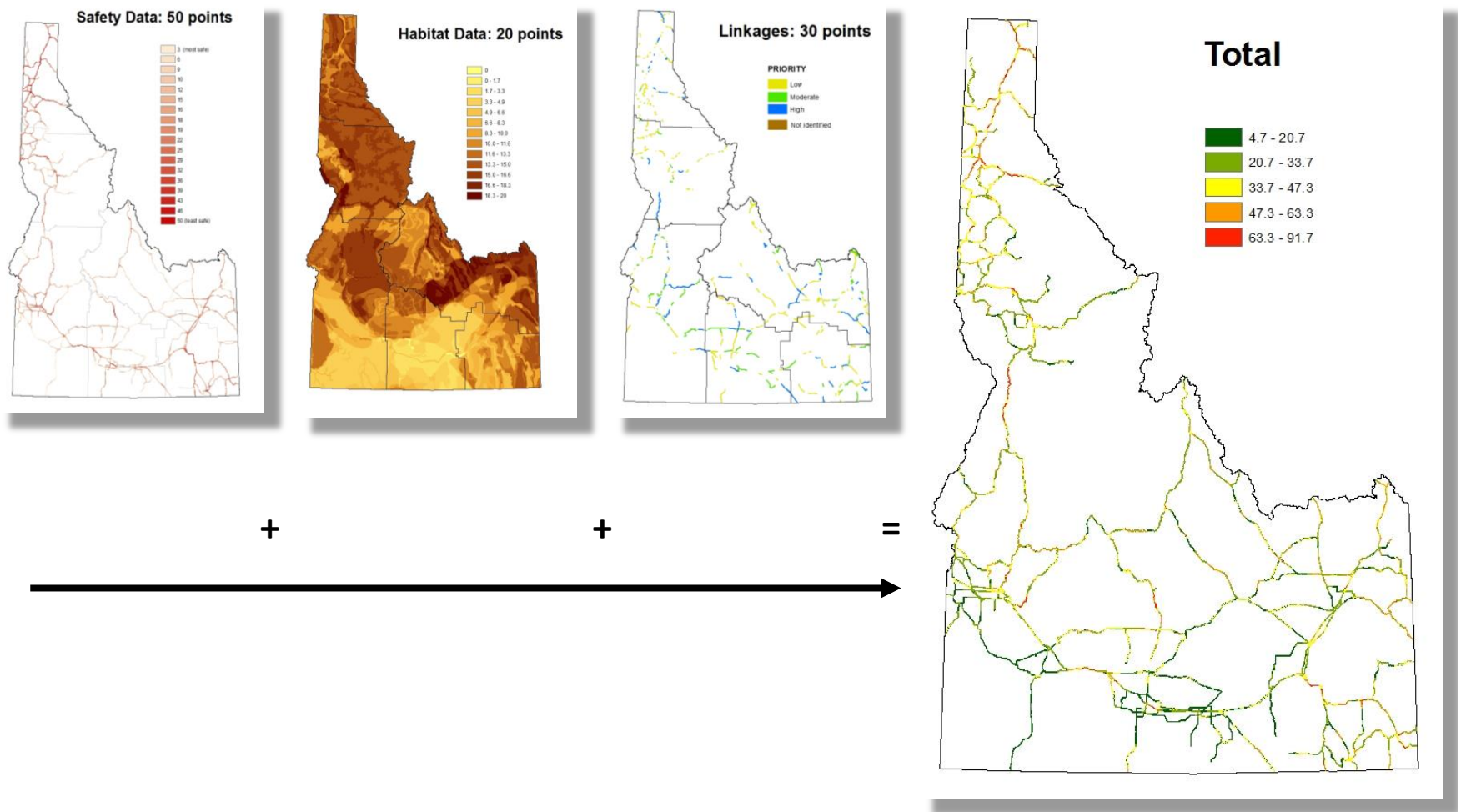


Figure 6. Three Layers of Maps that Were Brought Together to Create Final Wildlife-Vehicle Collision Priorities Map for Idaho

Step 2. Work with IDFG and Other Agencies to Form Needs Assessment Prioritization Document for ITD Districts and the State

Introduction

In Step 2, the objective is to receive wildlife needs input from outside of ITD to better inform the WVC Prioritization Process. The quantifiable value of this step is just 11 percent of the entire process. It is a safety catch for issues not reflected in GIS mapped data and the other steps. It helps ITD environmental planners integrate outside agency knowledge and needs into the process at the district and ultimately at the state levels.

This step allows for additional priority areas to be added to an ITD District's priority list that are not based on the mapping process in Step 1. The GIS mapping process was created without all the potential information on wildlife and transportation priority areas. For instance, Idaho does not have fine scale maps for each of the ungulate and bear species of concern in WVC. Other important wildlife, such as federally and state listed wildlife species will also need to be mapped and included in future WVC Prioritization Process iterations. In this step the process allows specific populations, and specific spots along roads at the ITD District level to be better evaluated. IDFG priorities would be ecological in nature, not necessarily based on upcoming road projects. In some ITD Districts IDFG staff has worked with the ITD environmental planners in creating such a priority list. This helps to make this standardized and bring wildlife data not mapped in Step 1 into the prioritization process. At the end of this part of the evaluation, a total of 15 out of the 135 total points in the WVC Prioritization Process are all that could potentially be added. At this point in the process, IDFG and other natural resource agency can give input yet it does not dictate what the ITD priorities will be. For instance, an ITD environmental planner may be comparing several different road sections for potential mitigation in an upcoming ITD project. This step helps the ITD planner bring in a quantitative ranking for each road section that reflects the wildlife agency's top wildlife priorities in the area. This step also helps IDFG personnel understand their role in providing input into future transportation projects.

Ranking areas in this part of the process at the state level would entail coordination from IDFG Headquarters throughout all IDFG Regions. This has been done in Utah with Utah Division of Wildlife Resources (UDWR) habitat section. It is possible IDFG could also coordinate with all IDFG region habitat biologists to contribute to an Idaho state list of top priority areas, as discussed at the ITD District and IDFG Regional levels. Threshold values for the statewide process will almost certainly be different among ITD Districts and IDFG Regions.

Rating a sole segment of road in this prioritization process does little to evaluate priorities as it is not possible to prioritize with just one entry to the process. *Therefore, the process described below is to be carried out on several different road segments within a district, or across the whole state, simultaneously.* As each district had different threshold values for the GIS mapping process, a common threshold value for a segment of road to rate as a priority would not work across districts. Each time the process is conducted on several different road segments, the threshold values for what becomes priority are different; it highly depends on the objectives of the person conducting the process. When it is

carried out at the state level, the Wildlife Connectivity Coordinating Committee should make a group decision on what the cutoff thresholds are, first for the top 10 state priorities, and then for the top 15 state priorities and further down the list. This will change from year to year.

Communicate ITD WVC Priorities Map to IDFG and Other Agencies and Develop a Needs Assessment

ITD environmental planners in each district and at the state level will need to come to a consensus on high priority WVC areas through the creation of a needs assessment document developed in conjunction with IDFG colleagues. The specifications on what that document would entail will need to be decided upon by the Statewide Interagency Wildlife Connectivity Committee. The way this document is created and its content are described below.

At each ITD District, the environmental planners will send the above GIS Statewide WVC Priorities Map to the IDFG regional wildlife manager who covers that specific ITD District. The IDFG regional wildlife manager will provide a wildlife mitigation priorities list in a needs assessment statement for each fiscal year. Step 2 is similar to what Utah DOT and Utah Division of Wildlife Resources do to gain consensus on priority areas. This helps ITD personnel know what is important to IDFG and for ITD to have some assurances they are also focusing their mitigation efforts based upon their partner agency's priorities.

The ITD personnel should also examine carcass data for the priority segments listed on the WVC priority map during this step to identify the species most often involved in WVC; this will in turn help plan for specific mitigation solutions. This exercise would also help the ITD personnel become more knowledgeable of the problem areas and allow them to ask IDFG questions as to potential creative solutions.

The GIS Statewide WVC Priorities Map developed in Step 1 could also be sent to state and federal natural resource agency personnel who could possibly be interested in wildlife mitigation on lands bisected or adjacent to ITD roads. This helps ITD plan for suites of species not accounted for in the mapping process but which may be of special interest to various agencies, such as the U.S. Fish and Wildlife Service. Although at this stage, the WVC Prioritization Process only involves ungulates and bears, in the future it may involve federally listed species. For the sake of the WVC Prioritization Process, the paragraphs below that better describe this step, describe only working with IDFG, but could also be followed for working with other agency personnel.

The Statewide Interagency Wildlife Connectivity Committee should also be involved in this process. There can be a parallel process for the state level examination of priorities and district level prioritization processes. The members of the Statewide Interagency Wildlife Connectivity Committee should also be examining state level mapping efforts to discern if they capture problem WVC areas of concern to committee members and their respective agencies or jurisdictions. These discussions should expand the qualifications of what constitutes a priority WVC area. Sheer numbers of crashes and carcasses are not the best qualifiers, and the topics below should play a role.

The Needs Assessment stage helps to define the boundaries of a WVC “hotspot.” This is important to the overall prioritization process. The mapping process in Step 1 was based solely on quantifiable map data. This research project did not define the boundaries of how large or small a WVC “hotspot” should be due to the natural variability across the state. With this flexibility in length of “hotspots” ITD environmental planners can work with other ITD and IDFG personnel in defining a length of road based on the natural phenomena occurring, upcoming ITD transportation projects, and potential solutions.

Criteria for Step 2 Evaluations

In order to standardize the process of including wildlife data not mapped in Step 1, the user of the WVC Prioritization Process will need to:

- Ground truth the areas of consideration.
- Consider urgent situations, labeled here as the Urgency Button.
- Consider areas where other entities may be looking for mitigation solutions.
- Consider Areas of Special Consideration that were not identified in the mapping process.
- Cross reference informative agency documents.

These steps are detailed below.

Ground Truth

All priority areas taken from the map need to be verified for accuracy. This would entail cross-referencing WVC carcass data, wildlife linkage maps, and visits to the site to assess what is happening on the ground, private land use and agricultural crops that may influence wildlife movement, and other factors not brought into the GIS map modeling. This allows ITD planners a fair degree of confidence in the priority area and begins to bring together the multiple factors that come into play.

The Urgency Button

The maps created in GIS are limited in their ability to show areas where wildlife populations are in danger of being extirpated. It is crucial that ITD and IDFG weigh assets of select wildlife populations that may be in danger due to WVC, but whose data were not included in the mapping process or are under-represented.

This involves looking at situations where the ITD District environmental staff and IDFG Regional staffs acknowledge problem areas that don't show up as “urgent” or priorities on the WVC priority maps. For example, the bighorn sheep population near Challis is in danger of its numbers dipping low enough that the population may have viability and stability issues (see Figure 7). However, this species isn't represented in current WVC priority maps, even though this population is exposed to higher than typical WVC (see next section for greater detail). This step requires both ITD and IDFG to concur on threatened wildlife populations subject to WVC that may jeopardize the remaining population. This step includes considering the following questions:

- Are there urgent situations in the district where large animal (for the purpose of this study but not limited to large animals in the future) populations are in danger of dying off in part due to WVC? Are there areas where the priority maps did not pick up the situation, such as a small population of animals with a significant proportion killed each year from WVC?

This also includes sensitive populations of animals that may be avoiding the road but need to cross it. These animals do not appear in WVC carcass or crash data, and are road-avoidance species like pronghorn antelope and grizzly bear.

- Are there populations whose numbers are so low that the road, vehicles, and fencing have worked with other factors to decrease the numbers so drastically that there are few carcasses from collisions to document the problem presently? For example, WVC on I-84 near the Idaho-Utah border may have decreased the Sublett mule deer herd to such low numbers that the WVC carcass and crash data has shown a steady decline along that stretch of highway. This may imply that there are no more problems, but it is more likely that the decline of the herd is actually so acute that we cannot rely on carcass/crash numbers. See maps in Appendix E for mule deer WVC carcass data, comparing data from 1967 to 2013 with data from 2011-2013: the mule deer carcasses on this stretch of I-84 have decreased.
- Are there areas where high tractor-trailer truck traffic is causing high amounts of WVC but because the data is not reported as crashes, our maps are skewed against this area? These problem areas would presumably be represented in the carcass counts, but due to less than uniform WVC carcass reporting among ITD maintenance districts, some areas may not be represented on the state-wide priority map. US-30 through Montpelier is an example of a similar situation that is urgent yet may not rank high in the state priorities. However, it did receive a priority ranking at the district level.
- Does the wildlife population in the area have an unusually large development that will impact it in the near future? This impacted area may work with WVC factors to cause serious declines in nearby ungulate and bear populations. In turn, the mitigation that this other development may be required to create could become wildlife crossing structures across the nearby road. For example, energy extraction activities such as mining and their concurrent roads, or pipelines and transmission corridors exacerbate WVC situations on nearby roads.⁽²⁾ The mining or energy companies may be required to mitigate for such situations and this could lead to a new priority area for potential wildlife mitigation on ITD roads nearby. These areas are also places IDFG should be viewing for potential wildlife mitigation, such as wildlife crossings. For example, in Utah, 2 separate mining-energy extraction roads on Bureau of Land Management (BLM) lands were required by UDWR to include 6 wildlife crossing structures on each road. These projects did not involve UDOT, but similar situations may occur in the future near state managed roads, thus invoking DOT involvement.

Migration Areas

Areas where wild large ungulates migrate across roads to access seasonal habitat are extremely important to the survival of those populations. These are areas the animals are known to reside in within Idaho. The mapping process in Step 1 did not incorporate migration corridors because habitat maps of such migrations are generalized. Some of these migration corridors are identified in the linkage analysis. It is critical to consider these migration areas by conferring with IDFG personnel, and in the future, incorporating migration maps in the GIS mapping process.

Areas of Special Consideration

The GIS research team took an extra step in this prioritization method and mapped areas of special consideration that were not included in the prioritization maps of Step 1 (Figures 7 and 8). These included areas where species data were not included in the original mapping due to the scope of the project original solicitation, and the limits on data on those species locations. These include:

- ITD District 1's MacArthur Lake corridor.
- District 4's Ketchum area elk linkage and high WVC area.
- District 6 bighorn sheep linkage and high WVC area near Challis (which was identified in the wildlife linkage analysis).
- District 6's documented grizzly bear road crossings on US-20 south of the Montana border and east of Yellowstone National Park.

ITD personnel will need to review these maps and future maps to help establish if there is a need to mitigate a priority area not displayed on the original WVC priority maps.

Documents to Cross Reference

Both ITD and IDFG could also cross reference state documents indicating areas of concern for wildlife in the face of transportation.

At the coarse scale, Long Range Planning Stage, refer to:

1. The [Idaho State Wildlife Action Plan](#) - the maps and goals in the plan help articulate areas important to wildlife according to IDFG.
2. [Western Governors' Crucial Habitat Assessment Tool](#) (WGA'S CHAT) developed maps of areas of crucial wildlife habitat and wildlife linkages. This is a coarse scale tool, with 3 mi² pixels. It is useful as a long range, initial planning document.

When a project is more specific and more fine scale data is needed, refer to:

1. [Wildlife Management Plans](#) - IDFG maintains plans for species of high priority, with maps on how those populations are to be managed. IDFG representatives would be knowledgeable in what plans would be most pertinent to specific areas.
2. IDFG data is available via their SHRP2 User Incentive and Lead Adopter projects. The ITD-IDFG User Incentive and Lead Adopter projects are collaborations among the agencies to both provide project specific data delivery to ITD for planning and project design, implementation, and mitigation as well as to update the working relationship between the agencies to help facilitate this. The Federal Highway Administration (FHWA) funding for these projects will allow IDFG to develop species and habitat specific data that is geospatially referenced and provided via ARCGIS online so that ITD and its contractors can plan, assess, and implement transportation projects as outlined in FHWA's Eco-Logical program. Such data will be regularly updated and pushed and/or consumed by IDFG and ITD's [IPLAN](#) application to provide readily accessible and useable data while reducing assessment costs and schedules.

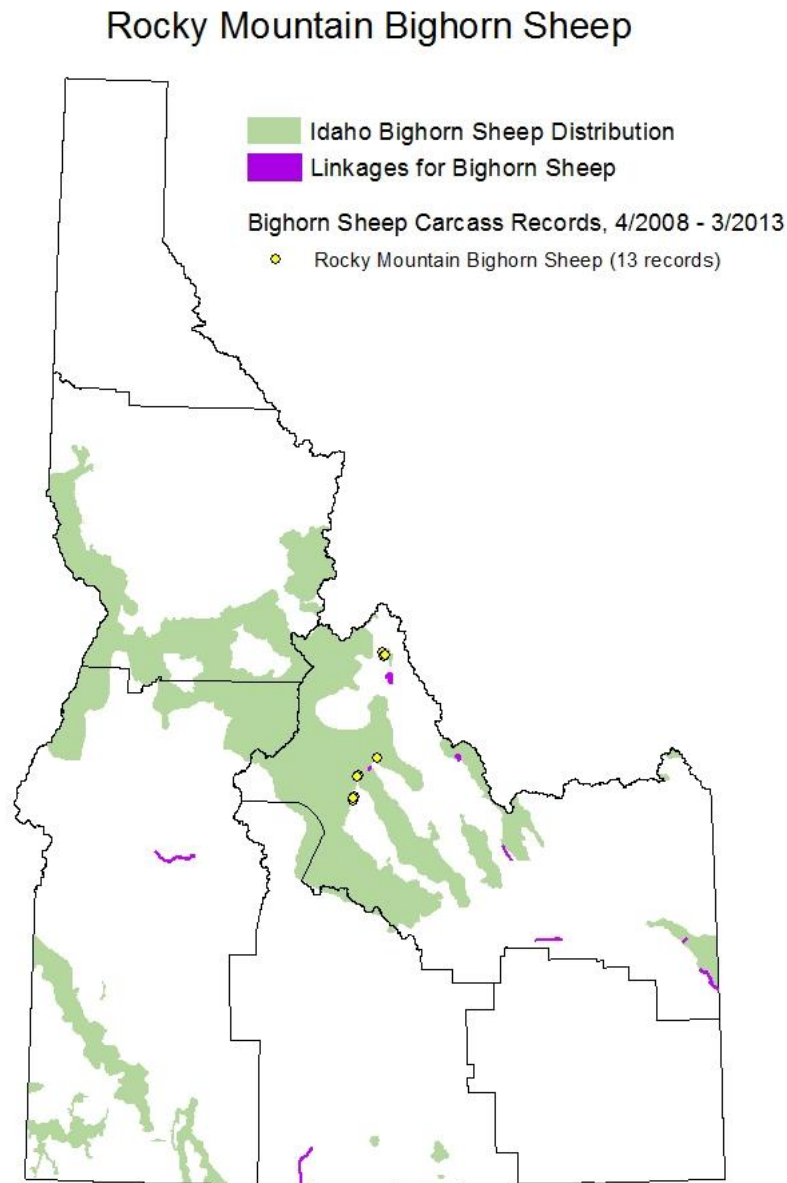


Figure 7. Areas of Special Concern for Bighorn Sheep WVC Priority Areas

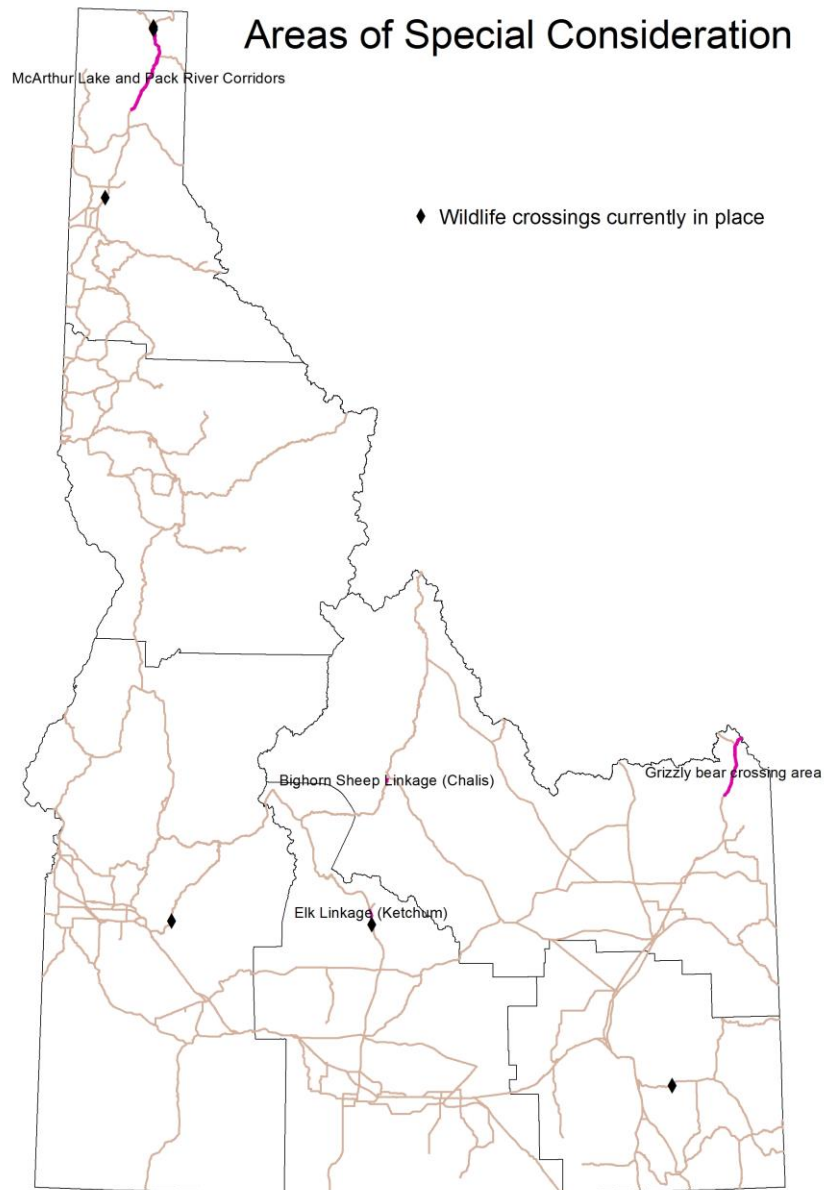


Figure 8. Areas of Special Consideration for WVC Priorities that Did Not Rank High in the Original GIS Analyses of WVC High Priority Areas

It is the role of ITD to then take these priorities and see how the areas can be included in upcoming projects, or addressed in stand-alone mitigation projects (Step 3).

ITD's District Environmental Planners will create a needs assessment for the district each year, with a list of top 10 priority areas based on both the ecological and WVC aspects presented in the GIS maps, and aligned with IDFG priorities.

Point Assignment

Urgency Value of a Segment of Road;

0 = No urgency in area.

5 = Some degree of urgency for wildlife and safety situation in area.

10 = Urgent situation, population of concerned species could be extirpated within 3 years. Three years is selected because the population numbers are low enough the population cannot recover itself to compensate for WVC deaths. In some slower reproducing species, this value may be 5 years.

IDFG Ranking of Road Segment;

0 = IDFG did not see area as a priority.

3 = IDFG listed this areas as a moderate priority.

5 = IDFG listed this area as a "Top 5" priority in ITD District.

Maximum Points for this Step: 15.

Step 3. State the Objectives of the Proposed Actions

The goal of all efforts connected with the WVC Prioritization Process is to reduce WVC with large ungulates and bear. This process is applied to different road segments simultaneously to see which areas are most urgent and cost-effective to create mitigation actions. There may be different objectives for different areas: on one road segment ITD may need to protect motorists from moose collisions while allowing the animals to move beneath the road; another road segment may need to pass thousands of mule deer on twice yearly migrations, while keeping the animals and motorists safe from one another. At this stage in the process, the user will need to define objectives of the mitigation actions needed for each road section in order to progress with options to meet those objectives. Those objectives will have to be stated in quantifiable ways so that performance measures can be applied to the final project to evaluate its efficacy in meeting those objectives. There should be three categories of objectives for a proposed project: Safety, Economy, and Ecological Considerations (See Appendix B, Sandra Jacobson's section titled, *Prioritization of Wildlife-Vehicle Collision Treatments*).

Objectives can be stated in a number of ways. Examples include:

- Reduce the WVC annual rate by 75 percent (Safety) while also passing 75 percent of the population of mule deer in the area under the road through the proposed wildlife crossing structures (Ecological) in a mitigation action that pays for itself in 40 years (Economic).

- Document at least 50 occasions when moose pass beneath the road under the new bridge structure (Ecological), and reduce moose-vehicle collisions to an average of 1 per year (Safety), and the structure is projected to be cost-effective over the life of the structure (Economic).
- Document an increased use of the new wildlife crossing structures and existing structures over 4 years as the mule deer and elk herds adapt to the wildlife fencing and structures (Ecological), thus decreasing WVC by 50 percent (Safety), and the bridge was found to be cost effective within 30 years (Economic).

These objectives will then be used to create performance measures in a later step. In turn, these performance measures will help ITD and partners judge if the project met or exceeded expectations. Rarely have WVC mitigation actions performed below expectations (author's experience).

Step 4. Examine Landownership Maps for Feasibility of Creating Mitigation Along Protected Lands

Users will need to examine the potential for installing wildlife crossings, fencing and other mitigation in an area based on land ownership. While some road mitigation such as driver warning systems may work on private land stretches, wildlife crossing structures are typically placed in areas where development will not occur. This does not preclude placing mitigation efforts adjacent to private land, but it is important that the land be protected from development in perpetuity. Counties may be important in future zoning actions in areas where wildlife connectivity across roads is crucial. Other states such as Montana have worked with land conservation groups to help secure conservation easements on such places. Users can access this information in ArcGIS in this project's MXD file. Users can also go to local and state land trusts and the Natural Resource Conservation Service (NRCS) to learn of existing or the potential for future conservation easements. This step also can highlight areas that are important for wildlife mitigation that could benefit from a partnership of other entities. Those partners could secure conservation easements or purchases on private land along roads that facilitate wildlife movement at future mitigation. The future Interagency Wildlife Connectivity Committee could be instrumental in both helping to identify these areas and raising support for partner activities.

Point Assignment

- 0 = Highly Developed Private Land.
- 3 = Mix of Private and Publically Protected Lands.
- 5 = Protected Public Land.

Step 5. Compare the WVC Priorities Map Transportation Plans to Determine if Mitigation Can Be Addressed in Upcoming Projects or Standalone Potential Projects

Step 5 looks to see how the WVC priority areas can be addressed within the context of future transportation projects, or if the priority areas require mitigation as standalone projects. Please note

that even if a priority area has no upcoming transportation projects, it still remains a priority. Once these data are gathered, the priority area will be addressed in the context of future projects or described in how the mitigation could be created as a standalone project. From this cross-referencing, the users of the process develop details on how the mitigation could be incorporated into a future project. This cross referencing typically occurs at the ITD District level of planning.

[Long Range Plan](#)

[Idaho Transportation Investment Program](#) (ITIP)

[Five Year Statewide Transportation Improvement Plan](#) (STIP)

The upcoming projects may not be in the direct area, but if within several miles of the WVC high priority area, the information from this process could inform the future project. For instance, in the 2013 - 2017 [ITIP](#) (Idaho's STIP), US-95 MP 196.725 in District 2, the Race Creek Bridge is scheduled for a replacement. This process could help ITD explore the possibility of making sure that bridge accommodates mule and white-tailed deer and other wildlife, because US-95 from MP 193 - 194 is the tenth highest ranking WVC priority area in the state, (see Table 1).

In District 3, the 2013 - 2017 STIP lists a Safety/Traffic project on SH-55 from Smith's Ferry to Round Valley, from MP 94 - 101. This straddles the district's second top ranked WVC priority area near Smith's Ferry, from MP 95 - 96. This upcoming project would be the prime time to incorporate structures or retrofit older structures and wildlife exclusion fencing to accommodate mule deer, white-tailed deer, elk, and moose beneath SH-55.

In District 4, the 2013 - 2017 STIP indicates that on I-84, MP 172.5 - 173.9 there is a planned Safety/Traffic project. This may pose an opportunity to add fencing to the area to funnel wildlife to potential bridges, improve or retrofit bridges for wildlife passage beneath the road, or some other WVC avoidance action. I-84 MP 176 - 179 is the ninth highest rated WVC priority area in the state, after GIS modeling in Step 1 was complete (Table 1).

In the 2013 - 2017 STIP, District 4 has an upcoming SH-75 Reconstruction project that has already begun. All bridges and potential places for bridges and culverts that could be retrofit or replaced to accommodate wildlife should be considered in this project between MP's 122.9 - 126.176. This area ranks as the second highest priority area for WVC from the GIS mapping of Step 1 in this process.

Also in District 4 on SH-75, the STIP indicated there was an Environmental Preservation project planned from Timmerman Junction to Ketchum Wetlands for a mitigation project, from MP 102 - 128. This area contains the two second highest ranked WVC problem areas in the state, based on the GIS mapping. Wildlife mitigation in the form of bridge and culvert structures that allow mule deer, white-tailed deer, elk, and moose movement are critical in this area and could become part of this project.

In District 6, a project was about to go to construction at the writing of this report, that was mentioned in the STIP that would have been a prime opportunity to incorporate WVC preventive actions into a project. SH-31, MP 9.472, the Pine Creek Bridge was to be replaced. This area was visited during the

development of the WVC Prioritization Process (see Appendix G). If this process had been in place during the planning of this bridge replacement, there may have been opportunities to access for terrestrial passage along earth pathways under the bridge replacement for mule and white-tailed deer, moose, elk, and other wildlife, and the placement of wildlife exclusion fencing leading to the bridge. This area is one of the top four priority WVC areas in District 6 as developed from the GIS modeling in Step 1.

Point Assignment

- 0 = No Projects.
- 2 = Long Range Plans.
- 3 = Corridor Plan and [STIP](#).
- 4 = [STIP](#) or [ITIP](#) and Long Range Plan.
- 5 = Project Plan.

This higher rating for project (5 points) helps the prioritization process to initially play “catch up” with projects that did not consider WVC mitigation potential. In future, these rankings should be changed to reflect a more inclusive transportation planning process. Thus, in the future, with no points for project plan, distribute the 5 points according to:

- 0 = No Projects.
- 2 = Long Range Plan.
- 3 = Corridor Plan.
- 5 = [STIP](#) or [ITIP](#), and Long Range Plan.

Step 6. Analyses of Existing Structures for Potential Retrofits along Road Segments - Office and Field Visit

In this step, the user looks at existing bridges and culverts to examine if there are opportunities for retrofit existing structures to improve wildlife permeability. Users should also assess whether topography and geology limitations are not too great to install potential bridges, or culverts, or fencing. In arid regions of the state, there will be fewer opportunities for retrofits of culverts and bridges, due to the lack of running water on the landscape. In these situations, any structures built for ranching and other agricultural operations would be of utmost importance for retrofits.

Examine GIS Layers for Bridges and Culverts

The user identifies existing bridges and culverts in the segment of road of interest using the bridges and culverts GIS layers (culverts were only available within ITD District 6 at the writing of this report) in the project MXD file. The user takes note of the culvert and bridge locations for field verification.

Field Visit to Examine Existing Infrastructure for Potential Retrofit for Wildlife Passage

ITD personnel will visit the priority segments of road being evaluated using a copy of Passage Assessment System (PAS) survey developed through a WSDOT led pooled fund to evaluate the potential for retrofitting existing infrastructure.⁽³⁾ This type of assessment is part of standard operating procedure for WSDOT biologists when examining potential for mitigation within a project corridor. The PAS is a question based survey that evaluates bridges, culverts, and fencing for potential small investment upgrades (retrofits) that could help enhance permeability of the road for different species. This step allows ITD to assess items to use with minimal investments that would assist in each situation. The PAS helps determine the cost categories and approximate maximum values necessary for building new wildlife crossing structures and related retrofits.

[PAS](#) is available on the WSDOT internet site and the forms are available in Appendix F. In coming years there will be a digital mobile version available at the completion of an FHWA pooled fund study underway in 2014 led by WSDOT. The PAS allows users to evaluate many attributes of these structures and to come up with a quantifiable ranking (numbers) for each structure and a list of potential retrofits that could improve the infrastructure for wildlife movements (permeability). See Appendix G for how this was done for high priority WVC sites in ITD Districts 5 and 6. This process provides a quantifiable method that can be repeated by environmental personnel familiar with how different wildlife species in Idaho react to different types of structures. For a review of the state of the knowledge on wildlife preferences, see Cramer et al.⁽⁴⁾ In the future, a full GIS map of all culverts in the state similar to the ITD District 6 culvert inventory will assist all ITD personnel in district and statewide evaluations of potential retrofits.

These sites can also be ranked for suitability and prioritization as initiated by AZDOT in a proposal for future actions.^(Norris Dodd, personal communication) AZDOT's system ranks existing structures for suitable passage, from a high score for bridges and culverts where species passage is already present and documented and appears to be suitable for target species to a low rating when the structures are greater than three miles apart and are not open enough for species' passage. This allows the planners/biologists to see how the existing structures could be minimally retrofitted and what areas need an entirely new structure to promote wildlife connectivity for the target species.

Point Assignment

- 0 = No Structures, or Structures Suitable But Greater Than 3 Miles Apart (Thus the Need for More Structures), and Topography Limits Types of Engineered Crossing Structure Solutions.
- 2 = No Structures and Terrain Suited for New Wildlife Crossing Structures.
- 4 = Existing Structures That Could Not Pass Many Individuals of the Target Species, Low Retrofit Potential Without Extensive Costs (< \$750,000).
- 5 = Existing Structures Appears Suitable and Can Be Retrofit with Minor Alterations Such as Rip Rap Removal, Paths, Fence Maintenance, Side Paths Under Bridge.

Step 7. Field Trip to Priority Segments

This step involves building consensus and partnerships for mitigation projects at the start of a prioritization process. This step does not necessarily lead to quantifiable results: thus there are no points assigned.

ITD District personnel should organize multi-agency and partner field trips to identify high priority WVC areas on specific roads where there is an immediate problem, or where there are upcoming opportunities for adding mitigation to future transportation projects. IDFG would need to strategize to determine if this would be developed from the state headquarters in Boise or the Regional level. The Interagency Wildlife Connectivity Committee would also be an entity that could coordinate and lead these opportunities. These types of field trips allow multiple questions to be addressed. Field trips also help to identify adjacent landowners, upcoming development projects that would affect future mitigation, geologic concerns, and the conservation priorities of the local community. Trips like these also helps ITD confer with IDFG on what type of mitigation opportunities may be best suited for the species and area. During Task 4, a small version of this field visit was conducted with ITD and IDFG personnel south of Pocatello, in the Inkom WVC high priority segment (see Appendix G).

Step 8. Select Type of Wildlife Mitigation Action

Once ITD planners and environmental staff have a better understanding of the potential problems with WVC, the ecological priorities, and potential opportunities and constraints; then the best wildlife treatment action type can be selected. While perhaps the most cost-effective solution to WVC may be to erect fencing, it is not by itself a viable alternative. Wildlife populations must move in order to survive; thus in almost all cases, wildlife treatment actions will involve wildlife overpass or underpass structures. Short-term and less expensive but smaller efforts could also be tried to reduce WVC in an area prior to the creation of wildlife crossings. These could involve slower traffic speeds enforced by law enforcement agencies, driver warning system, and end of fence cross-walks for wildlife in conjunction with driver warning systems.

Wildlife Mitigation Types

Wildlife mitigation actions are grouped into three categories and further explained in Appendix C. These include:

1. Treating areas near road through vegetation management or by keeping wildlife feeding stations away from road.
2. Influencing drivers with signs, animal activated warning systems, and reduced speed zones.
3. Influencing wildlife with wildlife exclusion fencing and wildlife crossings.

An overall list of potential mitigation solutions was presented in Chapter 1 and is reproduced below for ease of choice (Table 9). Mitigation or wildlife treatment actions will need to be based on the species involved with WVC; time of year; land ownership near the road, engineering, geologic, and landscape constraints; and the species of concern's ability to adapt to different types of structures to move below and over roads. It is important for the user of the process to examine the WVC carcass data to evaluate which species are the main species involved in WVC. After identifying the species most often involved in WVC within the road segment, ITD should work with IDFG and other natural resource agencies to determine if the movements of these animals are year round or seasonal. Seasonal and specific wildlife movements across roads could be partially mitigated for with driver warning systems, prior to adequate wildlife crossing structures in future efforts. Short term temporary and less expensive measures may be deployed first while more adequate mitigation is planned. See Appendix G for examples of how such recommendations were made for Districts 5 and 6.

If the personnel developing these mitigation measures are not familiar with how a particular species uses different types of wildlife crossings, they can reference Kintsch and Cramer, Cramer et al., and numerous studies and websites presented in Appendix B.^(2,3)

Table 9. Mitigation Options for Wildlife and Transportation: Low, Medium, and High Values of Difficulty in Deployment, Effectiveness, Use Across the U.S. and Cost

Measure	Difficulty In Effort & Time to Deployment	Effectiveness	Use Across U.S.	Cost
Public Awareness Campaigns	Medium	Largely Unknown	High	Low
Wildlife Crossing Zones with Reduced Motorist Speed	Low	Low - Medium	Low	Low
Static Driver Warning Signs	Low	Low	High	Low
Vegetation Management	Low	Low - Medium	Medium & Unknown	Low
Supplemental Feeding Away From Road to Draw Animals From Road	Low	Unknown	Low	Low
Variable Message Board for Drivers	Low	Low - Medium	High	Low
Reflectors, Whistles	Low	Low	High	Low
Wildlife Deterrent Devices Mounted on Roadside Posts That Produce Noise & Reflect Light	Medium	Low	Low	Medium
Boulder Fencing	Low	Medium	Low	Low
Thermographic Cameras to Detect Wildlife on or Near Road – Used in Vehicle or Along Road with Driver Warning System	High	Medium - 1 Study – Experimental	Low – ITD Districts 1 & 6	High, Future
Wildlife Fencing With Wildlife or Double Cattle Guards & Escape Ramps	Medium	High	High	Medium to High
Animal Detection Systems with Driver Warning Signs	High	Low - Medium	Low	High
Wildlife Crossing Structures With Wildlife Fencing, Escape Ramps & Guards	High	High	High	High

Details of and References on Effectiveness Presented in Appendix C

Wildlife Crossing Structure Spacing

Another important step in selecting wildlife treatment actions is answering the question, “What spacing is needed between structures to mitigate for a particular species?” This is a valid question that also needs to be expanded to the multiple species on the landscape; they are also affected by the wildlife exclusion fencing placed with wildlife crossing structures. Bissonette and Adair present a method to examine species’ size, home range size, and dispersal distances to compute the distance an animal would travel to find a crossing structure at a road.⁽⁵⁾ Basic generalizations taken from this are to space wildlife crossings no greater than the average distance the species travels in daily movements in the area of concern. For example, Bissonette and Adair estimated that wildlife crossing structures for white-tailed deer and mule deer should be placed no greater than one mile apart. Otherwise, the animals may not find the crossing structures, especially if the road and fencing are perpendicular to their direction of travel.⁽⁵⁾

These recommendations may be difficult for ITD to achieve, but in states where wildlife migrations are bisected by roads, these spacing distances and numbers are accepted. For instance, in the Pinedale, Wyoming area in 2012, WYDOT constructed 6 wildlife crossing underpass structures and 2 wildlife overpasses in a 12 mile stretch of US-191. These structures were monitored in 2013. In the first migration period (fall of 2012), 2,442 pronghorn antelope and 6,436 mule deer movements over and through these structures were recorded.⁽⁶⁾ In Utah, UDOT and UDWR added a 12 mile fence along US-89 near the Arizona border to help prevent mule deer collisions with vehicles and to guide the animals towards structures under US 89. The project included 3 existing culverts and 1 bridge as potential structures for mule deer to use as “de facto” wildlife crossings. UDOT then built 3 new wildlife culvert underpasses, for a total of 7 crossing opportunities for the migrating Paunsaugunt mule deer herd. In the first 76 days of the migration in the fall of 2013, over 3,000 mule deer passages were recorded through the structures.⁽⁷⁾

Large Herbivore Wildlife Crossing Structure Preferences

Research on large herbivore preferences for types of wildlife crossing structures is being conducted as of the writing of this report in all of Idaho’s neighboring states: Washington, Oregon, Nevada, Utah, and Montana. The results of these studies are ongoing, but several generalizations can be made of the different large herbivore species in Idaho and their preferences (see Table 10, below).

Table 10. Large Herbivore and Bear Preferences for Wildlife Crossing Structures in Western U.S. States

Species	Types of Structures It Has Been Documented to Use at High Levels	Recommendations
White-Tailed Deer	Most versatile large herbivore in the west will use bridges, culverts, & overpasses. In MT, Cramer et al. found they will pass beneath bridges as low as 4.5 ft high & 75 ft in span (wide). ⁽⁸⁾ They will readily use large (>10 ft high & 13 ft wide) culverts. More restricted culverts, ≤12 ft wide & high, have much lower success rates & use rates.	Culverts that are wide (>12 ft), but can be as low as 10 ft. The limiting factor is escape routes. If culvert or bridge is not high, it is especially important it is over 20 ft wide to allow escape routes. Bridges have the highest rates of success, typically 90 percent success rate or greater. ⁽⁸⁾ Keep culverts well under 200 ft long.
Mule Deer	Mule deer use culverts, bridges, & overpasses in all neighboring states. In UT, Cramer found that culverts should remain less than 140 ft long to ensure at least 75% of mule deer use them. ⁽⁷⁾ Bridges have high success rates, typically over 90%. Overpasses working well for mule deer in UT & NV. ^(9,10) Recent research on migratory herds of mule deer finds that one large structure in the path of the migrating herd may be more useful for mule deer migrations than several smaller structures across the road-migration area. ⁽⁷⁾	Overpasses work well for mule deer migrants. Underpasses of either culverts or bridges work well. Culverts should be less than 140 ft long to ensure success rates of 80% or more. Bridges should be at least 10 ft high, & wide to allow escape routes. Existing box culverts for farm operations & small roads may not allow mule deer to pass, due to their shorter height (8 - 10 ft) & short width (<12 ft).
Elk	Elk are one of the most wary ungulates in the west. Entire herds do not use culverts regularly, they are used by individuals & groups of <6, so should not be considered as an option. Bridged underpass structures can work. SH-21 bridge underpass outside of Boise was used by herds of elk (see Appendix H). Overpasses have been used by bull elk in UT, & very infrequently by solo cow elk. Also in UT, <20 cow elk movements were documented through all 38 structures monitored in a statewide 5-year study. ⁽⁸⁾ This is a very difficult species to convince to use structures near roads.	Overpasses in UT & NV have documented elk use, but numbers are less than 100 in the combined studies. Bridged underpasses are the only underpass option. Do not consider culverts for use by the majority of an elk herd. Culverts typically function for passage for only several individual elk through each year. Bridges can be as low as 10 ft high, as found in WA, but also make sure there is at least 100 ft in span (width of bridge) to allow for escape routes. ⁽³⁾
Moose	Rarely documented in any wildlife crossing studies. In UT, documented using a culvert only 13 ft high, 17 ft wide & 165 ft long, regularly (over 200 occasions when moose passed through, 82% success rate). ⁽⁹⁾ Documented to occasionally use bridged crossing structures in conjunction with streams in MT & UT. ^(8,9) <i>Note: in areas with top level carnivores such as wolves, moose may be less willing to use culverts due to the presence of predators.</i>	Bridged wildlife underpass structures work best. These are typically in conjunction with streams & rivers. May use culverts in ID, but would need to be studied. Not documented to use culverts in MT, making it more unlikely for ID. ^(8,7)
Pronghorn Antelope	Pronghorn are extremely wary & extremely difficult to pass herds under roads in any type of structure. May be the most wary large herbivore species in North America when approaching roads. Documented using overpass in NV & by the thousands on 2 overpasses near Pinedale, WY. ^(9,6) So resistant to crossing roads that this species has documented genetic isolation on 2 sides of a state highway. ⁽¹¹⁾ Recommendations across west call for overpasses. ⁽¹²⁾	Overpasses are the only option to pass herds of this species at this time. Several individuals may use a bridged underpass, or even occasionally a culvert. ⁽¹²⁾

Table 10 (cont.) Large Herbivore and Bear Preferences for Wildlife Crossing Structures in Western U.S. States

Bighorn Sheep	The second most wary large herbivore species in western U.S. when using culverts & bridges to pass beneath roads. Occasional rams will use bridged underpasses, but overpass is only mitigation proven to work for entire herds. ⁽¹⁴⁾	Overpasses are only option proven to work at this time. Overpass can be as little as 25 ft wide. See Arizona results for most up-to-date recommendations. ⁽¹⁴⁾
Black Bear	Black bear are very adaptable to different types of structures. In MT, approximately 65 black bear movements through structures involved culverts & bridges of varying size. ⁽⁸⁾ Culverts less than 12 ft wide did not have black bear use. In WA, dozens of black bear passes through a large (>15 ft high, >20 ft wide) culvert were documented under I-90 in just 6 months. ⁽³⁾ Heavily forested area, with no human development.	Bridge & culvert underpasses. Similar to mule deer preferences. Smaller culverts <12 ft wide have not been documented to pass black bear. Although they are predators, they also are wary of areas where humans could prey upon them, thus, areas with fewer humans & some cover work best for drawing black bear to a crossing area.
Grizzly Bear	Rarely documented to use wildlife crossing structures in the U.S. In MT, US-93 North of Missoula study has documented grizzly using large corrugated steel culverts. (P. Basting, MDOT, personal communication)	Culverts >15 ft in height & width, bridges, especially with water features. Although they are predators, they are extremely wary of humans & any development near a crossing structure.

Step 9. Benefit – Cost Analysis

Introduction

The prioritization process involves a benefit-cost-analysis (cost-benefit is typically used, here we name it as the equation is organized, and how FHWA uses the term) of the proposed wildlife mitigation actions.⁽¹⁵⁾ In a benefit-cost analysis, the division equation divides the benefits of the project by the cost of the project.

For example, Oregon Department of Transportation (ODOT) uses the equation:

$$\text{Benefit/Cost Ratio} = \frac{\text{Annual Benefits} \times \text{Present Worth Factor (10 - 20 years)}}{\text{Estimated Project Cost}}$$

If the quotient value (benefit/cost ratio) were less than one, the project would cost more than it would benefit. If the quotient value was one, it is a break-even situation. If the quotient value were greater than one, the benefits outweigh the costs. The higher the quotient value, the greater benefit the project provides in relation to its costs.

The benefit-cost analysis can also be used to evaluate how long it would take for a project to pay for itself or how much of a reduction in crashes the project would have to provide to pay for itself over the expected life of the infrastructure. The user will need to estimate the cost of action, and the saved costs to society from the action. Steps to create the costs and benefits are detailed below.

There are two main steps to a benefit-cost analysis:

1. Estimate the Cost.
2. Estimate the Benefits.

The sections below guide the user on how to quantify potential mitigation actions for this analysis.

Determine Benefit-Cost of Action

The cost of the proposed mitigation action is typically the one part of the equation that is established coming into this step. The costs of different options need to be determined in conjunction with ITD personnel familiar with the infrastructure or actions planned. This research did not establish typical costs of different treatment strategies because of continually changing prices in market fluctuations in materials such as concrete, steel, fencing, and technologies. General classes of costs, from low, medium, to high are presented in Table 10 to give the user a brief idea on treatment costs. In the cases below, the monetary benefits of the treatment action in reducing WVC can be quantified, and then used to predict how much money can be spent on the project based on how the reduction in WVC will help the project pay for itself over different time scenarios. This was done in the example prioritization process at the end of this chapter. For a brief example, if a project is predicted to save the motoring public and Idahoans 100,000 dollars per year on average, then in 10 years the project is predicted to save 1 million

dollars, and in 20 years, 2 million dollars. From these numbers, the user can then evaluate if the proposed action was in this range of cost, and then place a ranking in this step as to how well the project is expected to pay for itself.

Determine Benefits of Action

The benefits portion of the equation can be derived through several different methods. Typically, safety divisions within DOTs look at only the cost savings of reduced WVC, and do not give value to ecological factors. For now, this prioritization process will only give values to the reduction of WVC. In the future, ecological values of healthy herds of large herbivores and bear should be brought into the analysis. If these values are not incorporated, then simple barriers such as wildlife exclusion fencing would prove to be more cost effective than providing wildlife crossing structures. With only WVC being considered in a cost-effectiveness analysis, results should be viewed in context rather than solely as monetary values.

In order to estimate the benefits of a proposed mitigation project, the user would need to:

1. Estimate the current cost of WVC within the stretch of road.
2. Estimate the percentage in reduction of WVC the mitigation would provide.
3. Estimate the lifespan of the structure.
4. Then this value would be divided by the estimated cost of the structure.

To estimate the value of WVC on a stretch of road, there are several different methods, all slightly different and presented below. For this prioritization process, the “value” of WVC, better described as the costs of WVC to society are estimated. To create the WVC cost to society, the user will tally WVC crash data and add it to the estimated average annual cost of WVC carcass data (with crashes subtracted out). That value is then considered the average annual cost of WVC in the stretch of road. The reduction in WVC that the mitigation is expected to provide is then estimated and valued in monetary terms to provide the benefit portion of the equation. Specific sub-steps in this analysis are provided below.

Tally Crash Data and Estimate Cost of WVC Crashes

In this step the user will place a value on all reported crashes with wild animals in the stretch of road examined. The mitigation effort should be considered in the context of a stretch of road. This stretch should be at minimum a mile in length and extends to the length of wildlife exclusion fencing (or other types of mitigation) be placed with the planned mitigation. For example, in Utah, UDOT engineers performed a benefit-cost analysis (presented below) on 2 wildlife crossings placed with 20 miles of wildlife exclusion fencing along 10 miles of highway.

In Idaho, the user should cross reference the stretch of road with WVC Crash Data, using the online crash database, [WebCARS](#). Users should query the database for the past 5 years of crash data with wild animals: the database does not list the species of animal. Bayesian statistics, which are often used in traffic safety modeling, typically require the previous 5 years of data to predict future situations. The user then tallies the number of crashes reported to involve a wild animal which have occurred along that

stretch of road, while also tallying the severity of those crashes in terms of property damage, injuries, and/or fatalities. Users then tally the number of crashes within each of these categories for each year. The number of crashes in each category is then multiplied by ITD's 2012 average cost for those types of collisions in Table 11 below. The values represent the cost of reported WVC (crashes) per year on that stretch of road. For example, if there are no fatal accidents, there are no values tallied for that category; if there are 5 serious accidents, then the value is derived from $5 \times \$313,516 = \$1,567,580$ for that category of crash; then the number of visible injury accidents is valued, and so on until each category is given a monetary value for that year. The tallies are then added to find a final sum of values for all crashes with wildlife reported on that stretch of road for the year. The 5 years of data are then divided by 5 for an average cost per year.

Table 11. ITD Crash and Injury Type and 2012 Average Cost Estimates

Injury Type	ITD 2012 Cost Estimates (US Dollars)
Fatal	\$6,295,406
Serious	\$313,516
Visible	\$87,814
Possible	\$58,209
Property Damage Only (PDO)	\$6,739

Note: Table derived from data provided by Kelly Campbell of ITD'S Office of Highway Safety. Economic Cost Estimates of Crashes in Idaho will be conducted in the Future.

Tally Carcass-Based WVC and Calculate Cost of WVC Derived from Carcass Data

In this sub-step the user will place a value on the animals killed by vehicles but not reported in the crash data base but rather taken from the WVC carcass database. The user is instructed to look at latest IDFG carcass data for the selected stretch of road. Pull up the [IDFG website](#) and select for larger animals such as large ungulates and bear. Select for the past 5 years of data. Tally the total carcasses for each species for each year for that particular highway segment.

Compare the WVC crash data to actual WVC carcass data for each year on the stretch of highway. Subtract total WVC reported crashes from the total WVC carcasses for each year to estimate the number of unreported WVC. This is because it is assumed that when a crash happens with a wild animal, the carcass is not carted away immediately and is along the road for at least 24 hours and has a chance of being reported in the WVC carcass database. This approach prevents double counting. The resulting numbers for each year are the unreported WVC that will next be evaluated for monetary costs.

The Department could consider two approaches for estimating the cost of each accident that resulted in an animal carcass along the road from a crash that was not reported. Either the carcass can represent a collision and its combined costs, or the cost for the animal lost could be used. It is likely that carcasses

not reported in the crash data were those that either did not cause significant damage to motorists or property. As such, these carcass-based WVC monetary values are not as high as the average overall WVC value reported by Huijser et al. because more severe crashes inevitably involve highway safety personnel who report them.⁽¹⁶⁾ Table 12 below provides average values for WVC from various studies used in these types of analyses, should ITD decide to use one of these values to represent the unreported WVC that were derived from carcasses reported. These values are derived when all WVC data is combined, and reflect average costs of crashes with damages to vehicles and motorists. Because this step in the analysis involves only WVC that were unreported, the lower value of \$3,500 per crash should be used to estimate costs of carcass-based WVC.⁽¹⁷⁾ For each year of data, multiply the number carcass-based WVC by \$3,500 to find the cost of unreported WVC.

Table 12. Values of Average Estimated Cost of WVC, and Crashes with Property Damage Only

Reference	Average Cost in U.S. Dollars	Notes
ODOT Cost-Benefit Worksheet Value is Property Damage Only. ⁽¹⁵⁾	\$15,000	In a preprogrammed ODOT spreadsheet, this PDO average crash value was used for all WVC in a cost-benefit analysis. The worksheet did allow for estimates of more severe crashes, but none were indicated in specific case of the Lava Butte wildlife crossings near Bend, OR. See worksheet from 2008 that is placed on the ITD Research Reports Completed Projects website. This PDO crash cost is significantly higher than ITD's average PDO cost of \$6,739, see Table 11.
Estimates for North America Deer ⁽¹⁶⁾	\$8,388	This is the average cost estimated for all collisions with deer, it includes motorist injury & may include fatalities.
Estimate for North American Elk ⁽¹⁶⁾	\$17,483	This is the average cost estimated for all collisions with elk, it includes motorist injury & may include fatalities.
Estimate for North American Moose ⁽¹⁶⁾	\$30,760	This is the average cost estimated for all collisions with moose, it includes motorist injury & may include fatalities.
Utah Cost Estimates ⁽¹⁷⁾	\$3,500	This is the average cost of a WVC with a mule deer in Utah. It includes motorist injuries.

As an alternative, ITD could use the value of the animal to estimate the cost of these crashes. This would result in a lower value per crash. Idaho specifies values for large ungulates for use in penal cases. Table 13 presents the statutory values for the different ungulate species. It is suggested for every animal of the species found as a carcass, the average value of that species be used. If this approach is taken, each species' carcasses along the stretch of road should be tallied and then multiplied by the average cost from Table 13 to get a cost per species, which then would be combined for a total estimate of the cost of the WVC based on carcasses. This value will be much lower than the value derived from using the cost estimates of the crash in the above paragraph.

Table 13. Idaho Code, Title 36, Chapter 14 Values of Wild Animals in the Case of Penal Provisions

Species	Idaho Code, Title 36, Chapter 14 Values of a Single Animal, in US Dollars ¹	Average Value
Elk	\$750 Individual \$5,000 Trophy Animal	\$2,875
Bighorn Sheep Mountain Goat Moose	\$1,500 Individual \$10,000 Trophy Animal	\$5,750
Mule Deer White-Tailed Deer	\$400 Individual \$2,000 Trophy Animal	\$1,200
Pronghorn Antelope	\$400 Individual \$2,000 Trophy Animal	\$1,200

^{1.} <http://legislature.idaho.gov/idstat/Title36/T36CH14SECT36-1404.htm>

Estimate Costs of Reported WVC Crashes and Carcass-Based WVC for Past 5 Years

To estimate yearly costs of WVC in the stretch of road of interest, the user will add the monetary value of WVC crashes each year to the monetary value of carcass-based WVC. The user then can take those final costs for each year and average them among the five years to get an average annual cost of WVC in that stretch of road.

Estimate the Reduction of WVC Expected From Mitigation

There are 3 different levels of expected reductions in WVC from mitigation:

- 50 percent as used by ODOT in the Lava Butte Project near Bend, Oregon as derived from their benefit-cost analysis.
- 75 percent which is the typical portion estimated for most WVC mitigation.^(16,18)
- Or as much as 90 percent, which was the actual amount of WVC reduced in a project in Utah, described below.

The analysis can be performed with three different equations, each one with a different level of reduction of WVC. These different equations can then be instrumental in helping to decide how much WVC reduction is needed for the treatment to be considered effective. 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. Multiply this annual savings by the expected life span of the treatment. This can be 10, 20, upwards of 50 or more years. The final monetary value over these years becomes the benefit portion of the benefit-cost equation.

Annual Expected Savings = Percentage Reduction Expected x Annual Average Cost of WVC (\$)

Benefit of the Treatment = Annual Expected Savings (in \$) x Treatment Life Span in Years

For example: if a 5 mile stretch of road had an annual average of 30 mule deer WVC carcasses reported, and crash data reported an average of 5 crashes with PDO reported annually, and the 2 million dollar wildlife treatment and 5 miles of fencing was expected to last 50 years, the benefit-cost equations would be carried out in the several steps presented below.

$$\text{Annual Cost Of Reported WVC Crashes: } 5 \times (\text{PDO value } \$6,739) = \$33,695$$

Annual cost of unreported WVC as tallied from carcass data (30 carcasses - 5 crashes) = 25 WVC not reported but documented by carcasses on average each year. All were mule deer. The value of these crashes can be calculated two ways. The first method is to take a value for the unreported WVC from the Utah study, at an average of \$3,500 per collision: $25 \times \$3,500 = \$87,500$ annual cost of WVC with 25 mule deer.⁽¹⁷⁾ This value includes vehicle repairs and human injuries that were not reported to traffic safety. If only the value of the deer is considered, then the average value for a mule deer is multiplied by the 25 carcasses: $25 \times \$1,200 = \$30,000$ in WVC animal costs. The value of the 25 unreported WVC therefore lies between \$30,000 and \$87,000.

The expected reduction in WVC in the new stretch of road with the fencing and mitigation will be 75 percent. The expected annual benefit would therefore be:

$$0.75 \times (\text{crash cost: } \$33,695 + \text{animal and average damage cost: } \$87,000) = 0.75 \times \$120,694 = \$90,521.$$

If only the value of the mule deer were included for the WVC carcass data, the expected annual benefit would be:

$$0.75 \times (\text{crash cost: } \$33,695 + \text{animal cost: } \$30,000) = \$63,694.$$

If the lifespan of the structure and fencing is expected to be 50 years, then the benefit over 50 years if using the maximum cost for WVC carcass data, would equate to: $50 \times \$90,521 = \$4,526,025$.

If only the value of mule deer were used as the cost of WVC carcass data, the benefit over 50 years would be:

$$50 \times \$63,694 = \$3,184,700.$$

Divide Benefits by Costs to Evaluate Cost Effectiveness

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. In Utah, after 2 wildlife crossing structures and concurrent 20 miles of wildlife exclusion fencing (10 miles of highway, fencing on both sides) were in place for several years, UDOT performed a benefit-cost analysis in a slightly different method, see Table 14 below. The quotient was over 7, indicative of a rather large benefit-to-cost ratio. The UDOT engineers also conducted the evaluation to find the structures and fencing paid for themselves in less than 3 years. Users of the prioritization process are encouraged to work with the equations in manners

similar to this to evaluate how much of a percentage of reduction in WVC would be necessary for the structure to pay for itself, and how long it would take for the structure to pay for itself with different decreases in WVC over time.

$$\text{Cost Effectiveness} = \frac{\text{Benefit of the Treatment}}{\text{Cost of the Treatment}}$$

In our example above, the total calculated benefit when we used the maximum value for WVC carcasses was \$4,526,025 if the structure lasted 50 years.

With this value, the cost effectiveness, assuming a \$2M project = $\$4,526,025 / \$2,000,000 = 2.3$

The amount of time it would take for the structure to pay for itself would be calculated by:

$$\$2,000,000 / \$90,521 = 22 \text{ years}$$

If we used the lower value for a WVC mule deer carcass, the structure's cost effectiveness would be the total costs saved over 50 years, \$3,184,700 divided by the cost \$2,000,000 = 1.6. The structure would take 31 years to pay for itself.

These equations provide a standardized manner with which to compare several different values for WVC carcasses, projects, and treatment options. **In the case where the cost of the proposed treatment is not available**, then the predicted benefits of the project can be quantified over 20 to 50 years so the users of the process can provide data to engineers and planners knowledgeable of the costs of projects. This quantification of the **benefits** of treatment is more important in the negotiations of creating treatment actions than the estimation of cost estimates of the measures. The point assignment below can be adjusted for cases without cost estimates of the treatment by assigning a low, medium and high category for predicted payoff of treatment over time. See example at the end of this chapter to understand how the benefits could be projected over 10, 20, up to 50 years to get a general ballpark estimate of benefits and thus understand if the proposed project could pay for itself.

Table 14. I-15 Wildcat Wildlife-Vehicle Collision Benefit/Cost Analysis*

Prior Average Wildlife-Vehicle Collisions Per Year	265
Current Average Wildlife-Vehicle Collisions Per Year After Wildlife Crossings Placed	9.8
Net Average Reduction of Accidents Per Year	255.2
10% of Accidents Prevented at High Cost ⁽¹³⁾ = $25.52 \times \$8,388 =$	\$214,062
90% of Accidents Prevented at Lower Cost ⁽¹⁴⁾ = $229.7 \times \$3,500 =$	\$803,880
Estimated Annual Savings of Accidents Prevented (User Costs)	\$1,017,942
Total Initial Project Cost of 2 Wildlife Crossing Structures & Wildlife Exclusion Fencing	\$2,599.681
Payout Period for Wildlife Mitigation Slightly Under 3 Years, Benefit/Cost Ratio of 7.75	

* Analysis performed in 2012 by R. Taylor and M. Aldridge of UDOT for a 10 mile stretch of I-15 in southern Utah

Point Assignment

- 0 = Treatment cannot be predicted to reduced WVC over 20 years to pay for itself (ratio is less than 1)
- 3 = Treatment has high potential to pay for itself in 20 years with a 50-75 percent reduction in WVC (ratio is over 1, less than 5)
- 5 = Treatment has high potential to pay for itself in less than 20 years and with a 75 - 90 percent reduction in WVC (ratio is over 5)

Step 10. Identify Potential Funding Partners

As the potential problems and mitigation solutions become clearer, IDFG and ITD should work together to identify other partners willing to contribute not only funding, but necessary parts of the mitigation action solution. The future Interagency Wildlife Connectivity Committee would also play a role in developing partnerships in a proactive manner.

ITD environmental planners have learned that in order to see wildlife mitigation efforts to fruition, it often takes political and public support. For example Scott Rudel, the environmental planner in ITD's District 3, coordinated multiple partners to contribute funds for fencing and a wildlife crossing structure on SH-21, which was completed in 2010. ITD identified what could be accomplished with the resources available, then identified and approached various interested government agencies, non-profit groups, and others for the funds needed to complete the project. Another important component of the success of this project was the invitation to multiple key groups to come to the table and to make key decisions. After the completion of the wildlife crossing structure and some of the needed wildlife fencing, efforts continued for several years to raise funds for continued fencing of the project area.

A similar cooperative project was completed in ITD District 6, where Tim Cramer coordinated a multi-partner effort on the Targhee National Forest and Howard Creek fish passage project. Several agencies contributed money to assess the size and cost of structures needed to pass fish. The structures built allowed for natural fish passage up and down the stream. The agency partners were involved in survey and hydrology work along with the development of the National Environmental Protection Act (NEPA) document.

In Utah, the UDOT and UDWR partnership was able to secure funds from Arizona Game and Fish Department to assist in wildlife mitigation constructed in 2013 along the Arizona-Utah border for the Paunsaugunt mule deer herd. The wildlife mitigation was also supported with funds from sports groups such as the Mule Deer Foundation and Sportsmen for Fish and Wildlife for fencing and research, archeological surveys of the site from the BLM Grand Staircase Escalante National Monument, and double cattle guards from Kane County. In Colorado, the push for 1 or 2 overpasses over I-70 led to the formation of a non-profit entity, the [Rocky Mountain Wildlife Bridge Company](#) that can take donations from the public and jump start the funding process.

In other places, non-profits have been involved in securing conservation easements in areas on either side of wildlife crossing structures. This step points back to the importance of involving these potential partners early in this prioritization process. If ITD were to come to these potential partners with the decisions already made, the partners would be less likely to find funding. This part of the process gives greater validity to Step 5, where partners come together for a field trip to identify potential solutions. Projects with partners outside of ITD who are willing to contribute funds or in kind expenses would be ranked more highly in the process, but at this time we do not quantify those partnerships.

Step 11. Establish Performance Measures, State Constraints, and Estimate the Likelihood of Success

Performance Measures

It is prudent to create performance measures for wildlife mitigation projects. If only safety values are considered, success by just reducing WVC in an area could be achieved by fencing. If wildlife permeability and survival were also a consideration (which should always be the case), then a fence alone would not be appropriate, but wildlife crossing structures or retrofits of existing structures along with fencing and escape ramps becomes the appropriate mitigation strategy. To create performance measures we begin by framing the standards for success in these prioritized areas: do we want to just reduce WVC, or do we also want wildlife to move to necessary habitat to survive? These are typically detailed in levels of success:

1. Reduce WVC by a percentage somewhere near 75 percent.
2. Reduce WVC and pass a certain number of individuals of the target species annually.
3. Reduce WVC, pass certain numbers of target species, while also passing the majority of population of target species with different age and gender classes all using the structure.
4. All of the above performance measures plus evidence that the structure is passing a diversity of the species in the area, typically mainly mammals.

Success could also be defined by how effective the project is in garnering funding partners and those partners' commitment to supply the necessary supplemental funds to complete the project.

Constraints

Constraints for transportation are typically cost and time, but can also include landscape, wildlife populations, and maintenance concerns. It is important that the constraints of a potential project be listed so that it is understood how time and cost play a factor in bringing the project to fruition. If funding for a project is not available for a long period, as in over 20 years, the area's wildlife treatment could be put on a future priority list. If the best area for mitigation is not on public lands, as preferred,

but where land is privately owned and not protected from development, then additional land acquisitions or easements may be required. If the wildlife population has low numbers or shifting ranges then additional studies may be needed. If the fencing, culverts or other infrastructure proposed are too costly to maintain due to factors such as snowfall, sediment fill from waterways, or impediments to regular maintenance and operations then the project design may need to be altered. Readily presenting constraints helps all to understand how the predicted difficulties will be overcome for eventual success.

Estimate the Likelihood of Success

Estimating the likelihood of success is a difficult exercise at best. In order to build a community of trust among ITD personnel and members of various organizations, it is crucial that developers of a project for wildlife be upfront with possible limitations to the process and overall success. Stating how the project will be evaluated by performance measures and revealing constraints, the ITD user of this process should show the financial, time, political, and ecological limitations of the project in order to help all involved parties understand what is possible and what is not.

Step 12. Annually Select Projects at ITD Districts and State Level

In the states with dozens of wildlife crossings, a common feature is the regular meeting of the transportation agency and the wildlife agency to discuss wildlife and road issues. This is typically done at both the headquarters and individual DOT district levels. ITD and IDFG should host an annual, semi-annual, or even quarterly meetings, to review and rank priority areas for wildlife mitigation actions in the state, pursue potential funding options, and for all to learn about what has worked and not worked throughout the state. Each ITD District could create their list of “Top 3” priority areas which would be discussed at the regular meetings of the committee. The committee could coordinate how those areas may be built into upcoming projects, and help coordinate actions between ITD Districts and IDFG Regions. This process could also be conducted bi-annually or as ITD sees applicable, but without a commitment to an annual process there is a danger the focus will be lost statewide.

Step 13. Announce District and State Level Priorities, Begin Mitigation Actions

It is at the ITD District level where action happens, but it may become the role of the personnel at the headquarters of ITD and IDFG to make the Districts and Regions aware of priority areas and raise public support. Actually selecting priority areas and then taking these priorities to the next step of planning, constructing, and monitoring these structures would be the responsibility of the specific ITD Districts. Annually, ITD could release a list of the top wildlife mitigation priority areas for the state based on the input from each district. A press release with maps and stories of these situations could be delivered to the press.

Example on How to Compare Three Road Segments with the WVC Prioritization Process

Below is an example of how to apply the WVC Prioritization Process, and is intended to help the user understand its proper application. Three different road segments within a single ITD District are described for their WVC challenges, and potential solutions. These situations are theoretical in order to demonstrate how different WVC situations can be compared for prioritization.

Candidate Site 1

Site 1 is a typical Idaho WVC problem area: mule deer migrate across the road twice a year as they move to seasonal habitat. It ranked the third highest site within the District, with a GIS map score of 75 points (Step 1). IDFG has conducted a Needs Assessment with ITD and the area is urgent enough and important enough to receive a ranking of 13 out of 15 points for its need (Step 2). The objective is to funnel the majority of the herd beneath the road to prevent 90 percent of the average WVC annually (Step 3). Land ownership is public lands on both sides of the road (Step 4). This 10 mile segment of road is not in any of the ITD transportation plans (Step 5). There is one existing agriculture culvert in the study area, but it would not suffice to funnel all the animals (Step 6). The mitigation selected for this site includes retrofits to the existing culvert, 2 new bridged underpasses, 1 new culvert underpass, and 8 miles of fencing, both sides of the road, for a total of 16 miles of wildlife fencing (Step 8). In this one 10- mile stretch, there is an average of 30 mule deer carcasses recorded each year, and 10 WVC crashes with property damage, and 2 crashes with visible injury reported on average yearly (crash and carcass data, Step 9). The cost of the 2 bridges, 1 culvert, 1 retrofit culvert and fencing is estimated to be in the range of 4 million dollars (very high cost) (Step 9).

The benefit-cost analysis would be calculated in the following manner:

- Through meetings with ITD and IDFG and other agency personnel, it was decided the mitigation action would be expected to reduce WVC by 90 percent within 3 years. Use 0.9 as multiplier for percent reduction in crashes and carcasses.
- The property damage crash cost savings on average would be 90 percent of 10 = 9 collisions x \$6,739 PDO = \$60,651.
- The visible injury damage cost savings per year would be 90 percent of 2 = 1.8 x \$87,814 = \$158,065.
- The 30 carcasses per year would need the crash data subtracted out: 30 - 12 = 18 WVC carcasses. These then would be reduced by 90 percent: 16.2 collisions per year would be prevented. These are the WVC not reported because carcasses represent unreported collisions. There are now 2 different ways to place a value on these prevented collisions, either with a value of \$3,500 taken from research in Utah that includes human injuries for the average, or a value of \$1,200 which only represents the average value of a mule deer to IDFG and residents of Idaho. For the higher value, the 16.2 prevented WVC equate to \$56,700 annually.⁽¹⁷⁾ For the value of only the animal's worth to Idaho, the benefit would equate to \$19,440 annually.

- Add the average annual benefits: $\$60,651 + \$158,065 + \$56,700 = \$275,416$.
- If the cost of \$4,000,000 is divided by \$275,416 we would get a value of 14.5. This is how many years it would take the structures and fencing to pay for themselves.
- If we used the lower value for the carcass data, the average annual benefits would be: $\$60,651 + \$158,065 + \$19,400 = \$238,116$. For this value, we calculate years to payoff: 16.8. With either calculation of the value of the WVC carcass collisions, this site would payoff in less than 20 years and thus receives the highest ranking for the benefit-cost analysis.⁽⁵⁾

This site received a final score of 102 points out of a possible high of 135 points. These points are meaningless until the other sites are scored for comparison.

Candidate Site 2

Site 2 has a mixture of species that have been involved in WVC. There are mule deer, elk, and moose in the carcass database. Upon further inspection, it appears the animals are involved in WVC seasonally, when they come down to this lower elevation road site during colder winter months. The segment of road that would be in need of mitigation is a two mile area where wetlands and other natural features bring together a “perfect storm” of wild animals and the road. IDFG and ITD have not ranked this area as the highest priority, but give it a medium rank (Step 2). The road stretch has public lands nearby with private lands that could not be developed due to the wetlands nearby and topographic conditions (Step 4). The road stretch does appear to have a project for repaving in the area in the long range plan (Step 5). Because of topographic constraints there is a low chance of installing a bridge to accommodate these ungulates in the near future (Step 6). Due to the lower numbers of animals recorded killed here, it is understood this area would not be considered a high enough priority for a structure built for an underpass. However, ITD is willing to look at placing a driver warning system in the area seasonally to slow drivers and prevent WVC (Step 8). The crash data finds an average of less than one crash reported each year on average, and this is only for property damage crashes. No other crash types were reported. The carcass data query finds an average of 1 moose, 2 elk, and 5 mule deer are killed in this stretch each year (Step 9). The cost of this driver warning system is not known, but in an effort to create a benefit-cost analysis, the value first of \$500,000 then a value of \$1,000,000 are evaluated to see where a “break even” value would need to be in order for the benefit cost equation to have a quotient of 1 or greater.

The benefit-cost analysis would be calculated in the following manner:

- Through research of other driver warning systems in similar terrain, and an inter-agency meeting between ITD, IDFG and other involved agencies, the driver warning system is expected to decrease WVC by 50 percent.

- The property damage annually is: for simplicity, we will take the fraction and round up to one. If WVC reduction is expected to be 50 percent, then 0.5 WVC property damage crashes per year: $0.5 \times \$6,739$ for property damage crashes = \$ 3,370 saved in WVC property damage crashes per year.
- Annual carcass summary: 1 moose, 2 elk, 5 mule deer. This amount needs one WVC reported crash subtracted out. Since a larger animal WVC is more likely to be reported, we shall subtract out 1 elk WVC carcass, for an annual average of 1 moose, 1 elk, 5 mule deer.
- For each species type of WVC to be reduced by 50 percent, this would equate to: one half moose, one half elk, and 2.5 mule deer WVC carcasses less each year on average. The values of the individual animals would then equate to:
 - Moose is valued at: $\$5,750 \times 0.5 = \$2,875$
 - Elk is valued at: $\$2,875 \times 0.5 = \$1,438$
 - Mule deer is valued at: $\$1,200 \times 2.5 = \$3,000$
 - Total value for only the animals killed in WVC from reported carcass data: \$7,313 is predicted to be saved each year, to the public, for animals not killed as a result of the proposed mitigation action. This value does **not** include the values for the collisions, such as vehicle repair, towing, and carcass removal.
- Total annual estimated monetary benefit of proposed wildlife treatment action:
 $3,370 + 7,313 = \$10,683$.
- If the value of the mitigation action cost is not known, the user can take the annual savings value and multiply it by how many years the action is expected to last to see what the total cost savings would be (benefit part of equation). For a driver warning system, the length of time these have been placed on the landscape is less than 10 years. This kind of information is learned by the user conducting some research on the action. If the driver warning system was expected to last 10 years, it would provide a benefit of $10 \times \$10,683 = \$106,830$.
- The user would need to find out general ballpark estimates for what driver warning systems cost. The threshold value would be the benefit over 10 years, just over \$100,000. If the driver warning system costs more than this, then the mitigation action would not be expected to pay for itself.
- This is an example of how the user can predict benefits, and without the knowledge of the exact cost of the mitigation action, can make an educated guess on if the mitigation would pay for itself in 50, 30, 20 or less, so the user can assign a point value.
- For this example, the mitigation action of a driver warning system would not pay for itself in the amount of time it would last. The benefit-cost point assignment would then be zero.
- The final score for this site is 76 points.

Candidate Site 3

Site 3 is seen by ITD as a priority area within the ITD District, and ranked 77 points in the mapping process (Step 1). There are mule deer and elk movements and WVC collisions in the area. The regional IDFG biologists have not weighed in as to the urgency or need for wildlife treatment actions for this site (Step 2). Since their input was critical to Step 2, the ITD Environmental Planner went to the 2007 Idaho Wildlife Highway Linkages documents and found this area to have a moderate rating for a wildlife linkage. With this limited data, the ITD Environmental Planner gives this area a score of 8 out of a possible 15 points for Step 2. The land ownership in the area is a mix of private and public (Step 4). The area is in a potential project in the Long Range Transportation Plan (Step 5). A field visit finds there are 2 existing concrete box culverts 10 ft x 10 ft and 120 ft long. These are considered large enough and short enough to pass the mule deer in the area, and thus could be retrofit for this species (Step 6). The elk almost certainly will not use them and thus a bridge will need to be built for their passage (Step 8). These retrofits of existing structures with a high cost bridge are ranked in Step 6. The placement of fencing to the existing culverts and a new bridge are expected to be a high cost, from 1 to 2 million dollars (the specifics of the fence and structures are intentionally left vague at this point, Step 9). An analysis of the WVC crash data finds that over the past 5 years an average of 3 property damage crashes, 1 possible injury accident and 0.75 visible injury accidents occurred. Through discussions among agency personnel and a review of similar wildlife treatment actions in areas comparable to the site, the intended mitigation action is expected to reduce WVC in the area by 90 percent. The carcass data reveals an average of 7 mule deer carcasses and 3 elk carcasses per year (Step 9).

The benefit-cost analysis would be calculated in the following manner:

- The new bridge and fencing to existing structures are expected to decrease WVC by 90 percent.
- The crash costs expected to be decreased on average annually are calculated for each crash type. If WVC reduction is expected to be 90 percent, then 0.9 WVC property damage crashes per year: $0.9 \times 3 \times \$6,739$ for property damage crashes = \$ 18,195 saved in WVC property damage crashes per year. There will be a 0.9×1 possible injury crash $\times \$58,209$ average per crash = \$52,388 savings per year. There is an expected savings of 0.9×0.75 visible injuries per year $\times \$87,814$ per injury crash = \$59,274. The total cost savings annually is expected to average: $18,195 + 58,209 + 87,814 = \$164,218$.
- The AVC crash data documented an average of 4.75 collisions annually in this stretch. Since there are more mule deer collisions, subtract 3 WVC from the mule deer carcass data. Since elk are typically larger than deer and cause greater damage, subtract the injury crashes from the elk data, for a total of 1.75 from the elk carcass data.

- The annual cost per animal lost as estimated from the carcass data would be: 90 percent x number of animals on average killed annually x the species' value. For mule deer this would equate to: $0.9 \times (7 - 3 = 4 \text{ deer carcasses}) \times \$1,200 \text{ per animal} = \$4,320$. For elk this would equate to: $0.9 \times (3 - 1.75 = 1.25 \text{ elk carcasses}) \times \$2,875 \text{ per animal} = \$3,234$. Total average annual cost of animals lost to WVC = $\$4,320 + \$3,234 = \$7,554$.
- Total annual estimated monetary benefit of proposed wildlife treatment action: $\$164,218 + \$15,322 = \$171,772$.
- If just using this savings value, it is evident this mitigation action could pay off costs of 1.71 million dollars in 10 years ($\$171,772 \times 10 \text{ years}$). In 20 years it could pay off $\$3,435,440$ in costs. The user of this process could then go to engineers and planners and present these data to support the creation of mitigation that would be considered in the high values. With these savings, the ninth step in the prioritization process could rank this candidate project the full five points for this step.
- The final score for this site's project is 99 points.

All Candidate Site values were inserted into Table 15 below for a final prioritization ranking for each candidate project. The total scores allow a quantitative method to evaluate these different projects with different costs and projected benefits. Candidate Project 1 is ranked as the highest, with Candidate Project 3 a close second. If there had been theoretical input from IDFG on Candidate Project 3, it may have ranked as the top project. These candidate projects were theoretical to pose different types of situations ITD environmental planners may encounter in the process. From these quantifications, ITD District planners and ITD statewide planners can decide where their money is best spent to reduce WVC in Idaho.

Table 15. Example of Three Road Segment Sites Compared with the Wildlife-Vehicle Collision Prioritization Process

Step	Definition	Point Value	Value Description	Candidate Site 1	Candidate Site 2	Candidate Site 3
Step 1. GIS Map Value	Take Numeric Value of Road Segment From Map or Attribute Table	50 – 100	State Top 10: >73 Points	75	63	77
			State Top 15: >63 Points			
			District Top 4 Priority: Variable Points			
Step 2. Needs Assessment	ITD In Conjunction with IDFG Give Points to Road Segment	0 – 3	No Urgency, Low Rank	13	8	8
		5 – 8	Some Urgency, Moderate Rank			
		10	Urgent & Moderate Rank			
		13 – 15	Urgent & High Priority			
Step 3. State Objectives	Objective of Mitigation for Each Road Segment	0				
Step 4. Land Ownership	Determine Public & Private Lands & Degree of Protection	0	Developed or Potential to Be Developed Private Land	5	3	3
		3	Mix of Public/Private			
		5	Protected Public Land			
Step 5. Transportation Plans	Compare Location of Road Segment with Upcoming Projects	0	Segment is in: No Upcoming Projects	0	2	2
		2	Segment is in: Long Range Plan, Future Projects			
		3	Segment is in: Corridor Plan			
		4	Segment is in: STIP , ITIP , & Long Range Plans			
		5	Segment is in: Upcoming Project			
Step 6. Analyze Existing Structures for Retrofits	Evaluate Bridges, Culverts, Fences, & Terrain for Target Species' Movement	0	No Structures & Topography Limited	4	0	4
		2	No Structures & Terrain Suited for New Structures			
		4	Existing Structures and/or High Cost (>\$750,000) to Retrofit or Replace			
		5	Existing Structures Could Be Retrofit w/Low Cost			
Step 7. Build Consensus	Invite Potential Partners to Site Visits	0				
Step 8. Select Mitigation	Select If It Will Be Driver Warning, Fences, Crossing Structures, etc.	0				

Table 15 (cont.) Example of Three Road Segment Sites Compared with the Wildlife-Vehicle Collision Prioritization Process

Step	Definition	Point Value	Value Description	Candidate Site 1	Candidate Site 2	Candidate Site 3
Step 9. Benefit-Cost Analysis	Evaluate Potential for Reduction of WVC	0	Project Could Not Payoff in 50 Years	5	0	5
		3	Project Could Pay off In 30 Years			
		5	Project Could Pay off in 20 Years or Less			
Step 10. Identify Potential Funding Partners	Agencies, Non-Profits, Corporate, Citizens	0				
Step 11. Performance Measures, Constraints, Likelihood of Success	Establish the Range of These Potentials	0				
Step 12. Annually Select Projects	At ITD & State Level	0				
Step 13. Announce a State & District Level Priorities	Annually Make Selections & Begin Mitigation Action Building	0				
Total Points		Max = 135		102	76	99

In Summary

This WVC priority process is considered a dynamic partnering opportunity, and as such, it is conducted annually. **Step 1, the “Map Modeling Process” should be conducted each year**, and then additional steps carried out annually with this updated data. This document should be considered a living document, something to be updated in future projects. It should allow input from ITD users to adaptively manage the process.

Other components of the inputs to this process should be updated as required. ITD’s linkage analysis maps for wildlife connectivity workshops were conducted in 2007 and are due for a revamp in 2014 with more updated data and tools. AZDOT and WSDOT can be considered to have the most advanced, institutionalized prioritization methods, and they both have very scientifically based wildlife linkage analyses conducted at multiple scales. Idaho would need to plan on such an analysis for future prioritization. Standardized GIS modeling techniques for assessing wildlife connectivity are presented in Appendix A. With a newly updated wildlife linkages mapping process and this published WVC Prioritization Process, Idaho would then lead the way for all other states with its standardized, documented, and carried out processes of wildlife linkages and WVC Prioritization Process.

Chapter 3

Conclusions and Recommendations

In conclusion, this research provided a robust stepping stone along the path to enable wildlife passage across Idaho's roads. This research incorporated many databases and information from both the transportation and ecological perspectives. The consensus on this work is that it is a beginning, and the WVC Prioritization Process can be updated in the coming months and years. This will reflect more up-to-date concepts, accurate information, and methods. Perhaps the major conclusion of this research is that ITD is dependent on its sister agency IDFG in order for this WVC Prioritization Process to work. This means IDFG is responsible for significantly increasing its involvement in ITD's transportation planning. In the future IDFG will need to develop data that represent where large ungulates and bear are known to reside near roads and thus be most susceptible to WVC. This will greatly inform the WVC Prioritization Process. IDFG at the state and regional level will need to be involved in transportation planning by meeting with their ITD counterparts at least quarterly. For their role, ITD will need to foster productive collaboration with IDFG for the above work and to actually make wildlife mitigation happen across the state. This WVC Prioritization Process will be a failure if it does not result in dozens of new wildlife mitigation measures in the next decade. Idaho is poised to create many opportunities to demonstrate how wildlife can be accommodated along transportation corridors. Both ITD and IDFG are capable of and need to make these changes in the coming year. Once this WVC Prioritization Process is finalized, it is time for both agencies to act! Suggested future steps are presented below.

Top Priority – Interagency Wildlife Connectivity Committee

It is prudent for Idaho to organize a standing "Interagency Wildlife Connectivity Committee" that oversees statewide priorities, and to form similar temporary committees that oversee individual projects. These groups would involve ITD, IDFG, federal landholders, interested public and non-profit groups, and members of the public. The USDA Forest Service and BLM are major landowners in the state and should be involved. The statewide committee would function more as a state-wide big picture group. Smaller, project-specific committees involving local representatives from the key agencies (counties and other local players for the specific project) would convene temporarily around a particular project to go through some of the on the ground steps in the prioritization process. ITD can learn about the committee process from ITD's District 3 where a similar partnership was brought together for the SH-21 Lucky Peak wildlife crossing and fencing, and in Colorado where the Colorado Department of Transportation (CDOT) convenes a Project Leadership Team and an "*A Landscape Level Inventory of Valued Ecosystem*" (ALIVE) Committee, both of which consult with CDOT. The Project Leadership Team helps CDOT to consider wildlife needs from the outset of planning to project design and implementation, and to conduct field trips and assess mitigation options. See the [Memorandum of Understanding](#).

This Interagency Wildlife Connectivity Committee would be responsible for later WVC prioritization steps at the state level. It is not necessarily for the same people to be at the table through each of the

steps outlined in the WVC Prioritization Process. Having a long-term “big-picture” committee and temporary project committees can provide a better job of getting the right people to the table at the right time. Vermont Transportation Department (VTrans) and Vermont Fish and Wildlife (VTFW) have such working groups and hold meetings on a quarterly basis. Utah began these meetings concerning a specific road with several mitigation measures, and it has evolved into a statewide committee. Colorado’s Wildlife Connectivity Committee holds regular meetings with the agency partners. Idaho would be wise to form such a committee as soon as possible. This committee would help take this research’s WVC Prioritization Process to the next level.

The WVC Prioritization Process created by this research raises questions such as:

- Who is going to oversee that this process is used?
- Who is going to train ITD personnel responsible for carrying out this process?
- Who is going to document the different ITD District priorities and make sure they are included in a statewide analysis?
- How will we ensure that this process is carried out each year at each ITD District and then brought together at the state level?
- Who is going to document the changes in ITD and IDFG over time to see if progress is made toward the performance measure goals of this research?

The best people to answer these questions are those who take up the torch of this process and see it through to fruition; members of the Interagency Wildlife Connectivity Committee. This research project presented many ideas; it is up to the ITD and IDFG personnel committed to reducing WVC in Idaho to work out the details of individual responsibility.

Wildlife Mitigation Actions Recommendations

Several generalizations can be made about wildlife crossing structures types that work for different ungulate and bear species. Idaho has created 10 wildlife crossing structures for mule deer and other ungulates: 7 are bridges, and 3 are culverts. Research presented in this report verifies that mule deer will use both these types of structures. Culverts should be under 140 ft in length as the animals traverse the width of the road, a minimum of 10 ft high, and as wide as possible to allow these prey species escape opportunities. Bridge spans are typically wide enough to provide escape routes ungulates find necessary. Their open nature and the streams that are typically accommodated under these structures encourage multiple species use. Elk, pronghorn antelope, and bighorn sheep are the most difficult species to pass beneath roads, even with bridges. These three species are best accommodated at road interfaces with overpass structures, where the animals move above the flow of vehicles. Elk may use bridged underpass structures, but research in neighboring states find that at best, less than two dozen animals use each structure annually, and they are typically bull elk, and do not include cows and calves. Black and grizzly bear will readily use culverts and bridges, and can be accommodated more readily with different structure types than the elk, pronghorn antelope, and bighorn sheep. All these wildlife crossing structures should be placed in conjunction with wildlife exclusion fencing, 8 ft high. Fencing can extend

from several hundred feet to several miles. Placing of crossing structures should be no more than 1 mile apart. Ingress and egress points should have double cattle guards, wildlife guards, or electric mats to deter animals from entering roads. Those guards should have rounded rather than flat surfaces to help deter animals from walking across the support beams and bars. Escape ramps are placed along the fencing line to allow wildlife caught in the fenced area to jump over the fence. These ramps are typically spaced from 1 to 4 per mile in Utah. Idaho has placed these structures and fencing and has ample knowledge within agency ranks to place dozens more. Other options for allowing wildlife to pass across roads include: driver education campaigns; driver warnings with variable message boards; driver warning systems connected to animal detection systems; wildlife crossing zones with these driver warning systems; reduced speed zones with enforcement; and vegetation reduction to keep animals from entering the road right-of-way and to help motorists see wildlife. The entire practice of wildlife crossing structure planning, building, and maintaining would be best served with camera monitoring over several years at established and newly built structures. Adaptive management of the structures and fencing would help ensure the mitigation actions performed as intended.

ITD should develop a set of Best Management Practices (BMP) and guidelines for reducing WVC while promoting wildlife connectivity across or under roads. This would be a more formally developed set of guidelines that would be useful for planning and engineer teams. It would detail where different mitigation actions would work, where they should and shouldn't be used, and the pros and cons of each.

Consistent WVC Carcass Data Collection Across the State

WVC Data Collection by ITD maintenance personnel is crucial to WVC mitigation efforts. Reliable and continuous carcass data needs to be collected by ITD personnel across the state. ITD maintenance personnel should be brought into the information sharing process to better understand how their efforts can result in a decrease in WVC and thus fewer carcasses. **Upload this maintenance collected WVC carcass on a daily basis** to the TAMS site.

TAMS carcass data should be uploaded to IDFG WVC carcass website nightly. The steps necessary for this automated upload were begun during this research. This process was expected to be completed by the summer of 2014.

A statewide education effort could be made to expand the use of the Idaho Fish and Wildlife Information System (IFWIS) by ITD, IDFG, and the public which would increase the reliability of the data and expand on the collection of not only WVC carcass data but on temporal and spatial movements of wildlife.

Monitor Wildlife Mitigation Action Efforts

There should be wildlife monitoring research of all wildlife mitigation action efforts in the state to better evaluate effectiveness. Standards of monitoring should be applied, where data is tallied in scientific manners similar to other wildlife studies. No monitoring funds should be provided for studies unless the researchers agree that the resulting photographs from camera traps and other equipment are scientifically tallied and reports delivered. These actions will help with adaptively managing all infrastructure and motorists.

Train Personnel to Implement the WVC Prioritization Process

Personnel within ITD and IDFG need to receive regular (minimum of annually) training on:

- How to use the prioritization process and new incoming data.
- How to work collaboratively to use data to make informed decisions on where and type of mitigation is necessary in hotspots.
- To work proactively in defining and mitigating problem WVC areas across the state.
- How to budget time for district and region level meetings.

While there is currently no personnel qualified to train others, several District environmental planners have been conducting similar evaluations at their Districts, and could adapt their approach with this process to instruct others.

Improve GIS Mapping Models

Most Important: IDFG Creates Accurate Wildlife Habitat Maps Using Empirical Study Data

The habitat maps used in this process were heavily weighted toward mule deer and elk because they are the two species with the most data, and because more WVC occur with these species, except for White-tailed deer. Future mapping processes will need to include more updated data. For instance, it is important to introduce empirical data from studies where we have data points defining where we know grizzly bear, for example, are near the road and even crossing the road. These data are important and should be included. No researchers or agency personnel produced this type of data or maps for this project except for Tim Cramer in ITD's District 6 who produced grizzly bear data on GPS locations. This type of empirical data should be considered an important addition. It is also important for IDFG to create better quality maps for all other species.

IDFG Should Create More Accurate Maps of Mule Deer, Elk, White-Tailed Deer Populations and Other Species Based on Wildlife Management Units

Every state wildlife agency has an understanding of the population density of the different management units of a specific species. Hunter harvest data could be used to predict population densities, project future increases and decreases in populations and to create population density maps that would better

represent these species than just the presence-absence maps worked with for this project. These maps should also be developed in conjunction with wildlife linkage-connectivity mapping at the landscape level. It is critical that others species such as Species of Greatest Conservation Need (SGCN) and Threatened and Endangered Species (TES) be considered in these mapping processes.

Migration areas for large herbivores are important to locating WVC priority segments. Research team members and district level TAC members stressed the importance of migration areas that need to be better mapped and perhaps receive a higher score during this research project. This information is needed in future maps.

IDFG Should Use Actual GPS and Radio Locational Data to Verify the Accuracy of the WVC Prioritization Process Maps

The WVC prioritization map can also be validated in the future with actual wildlife locational data. This can be conducted in specific segments of road with radio collar data locations, GPS collar data locations, and other empirical data that could show how the species of interest move across and near roads.

Rank Wildlife Linkages in a Standard Process

The different ITD districts ranked their wildlife linkages slightly differently. Thus, some linkages in ITD District 6 did not float to the state top wildlife linkages, which then handicapped the district in the overall state ranking. In the future there needs to be a standard process for rating wildlife linkage areas.

Rank Rural Roads According to Their Higher Preponderance of WVC

Arizona's method of prioritizing WVC stretches looks at rural roads as possible areas of high "hotspot" problems with WVC. These areas do not typically rank high statewide because of low traffic volumes. Arizona's prioritization system looks at the percentage of single vehicle crashes that involved a wild animal. A high ranking is assigned to those mile segments where 20 percent or more of the single vehicle crashes were with wildlife. This helps these less traveled road areas rank higher. At this time, the TAC decided that the information involves roads other than ITD administered roads and that it is a task for future projects.

Rank Traffic Volume Differently

The ranking method used in this report ranks higher traffic volume areas as the highest rated category, insinuating a one-to-one direct cause-and-effect relationship that is not entirely consistent with published scientific studies. Future work could model traffic effects on wildlife species and also model projected future traffic volume. These data could be translated into maps or tables the users could consult during the prioritization process. At this time there is only a one point difference between traffic volume classes and thus only minor changes in values would be predicted.

Make Sure IPLAN Includes Transportation Planning Documents

Future [IPLAN](#) software will need to take into consideration Long Range Transportation Plans and the [STIP](#) so they can be used to assist in this prioritization process.

Next Step, Prioritize Other Species of Concern

This project focuses on large ungulates and bear most typically involved in WVC, and is supported with funding from the Office of Highway Safety at ITD. This is a first step, but should not be the end. The most progressive western states for prioritizing areas of road for wildlife mitigation - Washington, Colorado, and Arizona all include federally and state listed species and species of interest, from Grizzly Bear and Lynx to Preble's Jumping Mouse and Leopard Frogs. The next step would be to decide which additional species to include and create maps that are more informative on their locations than a simple presence-absence map. A formal linkages modeling effort should be conducted in Idaho prior to 2017, the 10 year anniversary of the first linkages report.

Include WGA CHAT in Next Round of the WVC Prioritization Process

Western Governors' Association Crucial Habitat Assessment Tool (CHAT) is used in the majority of western states to delineate areas of critical wildlife ranges and movement pathways. The map for Idaho should be incorporated in the next iteration of the prioritization process. Arizona has included this map (called AZGFD's HabiMap Arizona SERI and Species of Greatest Conservation Need (SGCN) GIS Layers, see Appendix A) in their prioritization process for mitigating roads. Arizona's maps are considered to be their wildlife diversity maps and are given a maximum of 20 points out of a total of 130. Due to Idaho's map's coarse scale (3 mile pixels), it should be used as an early planning tool. The CHAT should be used at a landscape level of planning, which would be in the early stages of transportation planning, as in long range, corridor and STIP planning.

Add Ecoregion Representation to the Process

Colorado added a section to their WVC prioritization process on ecoregions, to make sure the prioritization process included a priority in each ecoregion of the state. This may be a way to ensure ITD does something in the Great Basin ecoregion of southern Idaho, where pronghorn antelope are in need of safe crossing opportunities. Due to our rankings, this area does not come up as a priority. ITD's TAC on October 30, 2013 deemed this a future step in the process; outside of this project.

In the Future Explore How Changes in GIS Layer Rankings Affect Priorities Outcome

The GIS research team coded the GIS data so the ranking of different GIS layers' output was tabulated in a manner that allows rankings to be changed with little effort. This presentation of the values of data for each mile allows transparency and can allow future users to repeat the process with different scenarios. Future model iterations can use these tables to change rankings of GIS layers.

Crash Data Will Need to be Explored and Values Changed to Observe Effects on Various Road Segment Rankings

WVC crashes are typically under reported when tractor trailer truck are involved. As a result, when an ITD road has heavy truck traffic the WVC with those trucks are not typically reported in the **crash** data. Areas such as ITD District 5's US 30 through Montpelier may have heavy WVC but there are little crash data due to heavy tractor trailer traffic. As a result, this area did not receive as high a ranking in the overall state priorities as may be expected due to under reported WVC crashes. Future modeling of the GIS layers and WVC data may find a more appropriate crash ranking in areas where this may be the case.

Validate GIS Maps with District Environmental Planners' Realities

ITD could use the data in Table 21 in Appendix D to further evaluate the GIS mapping process priorities against what district environmental planners view as priorities. If the GIS processes used in this research do not produce maps accepted by ITD personnel, future efforts could use other GIS techniques, possibly more similar to those described by Fraser Shilling in Appendix A, 'Mapping Wildlife-Vehicle Collision GIS Considerations.'

ITD and IDFG Cooperative Agency Actions

Develop an ITD IDFG Needs Assessment Template for all ITD Districts and the State

ITD and IDFG, through coordination with the Statewide Interagency Wildlife Connectivity Committee should develop a "Needs Assessment" document template for each ITD District that details areas where IDFG and ITD agree that there are WVC problem areas that need mitigation actions. Those areas can then be prioritized for mitigation through a cooperative effort between the two agencies. Additional input could come from outside interests, such as federal and state natural resource agencies, cities and towns, non-profit organizations, and the public.

Establish ITD Approved WVC Benefit-Cost Analysis Method

This analysis can be standardized, much like Oregon Department of Transportation produces with an accepted spreadsheet that calculates costs and benefits in pre-programmed cells. This benefit-cost analysis would also select an agreed upon value for WVC that are not reported as crashes and derived from WVC carcass data. The future Interagency Wildlife Connectivity Committee would also play a role in developing a state-wide standard that includes ecological values.

In the benefit-cost analysis assign value to long-term benefits of providing roadway permeability for wildlife, not just WVC avoidance. How do we compare the value of just placing a fence to deter WVC and a broader solution that involves a fence plus wildlife crossing structures? Although fencing is not a wildlife mitigation action that allows populations to survive, it will inevitably be considered an option. The cheaper fence-only action would rank as more efficient unless we recognize the fence itself may

lead to not only individual animal deaths due to reduced access to crucial resources, but entire populations. In other words, the user must place a value on wildlife populations staying alive. The user needs to evaluate how to include benefits of providing wildlife populations permeability across the landscape and thus a continued existence.

Motor Vehicle License Plates Can Raise WVC Mitigation Action Funds

There should be consideration to an increase of a \$1 or \$2 on wildlife specialty license plates (and possibly other specialty plates) that would go towards projects related to WVC mitigation strategies. This would help make projects come to fruition, as funds are a major reason for delays in WVC mitigation actions.

Performance Measures Can Be Used to Evaluate if This Research is Used

These could be an evaluation of how ITD is performing toward creating wildlife mitigation across the state as evaluated from a survey. The survey would ask ITD District Environmental Planners questions dealing with:

- How many existing wildlife crossing structures and other mitigation exist in your District?
- How many wildlife mitigation measures are in the “Planning Stage?”
- How many wildlife crossings are under construction?
- How many wildlife mitigation measures have been monitored in the past 12 months?
- How many times did you speak with your IDFG counterparts this year?
- How many times did you go out in the field with IDFG and other environmental entities this year?

Statewide, ITD and IDFG should evaluate how the effort to reduce WVC and provide wildlife connectivity across roads is advancing. Quantifiable measures are needed. The number of mitigation projects could be used, as a measure, but WVC total numbers may remain the same or continue at present levels or even increase over the years due to increasing numbers of motorists and miles driven. Therefore, a combination of measures should be used. When wildlife crossing are evaluated for success, there are several levels of performance measures. These are provided here to help evaluate not only individual projects, but to view the overall Idaho effort to mitigate roads for wildlife.

1. Reduce WVC by a percentage, in the range of 75 percent.
2. Reduce WVC by above level, and the mitigation measures pass a certain number of individuals of the target species annually.
3. Reduce WVC by above, pass a certain numbers of target species while also passing the majority of the population of the target species with different age and gender classes all using the structure.

4. All of the above performance measures plus evidence that the structure is passing a diversity of species in the area, typically mammals.

These measures should be applied at both the project level and the state level to help evaluate how cost-effective projects and the WVC-wildlife connectivity efforts were for the year.

Future Research

Many of the above actions could be included in future research projects. Overall these could be summarized into the following types of research:

1. GIS mapping procedures by IDFG will need to incorporate accurate field based data on wildlife locations, habitat, and movement patterns in relation to roads. These more accurate maps could be included in future iterations of the WVC Prioritization Process and could be used to test the results of the process for accuracy in selecting areas of highest WVC concern.
2. A future research project could examine how the ITD transportation planning process changed over time to include wildlife concerns. The above performance measures mentioned to examine the results of this work could be used to see if ITD progressed toward goals of including WVC mitigation actions.
3. Wildlife mitigation efforts need to be monitored in systematic scientific approaches to evaluate how well the structures performed in passing the target species, in increased wildlife use over time, in allowing for a diversity of species to use the structure, and in decreasing WVC in the area. Almost anyone can put out cameras to photograph animals. It is the systematic analyses of the photos to quantify results that are needed to provide accurate performance measures to evaluate the efficacy of wildlife infrastructure and provide evidence to the public that these structures work. These efforts also help agencies manage the infrastructure in an adaptive management context to ensure they continue to perform as intended.
4. A benefit-cost analysis of all actions performed by ITD to reduce WVC could help to quantify the success of such actions. Methods for analyses would need to be agreed upon by ITD and IDFG.

This research provided many future opportunities for ITD and IDFG to work toward an efficient set of methods and processes to mitigate WVC areas across the state. It is based largely on what has already happened to some degree in different ITD Districts throughout Idaho. These successful approaches can now be applied consistently across Idaho to help reduce WVC and make Idaho roads safer for all.

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Appendix A

Wildlife Linkages Maps, Methods, and Considerations, Wildlife-Vehicle Collision Documents, and Websites

Idaho

Idaho Fish and Wildlife Information System Highway Wildlife Linkages GIS and Metadata Files Portal
<https://fishandgame.idaho.gov/ifwis/portal/opendata/idaho-highway-wildlife-linkages>

* Not only can you download in shape file, but a kml file - Google map. When you get close enough into the map (fine scale), the ID numbers are actually associated with blue “caterpillars” where their problem areas are along specific roads.

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Colorado

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I-70 Mountain Corridor Regional Ecosystem Framework, integrated into I-70 Context Sensitive Solutions website. See the sidebar “Must See, Must Do” for I-70 EcoLogical Report, ALIVE Implementation Matrix and associated documents, Denver, CO: Colorado Department of Transportation, 2013.
<http://www.coloradodot.info/projects/contextsensitivesolutions/corevalues/healthy-environment/wildlife>

I-70 Wildlife Watch. Citizen reporting website of live and road-killed animals along the I-70 Mountain Corridor. Denver, CO: Rocky Mountain Wild, <http://www.I-70WildlifeWatch.org>

Nevada

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New Mexico

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<http://www.nmlegis.gov/sessions/13%20Regular/memorials/senate/SM011.html>

Ontario, Canada

Kari Gunson worked with the Toronto Zoo to create a linkage analysis for Ontario, with specific emphasis on herps. <http://www.torontozoo.com/pdfs/gunson.pdf>

Utah

Utah has a wildlife-vehicle collision reporter app for smart phones. The website also allows select users to input data on carcasses found along roadways. The select users can also map the data according to pull down filters. <https://wvc.mapserv.utah.gov/wvc/desktop/>

Listen to how Utah does it all, with an interview of Brandon West of UDOT, and Ashley Green of UDWR, a radio interview: <http://kcpw.org/blog/the-rundown/2013-09-12/the-rundown-udot-dwr-wildlife-crossings/> click on feature interview.

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Wildlife Linkage Mapping Software Available for Free on Internet

Circuitscape: <http://www.circuitscape.org/>.

Borrows algorithms from electronic circuit theory to predict patterns of movement, gene flow, and genetic differentiation among plant and animal populations in heterogeneous landscapes. It complements least-cost path approaches because it considers effects of all possible pathways across the landscape simultaneously.

Connect: <http://www.unc.edu/depts/geog/lbe/Connect/>

A set of tools that helps researchers and conservation planners model landscape connectivity for multiple wildlife species in complex heterogeneous landscapes. This planning tool packages three connectivity modeling tools: Circuitscape, NetworkX, and Zonation into user-friendly geo-processing toolbox for ArcGIS 9.3

Connectivity Analysis Toolkit (CAT): http://www.klamathconservation.org/science_blog/software/

Combines several new connectivity analyses and linkage mapping methods in an accessible user interface. Through centrality metrics it evaluates paths between all possible pairwise combinations of sites on a landscape to rank the contribution of each site to facilitating flows across the network of sites, indicating continuous gradients of habitat quality. It helps one to avoid the focus on delineating paths between individual pairs of core areas characteristic of most corridor or linkage mapping.

Conservation Corridor <http://www.conservationcorridor.org/>.

North Carolina State University's site on the science of connectivity. This is not software, but tracks the latest news and peer-reviewed literature on wildlife corridors and connectivity, and aims to bring the information to practitioners.

Corridor Design: <http://corridordesign.org/>

Paul Beier's, a leader in connectivity analyses, hosts this website for his software. It gives the user a suite of ArcGIS tools to design and evaluate corridors that have been carried out by the State of Arizona.

Landscape America: <http://www.landscape.org/focus/connectivity/>

Helps to plan for connectivity for wildlife. Presents different methods and tools. It is meant to complement. Companion tool for North Carolina State University Conservation Corridor site.

Linkage Mapper: <https://code.google.com/p/linkage-mapper/>

A GIS tool designed to support regional wildlife habitat connectivity analyses. It was created for the Washington Wildlife Habitat Connectivity working group. Launched in 2013. It uses Circuitscape to ID pinch points within least-cost corridors and to analyze linkage network centrality. *Note: They have a Climate Linkage Mapper – that maps corridors following climatic gradients to facilitate species' range shifts under climate change.*

MultyLink: <http://pascal.iseg.utl.pt/~rbras/MulTyLink/>.

Is an open source software application designed to select connectivity linkages for distinct types of habitats, under cost-efficient protocols. Looks at linkages free of barriers, [may not work for landscapes with roads]. Shows right on first page how it could be applied to climatic classes and protected areas. European created.

NetworkX: <http://networkx.github.io/>.

Software for the creation, manipulation, and study of the structure, dynamics, and functions of complex networks. It is made for anything with nodes and networks.

Zonation: <http://cbig.it.helsinki.fi/software/zonation/>.

Is a conservation planning framework from Helsinki. It produces a hierarchical prioritization of the landscape based on the occurrence levels of biodiversity features in sites or cells, by iteratively removing the least valuable remaining cell while accounting for connectivity and generalized complementarity.

Mapping Wildlife-Vehicle Collision GIS Considerations

Fraser Shilling, University of California, Davis

In this section, research team member Fraser Shilling describes some important considerations in mapping WVC in GIS.

Wildlife interacts with highways in complex ways. At the individual-level, animals may cross, successfully, fail to cross because of a collision with a vehicle, or fail to cross because of an aversion to the roadway. Identifying the places of wildlife interaction from the population to the individual scale involves a combination of GIS modeling, wildlife observations, wildlife movement analysis, and measuring genetic connectivity.⁽¹⁾ Animal carcasses that are a result of unsuccessful crossing attempts by individual animals are an important type of observational data which can be used to support highway mitigation decisions. There are several ways that wildlife-vehicle collision (WVC) observations can be used:

1. Determine whether or not and where there are “hotspots” (statistically-significant clusters) of collisions.
2. Estimate impacts of WVC to wildlife populations.
3. Estimate potential costs to society of WVC on highways segments or individual shield highways.
4. Determine proximate causes (e.g., adjacent habitat) of WVC in particular regions.
5. Comparison with observations of rate of and locations of successful crossing via crossing structure.

One common finding with spatial analysis of WVC is that collisions are clustered, which often leads to analysis of proximate causes of clustering for individual species (e.g., road or landscape features).⁽²⁾ One

approach is to use previous collisions to develop predictive landscape models to find “hotspots”, or seasonality models to find “Hot Moments”.^(3,4,2,5) This is often done for ungulates because collision with ungulates is both a conservation and a safety concern.⁽⁶⁾ There are various costs associated with a collision between a deer and a vehicle; on average, a collision with a deer costs \$6,671.⁽⁷⁾ This kind of cost-equivalent means that WVC can be measured in terms of their cost to society, which can matter regardless of clustering of WVC. Less well-studied than WVC clustering is the idea that for broad taxonomic groups, “sheet flow” of animals may result in WVC everywhere and statistically-significant clustering may only be found because of limitations in the study area, or data collection. Although understanding clustering for individual species is important for each of those species in each of its habitats and landscapes; for highway planning, it is also important to understand whether or not and why there are patterns of WVC for most or all vertebrate fauna present in an area.

California Department of Transportation (Caltrans) and MaineDOT have been collecting carcasses from state highways for over 30 years. Recently, the records corresponding too many of the carcass retrievals and locations in each state have been entered into

1. A queryable database maintained by Caltrans headquarters.
2. A single spreadsheet maintained by MaineDOT.

In addition, many Caltrans Districts also maintain databases of carcass retrieval, though this is usually in a spreadsheet format. Although Caltrans does not use these data systematically to find the best places to reduce WVC, when a highway project is proposed in a rural area, quite often District and Headquarter biologists will consult the WVC databases to see if mitigation to reduce WVC is justified as part of the project. The good part of this approach is that often the mitigation is sited so that it will demonstrably reduce WVC. The less-optimal aspects of this approach are that usually no effectiveness monitoring of the mitigation takes place and the mitigation location may be easily compared to other nearby locations where collision rates are higher. MaineDOT has similar limitations in their approach, though they have examined statewide ungulate collision data and found that there are few “hotspots” around which they can generate mitigation proposals; instead, collisions occur fairly homogeneously along highways.

Caltrans typically has not consulted a wide range of biologists when planning and constructing mitigation for WVC reduction. In a few cases, they have drawn in interested academic, agency, and non-government organization (NGO) partners to study WVC and help plan and fund mitigation. For example, on SR-89 in the Sierra Nevada Mountains, a planning group has periodically met for almost a decade to collaboratively understand and plan WVC reduction (primarily deer), which led to a combined fencing undercrossing project at 2 locations where rates of collisions were high and the local topography facilitated construction. Since construction, parties other than Caltrans have monitored the crossings and found use of the structures by many animals. In Maine, a similar approach is used, but typically with more consultation with local NGO partners, such as Maine Audubon. In both cases, it seems that individuals within the DOT decide that it is a good idea to include partners and pursue that approach.

California has two systems for recording WVC. One is the HQ and District sets of databases on carcass retrieval, which includes tens of thousands of observations of < 10 species. The other system is the California Roadkill Observation System (<http://wildlifecrossing.net/california>), which is maintained by the University of California-Davis, Road Ecology Center (REC) and relies on volunteer contributions of WVC observations. As of March 25, 2014 it had >25,470 observations of 377 species, collected by >960 observers. The REC has found that the accuracy of species identification (based on pictures of the carcasses) is >95 percent, that most of the observers contributing frequently are professional biologists, and that the observations are complementary to the Caltrans collection of WVC carcasses. In other words, the systems do not duplicate each other. This suggests that it would be important to maintain both systems and possibly combine them into one common database. Records within this common database would still include identification of who collected and identified the WVC and would allow for a richer understanding of the locations of WVC for conservation and driver safety concerns. Until quite recently, wildlife crossing issues were considered as appropriate only for the Biological Permitting staff with Caltrans Districts. However, interviews with these staff indicate that they are usually given no direction, time allotment, or types of work outputs for this kind of issue analysis. Their typical work involves designing mitigation for threatened and endangered species and habitats, not for safety concerns about collisions involving large mammals on the roadway, or conservation concerns about collisions with animals in general. Recently, a new direction has started to form in Caltrans HQ and in some Districts, involving Planning managers and staff. Although this staffs does not have the expertise to design mitigation actions for WVC, they do have the appropriate understanding of how to use geographic tools and statistical analyses of safety risks to plan for safer, more sustainable highways. Projects staff have identified two planning tools that have the potential to serve as vehicles for concerns and studies about WVC, the Project Initiation Document and Corridor System Management Plans.

Proposed Approaches/Methods

To identify areas where mitigation might be effective in reducing WVC, two complementary methods can be used to estimate WVC intensity for highway segments. One method is to calculate the density of WVC per unit length (e.g., per mile) and unit time, which allows comparison of WVC against some threshold of concern.⁽⁸⁾ Another method is to look for clusters or “hotspots” of WVC. Clusters of some event of interest are often measured by estimating the spatial autocorrelation of the events. A useful test of spatial autocorrelation that can be implemented in ArcGIS is called Getis-Ord, which results in a measure of statistical significance of the correlation, the “GiZ” score. The method compares the density of an event (i.e., number of carcasses per highway segment) for each set of neighboring analysis units. If there are big differences between a highway segment and its neighbors, a significant result will be found (Figure 9, red segments). If similarly low or high densities of an event are found among segments, then there may be a finding of no significance (and thus no “hotspot”). The GiZ score can be calculated for different lengths of highway segment, which can affect where “hotspots” are identified. Shorter segment lengths (e.g., 1/10th of a mile) may result in more “hotspots” than longer segments (e.g., 1 mile) because there is greater likelihood at shorter distances that there will be a difference between the number of carcasses averaged over segments than at greater distances (Figure 9).

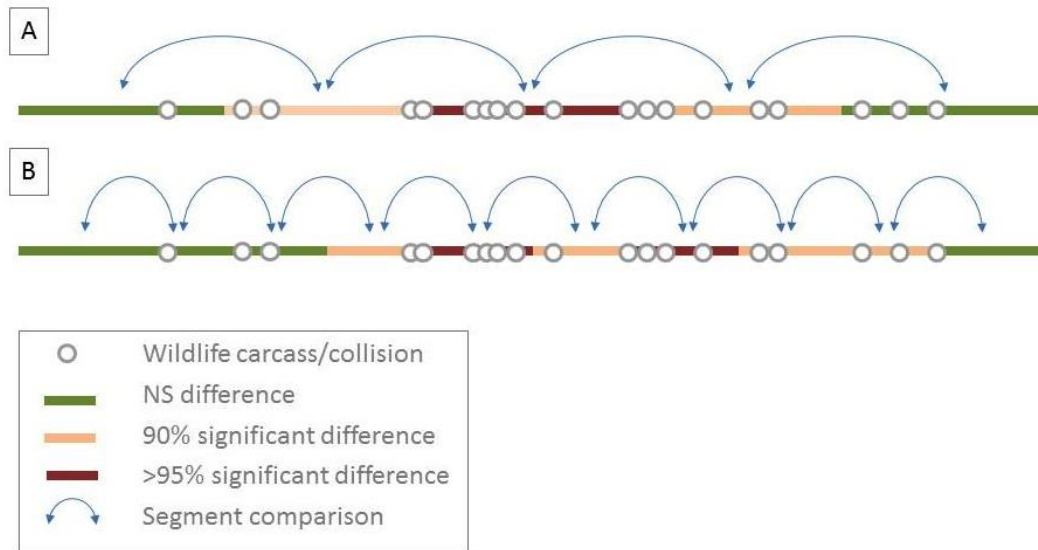


Figure 9. Diagram of Test for Clustering of WVC among Highway Segments

Note: The density of WVC per segment is calculated. The test compares the density for each segment with its neighbors.

An important note about these two approaches (density calculation and cluster analysis) is that they provide complementary types of data for decision-making. A highway might have similar rates of WVC along its length, meaning that “hotspots” will not be identified (because there aren’t any), whether the density of WVC is high or low. However, it is important to know if the WVC rate is high for a particular highway (high density), that highway should then be a priority among highways in a region. WVC density and in particular ungulate-vehicle collisions can also be used to calculate an annual cost of collisions for highways or highway segments.⁽⁷⁾ This helps to determine if mitigation actions will be cost-effective.

Cluster Analysis Steps

Study highways should be examined for sufficient density of observations across 1-mile highway segments (>10 WVC/mile for at least one segment) and length of time of surveying (>1 month). Each highway is dissolved into 1 long segment and subsequently cut into regular-length segments of 0.125, 0.25, 0.50, or 1.00 mile (or similar metric scale lengths). These lengths are based on previous research indicating that these are appropriate road segment lengths for studying wildlife crossings and WVC.^(9,10) WVC observations are forced into co-location with their respective interstates using a “snap-to-line” tool (<https://github.com/robintw/RTWToolsForArcGIS>) implemented in ArcGIS. The “spatial join” tool in ArcGIS is used to sum the number of observations per line segment and these sums per line segment length are used as the basis for density-based analyses and for subsequent spatial autocorrelation (“hotspots”) analysis. It is also possible to carry out this step for specific taxa, such as ungulates. Estimates of ungulate-vehicle collisions (Figure 10) can be used to provide estimates of the cost per mile segment per year from collisions.⁽⁷⁾ This provides another way to prioritize areas for mitigation, including both spatial location and economic benefits from mitigation action.

The spatial autocorrelation test and statistic “Moran’s I” and the Getis-Ord Gi* z-score statistic can be used to determine whether or not WVC observations are spatially clustered in “hotspots” along highways.⁽¹¹⁾ The Moran’s I tool in ArcGIS 10.1 is used to test for spatial autocorrelation among highway line segments and to determine the threshold distance to use in calculating the Getis-Ord Gi* z-score. The Getis-Ord Gi* z-score is a measure of the statistical significance of clustering for each analysis unit, in this case highway segments. The Getis-Ord Gi* z-score can be calculated for different lengths of highway segment, which can affect where “hotspots” are identified. Shorter segment lengths (e.g., 1/10th of a mile) may result in more “hotspots” than longer segments (e.g., 1 mile) because there is greater likelihood at shorter distances that there will be a difference between the number of carcasses averaged over segments than at greater distances. Implementing the Gi* z-score can be done using several variations (“inverse distance,” “zone of indifference”) that affect how much the test considers neighbors of individual highway segments, beyond the immediate neighbors. The product of this analysis is a map showing the places where the concentrations of WVC are statistically significant (Figure 10).

Sample results

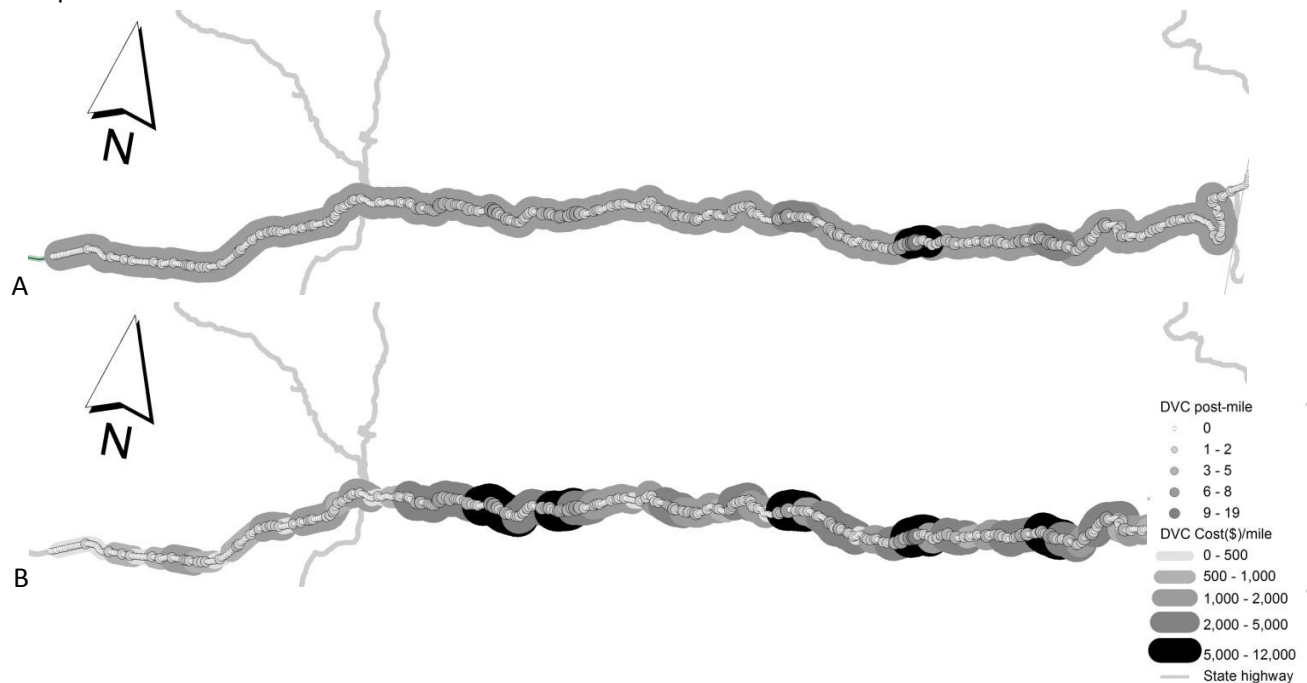


Figure 10. Locations of Potential Areas for Mitigation (Dark Segments), California SR-50

Note: A. Statistically-significant clusters using DOT observations (Gi z-score)*

B. SR-50 rates of density of DVC per post-mile (points) and associated costs (\$/mile).

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Appendix B

State and Provincial Approaches to Prioritizing WVC

Idaho

WVC Carcass Collection Method

Maintenance workers enter data on carcasses collected: the time, GPS locations or mileposts, and species into electronic database (TAMS). They turn these data entries to ITD headquarters as part of their time card (part of TAMS). Compliance is considered part of standard operating procedure, but was highly variable among maintenance districts. Data was to be uploaded to IDFG site quarterly but was more often annually. In Idaho, there is a new 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 reports carcasses collected.

WVC Carcass Mapping

Public and agency website reporting with various location methods. IDFG website brings up maps at user defined scales, of carcass locations, but does not cluster them, so multiple pin points, rather than a display of “hotspots.” Very advanced site and method as compared to rest of country.

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 are available.

Planning and Prioritization Process

Prior to 2013, prioritization and actions for mitigation were created on an ITD District-level, highly dependent on local personnel. Process could be subject to some political pressures. Local IDFG biologists and ITD personnel find creative ways for funding. No statewide analyses.

Arizona

WVC Carcass Collection Method

Unknown for this research

WVC Carcass Mapping

See below.

Wildlife Linkage Mapping

Arizona conducted one of the premier wildlife linkage studies in the country in 2006. It was sponsored by AZDOT and AZGF, and many other agencies, non-profits, and Northern Arizona University. A scientifically conducted GIS least cost path analyses of whole state.

http://www.azdot.gov/docs/planning/arizona_wildlife_linkages_assessment.pdf?sfvrsn=7

Planning and Prioritization Process

In 2013 AZDOT proposed a prioritization process (N. Dodd, personal communication) that was used extensively to inform the Idaho prioritization process. It will be highly based on GIS maps of: wildlife linkages, WVC crash data, proportion of crashes involving wildlife, WVC carcass data, AADT, maps of species of economic and recreational importance, and species of greatest conservation need, and on the ground surveys using the Passage Assessment System developed in Washington.

California

WVC Carcass Collection Method

Caltrans maintenance collects WVC carcass data, and records them on field sheets. Data is entered into a spreadsheet back in the office. Maintenance collects and keeps the data at the District level, not in a centralized database. The statewide database includes tens of thousands of observations of <10 species that can be queried by select Caltrans personnel. University of California-Davis, Road Ecology Center maintains a publicly accessible system, the California Roadkill Observation System (CROS), <http://wildlifecrossing.net/california>), which is maintained by the Center and relies on volunteer contributions of WVC observations. As of 12/16/2013 it had >24,700 observations of 373 species. Carcass data in the system was collected by >940 observers. Accuracy of species identification is greater than 95 percent (verified using uploaded photographs of carcasses).

WVC Carcass Mapping

No single Caltrans statewide mapping project is known by those outside the agency. Some districts may hire consultants to map carcass data points. Even the senior environmental personnel within Caltrans have very little access to GIS. No website with WVC mapped by Caltrans. University of California-Davis, Road Ecology Center website has a mapping tool for the public to use. Fraser Shilling at the Center is also mapping roadkill “hotspots” (density and spatial clustering) along several thousand miles of state highways using data from Caltrans and from the CROS website.

Wildlife Linkage Mapping

California Essential Habitat Connectivity Project: A Strategy for Conserving a Connected California: <http://www.dfg.ca.gov/habcon/connectivity/>

Planning and Prioritization Process

See description of California below by researcher Fraser Shilling of California.

Colorado

WVC Carcass Collection Method

Maintenance workers collect carcass data to nearest 1/10th mile, compliance is voluntary. It is thought they record on average of 50 percent or less of carcasses that are solely on the pavement; reporting is variable by district. Data are entered into an electronic program. Data are compiled regionally and submitted quarterly to a statewide manager. CDOT sends reports to multiple agencies, totaling about 85 people. Citizen live animal and carcass reporting along the I-70 Mountain Corridor use <http://www.I-70WildlifeWatch.org> and for the whole State of Colorado use <http://www.wildlifecrossing.net/colorado/>.

WVC Carcass Mapping

WVC carcass data is not mapped and used for planning due to inconsistent reporting at CDOT. Crash data is mapped and analyzed for WVC “hotspots.” In local projects a District may map their carcass data for use in project planning. Exception: carcass data was used on I-70 Corridor. I-70 Mountain Corridor websites supports mapping.

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

Not a statewide process, but 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. See details provided in Colorado summary written by Julia Kintsch, in this Appendix under *Select State and Province Summaries on Prioritizing WVC*.

Florida

WVC Carcass Collection Method

State wildlife agency, Florida Fish and Wildlife Commission (FFWC) and Florida DOT collect carcass data. Florida panther deaths are always reported to Florida FWC panther biologist.

WVC Carcass Mapping

Carcass data on Florida panthers and black bear are GPS mapped within FFWC.

Wildlife Linkage Mapping

GIS least cost path analysis conducted for state.

Planning and Prioritization Process

For panthers, they laid down the GIS least cost path layers, then the locations of panther WVC, existing crossings, and saw priorities for future crossings. FLDOT & FLFWC came up with 7 guidelines for placing crossings.

Montana

WVC Carcass Collection Method

Maintenance workers fill out paperwork on carcass collection, data to the 1/10th of a mile. Available locally in specific MDT districts. This research did not learn of how it is handled at state level.

WVC Carcass Mapping

Unknown for this research.

Wildlife Linkage Mapping

No statewide mapping with MDT, but other efforts, including: MT Natural Heritage Program has a website to see locations of wildlife species. Montana is also using WGA-CHAT method developed in MT.

Planning and Prioritization Process

Mitigation efforts very much dependent on MDT district personnel, not a formal state process of prioritization.

Nevada

WVC Carcass Collection Method

Unknown for this research.

WVC Carcass Mapping

See below.

Wildlife Linkage Mapping

No statewide effort by agencies. 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=view&id=504&Itemid=1

Planning and Prioritization Process

From Nova Simpson, Environmental Scientist, NVDOT: “Each project has been put in motion by a few select people that are strong advocates within both NDOT and NDOW. At this point we do a lot of talking. We work closely together with constant communications between the biologists, planners and engineers.”

New Mexico

WVC Carcass Collection Method

New Mexico House Memorial 1 established that NMDOT & NMGF look to establishing a citizen monitoring program for collecting carcass data.

WVC Carcass Mapping

This research did not learn of how WVC carcass or crash data is mapped. Not known.

Wildlife Linkage Mapping

2003 there was a critical mass workshop on wildlife-vehicle collisions & linkages. Sky Island Linkages interactive map: <http://www.skyislandalliance.org/map.htm>.

Planning and Prioritization Process

New Mexico State Legislature passed House Memorial 1 requests that the NM Game and Fish and DOT work with the University of New Mexico, Division of Government Research (UNM) to hold a critical mass workshop by 06/30/2013, in order to: collect updated information showing where vehicle-wildlife collisions occur, produce a list of road segments with the greatest number of collisions, and send a report to the appropriate interim legislative committee by 10/1/2013. 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 11.

To view the 2012 effort in New Mexico. PDF:

http://www.nmlegis.gov/lcs/handouts/WNR%20101512%202.%20HJM%2010%20Report%20Final_June20%202012.pdf Accessed May 2, 2014.

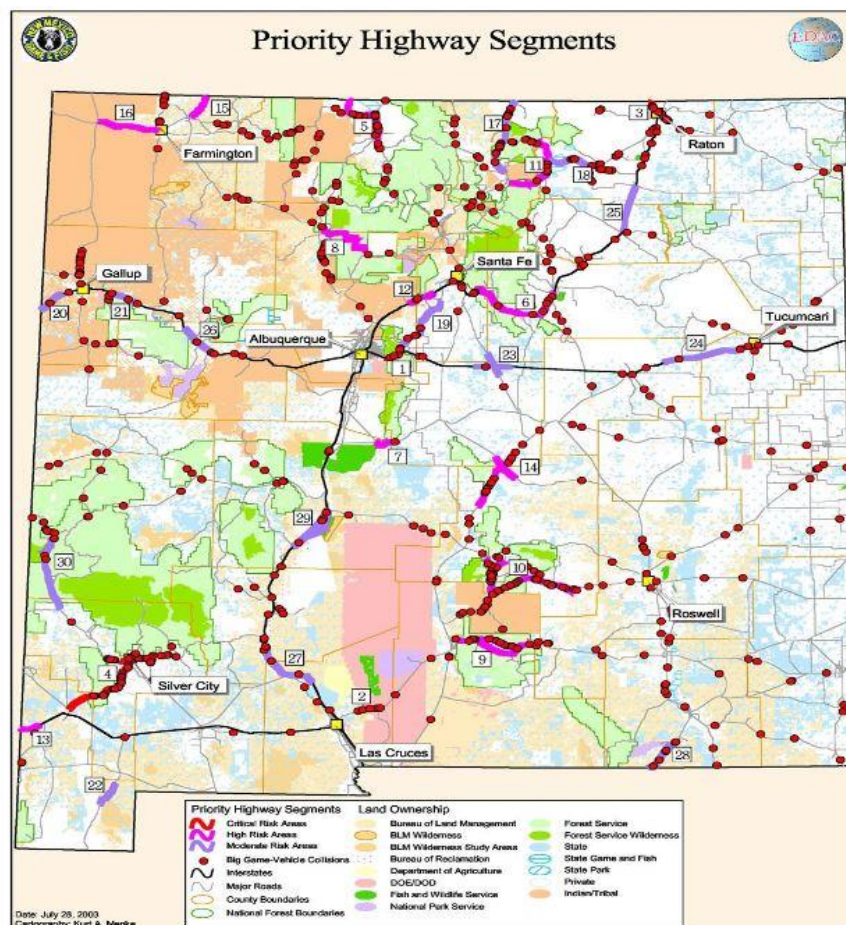


Figure 11. New Mexico Road and Wildlife WVC Priority Segments

Ontario, Canada

WVC Carcass Collection Method

Since 2006 provincial highway maintenance crews collect carcass data for large animals. Spatial accuracy varies; sometimes use GPS in trucks or sometimes only a descriptive location. Carcass data collection is only conducted by the Ontario Ministry of Transportation (MTO) Northeast Region.

WVC Carcass Mapping

In 2013-2014, a concurrent study led by K. Gunson is being conducted with the MTO using province-wide crash data collected by the Ontario Provincial Police. The crash data will be mapped using the linear highway referencing system (LHRS), and hotspots will be 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.

Wildlife Linkage Mapping

The above WVC mapping is solely based on safety criteria, e.g. number of crashes involving wildlife, and wildlife corridor and linkage mapping for large animals has not been completed in Ontario and its integration will be considered next steps for the WVC “hotspot” prioritization process.

The Ontario Road Ecology Group and Kari Gunson created analysis province-wide road mortality “hotspot” analysis 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

Traffic volumes and other metrics such as number of WVC per total crashes will be used to assess the safety risk of each highway segment for WVC.

The Ontario Ministry of Transportation is currently developing a Wildlife Mitigation Strategy in 2013-2014 to prioritize where short- and long-term mitigation for small and large animals are most required on provincial roadways. This is 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, and other metrics, e.g. wildlife and traffic volume abundance trends, to prioritize where mitigation is required for specific large animals. 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, and other metrics. Criteria will be compiled into a decision-planning tool and weighting importance can be determined by the stakeholders and experts within each planning region. See more in K. Gunson write up for Ontario.

References

Gunson, K. E., D. Ireland, and F. W. Schueler. "A Tool to Prioritize High-Risk Road Mortality Locations for Wetland-Forest Herpetofauna in Southern Ontario, Canada." *North-Western Journal of Zoology*, Vol. 8, No. 2 (2012): 409-413.

Schueler, F. W. and K. E. Gunson. "The Road Ecology Circuit in Leeds & Grenville." *Trail and Landscape*. Vol. 45, No. 4 (2011): 155.

Oregon

WVC Carcass Collection Method

Maintenance workers fill out paperwork on carcass collection, data to the 1/10th of a mile. State is moving from paper records to a statewide data collection in electronic data device.

WVC Carcass Mapping

2009 study used Kernel Density Analysis to map WVC carcass data by ODOT region and for whole state. Results in a study, but not in a GIS website. Wildlife Vehicle Collision "Hotspots": https://nrimp.dfw.state.or.us/web%20stores/data%20libraries/files/ODOT/ODOT_887_2_WildC_ollHots_SummFIN.PDF. Accessed May 2, 2014. Figure 12, below, taken from report.

Wildlife Linkage Mapping

Oregon Wildlife Linkages: created and organized Oregon Department of Fish and Wildlife. Compilation of products from four workshops held throughout state in 2007-2008. Linkages were for focal species. Polygons were digitized during workshops. This is considered the first step. There are 723 lineage buffers digitized. ODFW, 06/21/2010, Oregon Wildlife. The Linkage workshop was summarized at the website: http://www.dfw.state.or.us/conservationstrategy/docs/Linkages_Report_Final_2009.pdf Accessed May 2, 2014.

Planning and Prioritization Process

One person within ODOT is the motivating force for wildlife mitigation efforts at ODOT, and at the end of 2013 had left the agency. The 2009 WVC Collision Hotspot Analysis report (above) gives each ODOT District a list of priority areas to work with, as well as a statewide list. There are less than 6 wildlife crossings in OR, and reason to create crossings appear to be outside parties, such as US Fish and Wildlife Service – 2 lynx crossings, U.S.D.A. Forest Service – 2 mule deer crossings in Bend. Other wildlife crossings were constructed for mule deer on ODOT roads, where ODOT took the initiative with Oregon Fish and Wildlife Agency.

Map

Figure 1. Wildlife collision hot spots on Oregon highways, based on a Kernel Density analysis of carcass reports.

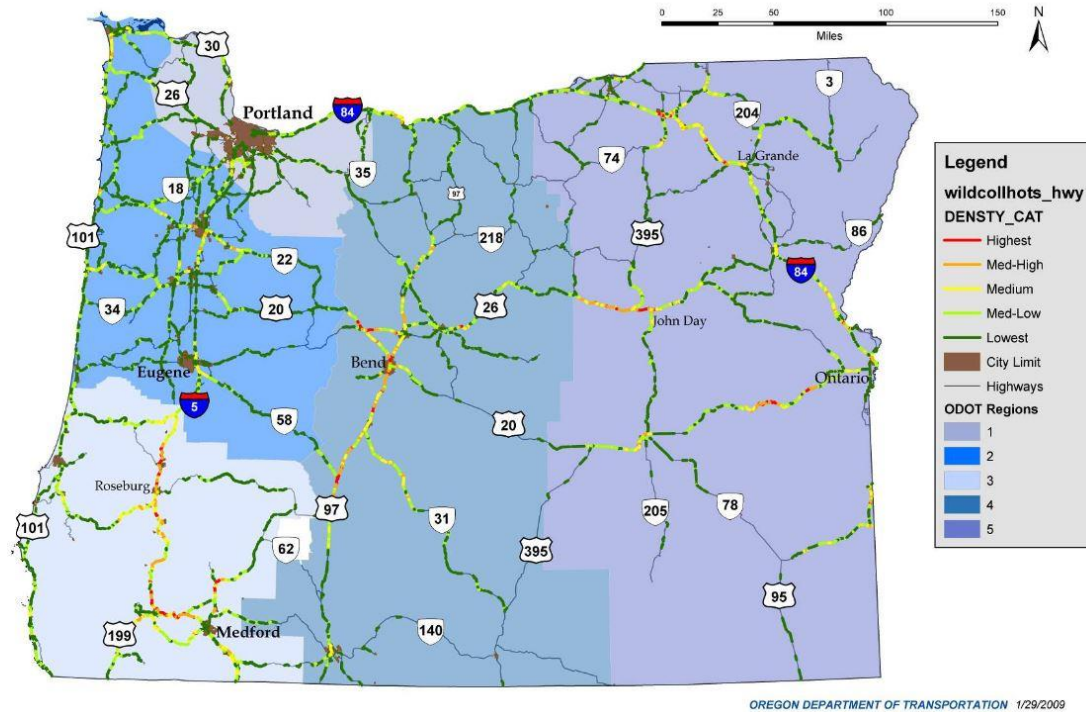


Figure 12. Oregon Priority WVC Hot Spots Mapped in 2009

Taken from the site:

https://nrimp.dfw.state.or.us/web%20stores/data%20libraries/files/ODOT/ODOT_887_2_WildCollHots_SummFIN.PDF

Texas

WVC Carcass Collection Method

No statewide process, TXDOT Headquarters environmental staff are unaware of the magnitude of WVC in state (P. Cramer, personal visit with TXDOT staff September, 2013).

WVC Carcass Mapping

None

Wildlife Linkage Mapping

None

Planning & Prioritization Process

Locally driven, and USFWS driven for ocelot. Texas rarely conducts any kind of wildlife mitigation. 9/17-18/2013 Dr. Cramer met with TXDOT to discuss potential actions to change this in order to record WVC carcasses, find outside the agency partners in addressing wildlife connectivity, and creating wildlife crossings. 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

Contractors record GPS location and species, gender and age of every carcass on mobile phone app. <https://wvc.mapserv.utah.gov/wvc/desktop/> Phone app and use of mapping process are by permission only and include UDOT, Utah Division of Wildlife Resources (UDWR), and other natural resource agency personnel. Data upload close to immediate.

WVC Carcass Mapping

The GPS carcass data is immediately uploaded to map website and accessed by password protected users. Data points are clustered according to the user defined scale.

Wildlife Linkage Mapping

Utah conducted a 2004 Rapid Assessment mapping of wildlife linkages; it is rarely used. Looking to WGA-CHAT for future use to map wildlife linkages.

Planning and Prioritization Process

Prioritization process is heavily dependent on individuals in UDOT regions and UDWR districts. Currently each UDWR district is instructed to 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 crash and WVC data on Excel spreadsheet graph with mileposts 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.

Close working relations with the UDWR personnel in counterpart district. UDOT engineers are beginning to use UPLAN, an interactive mapping platform on the Internet, for such analyses of WVC.

Washington

WVC Carcass Collection Method

Maintenance workers fill out paperwork on carcass collection, data to the 1/10th of a mile.

WVC Carcass Mapping

WVC data mapped for hotspots. *Washington Report: An Analysis of Deer and Elk-Vehicle Collision Sites Along State Highways in Washington State*. 2008.

<http://www.wsdot.wa.gov/research/reports/fullreports/701.1.pdf> (See Map in Figure 13)

Wildlife Linkage Mapping

Statewide Wildlife Connectivity Analysis: <http://waconnected.org/statewide-analysis/>

Planning and Prioritization Process

Systematic method was created in 2013 by WSDOT Ecologists where GIS modeling with maps created WVC priority segments across state based on: crash data, carcass data, roads, wildlife linkages maps, and federally and state listed “species of concern” habitat maps. Then through an intranet based environmental workbench, WSDOT biologists 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, conduct an evaluation using the PAS system to determine if existing structures could be retrofit for target species’ movement. See report on PAS: http://www.wsdot.wa.gov/environment/biology/bio_ea.htm#Connectivity. Final plans for mitigation are based on upcoming projects, including many bridge and culvert replacements.

Map

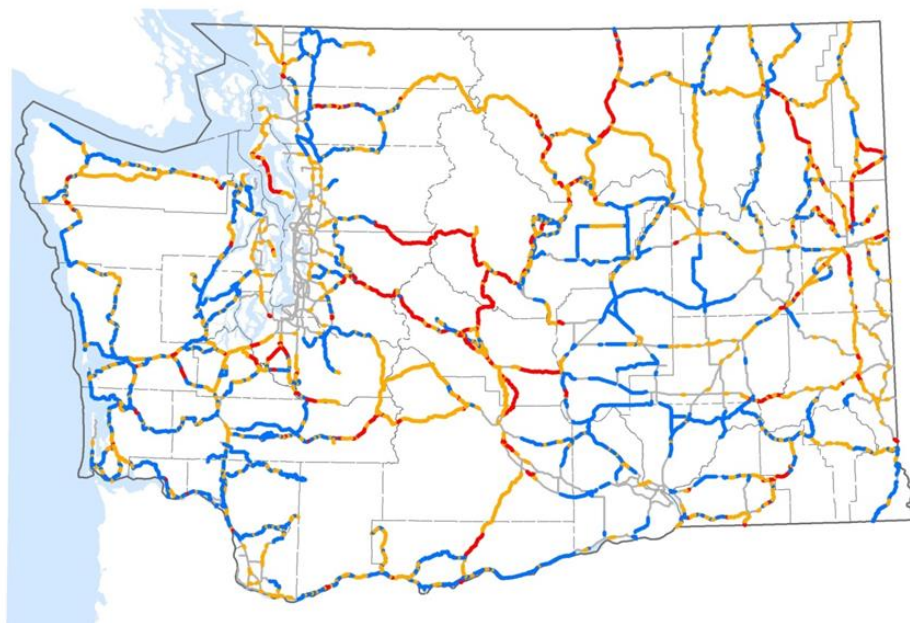


Figure 13. Washington State WVC Priority Road Segments

Taken from: <http://www.wsdot.wa.gov/research/reports/fullreports/701.1.pdf>

Wyoming

WVC Carcass Collection Method

Unknown

WVC Carcass Mapping

Unknown

Wildlife Linkage Mapping

Unknown

Planning and Prioritization Process

2013 Study to look at mapping WVC across Wyoming. **Graham, M. W. and C. Riginos.** *Evaluating the Effects of Deer Delineators on Wildlife-Vehicle Collision in Northwest Wyoming*. Cheyenne, WY: Conservation Research Center of Teton Science School, Research in Progress for Wyoming Department of Transportation, 2013. <http://trid.trb.org/view/2012/P/1265927>
Accessed December 22, 2013.

Select State and Province Summaries on Prioritizing WVC

Two team members, Julia Kintsch and Kari Gunson described in detail the WVC prioritization processes they are helping to develop in their state and province.

Colorado

Reported by Julia Kintsch of ECO-resolutions LLC

In 2005, the Colorado Department of Transportation (CDOT) instituted a voluntary program encouraging maintenance crews to record carcass removals and clean-ups into a statewide database. The program is designed to capture WVC that are not recorded as incidents by the Colorado State Patrol (CSP). Maintenance personnel are requested to record carcasses to the nearest 1/10 mile and species, if known. Only carcasses on the roadway pavement are recorded. The CDOT program is not mandatory and not tracked, so it is difficult to record reporting effort for a given highway segment, although in one area it was estimated by the CDOT maintenance crew leader to be around 50 percent.

At the outset of the program, data were collected on paper. In 2007, maintenance workers began recording carcass data using electronic SAP program available in their trucks that are also used to record timesheets. The electronic system facilitates ease of recording, but still requires multiple steps for compiling the data in a single statewide database. Data compiled by each maintenance section are submitted to the regional environmental office, which then compiles the raw regional data for submission to the headquarters office on a quarterly basis. The compiled carcass data are available to

anyone upon request, and are distributed quarterly to about 85 people, including regional environmental staff, biologists, regional engineers, several Parks and Wildlife staff, and other interested individuals. The quarterly data compilation includes the following metrics for each region:

- WVC's by month.
- WVC's by species.
- WVC's by species by highway and mile marker.
- Chart of total WVCs by month over the last 4 years for that quarter and in that region.

CSP data are the only data used for identifying WVC “hotspots” or comparing collision rates among highways or highway segments because, while an incomplete representation of the number of WVCs, accident reports are the only consistently compiled data across the state. The reporting effort in CDOT's maintenance roadkill database is too uneven to be useful for comparisons or analyses except for within the same maintenance section. However, these data may be requested and integrated into project-level analyses to help identify “hotspots” within a given highway segment. Where both datasets are being considered, it must be recognized that there is some overlap between CSP and CDOT data as they may each record the same incident and the data are not filtered for possible duplication. The CSP data is also limited in that often species is not distinguished in the accident reports.

CDOT's ability to collect consistent high-quality carcass data is hamstrung by three primary factors:

1. The agency's insistence that the program be voluntary.
2. Lack of support for training maintenance personnel in data collection and the value of these data.
3. The effort required to record the data.

Despite these difficulties, DOT maintenance programs offer great opportunity for collecting carcass data. The manager of CDOT's maintenance roadkill database offers the following advice for advancing a typical DOT effort to collect WVC carcass data:

- Get maintenance supervisors on board first, and build support for training maintenance personnel in data collection protocols.
- If possible, require carcass data reporting rather than having a voluntary program.
- Facilitate ease of reporting by automating the reporting as much as possible. For example an app (but can't be used when driving) or dashboard-based control that automatically records the GPS location and date so that the user need only specify species and any ancillary information that they wishes to report.

Because of the inconsistencies in the dataset, the data are not mapped, except for local use for individual projects due to concerns that variances in reporting effort could skew decision-making. For example, it is generally recognized that maintenance personnel on the Western Slope tend to

participate more in the program because of their personal interest in wildlife and hunting, whereas as staff in the eastern plains have lower participation rates. The resulting data do not accurately reflect WVCs across the state. While the data are of limited utility now, CDOT the program manager is optimistic that over time, with a new generation of workers, the data collection effort will be more integrated, resulting in a more consistent reporting effort across the state.

Despite these restrictions, there are several examples where the CDOT maintenance roadkill dataset has been used to guide priorities and inform decision-making. Notably, the data were used by the ALIVE Committee – an inter-organizational stakeholder group invested in the I-70 Mountain Corridor – to feed into the process for identifying Linkage Interference Zones as a part of the I-70 Eco-Logical Project. Specifically, WVC data were used in conjunction with species habitat data in a GIS to delineate 13 linkage zones along 130 miles of interstate.⁽⁵⁾ Along other roadways, these data may be considered locally for specific project areas with known WVC problems. In these instances, the data are used to help pinpoint specific mile markers that are problematic.

The maintenance road kill database also helped in the identification of WVC “hotspots” across the state for the establishment of wildlife crossing zones. The identification of these WVC “hotspots” was required by the Colorado Legislation, signed into law in 2010, and resulted in 14 wildlife zones being identified across the state with lowered seasonal and/or nighttime speed limits, with increased traffic enforcement along these segments.

An observational website was created in 2009 for the I-70 mountain corridor from Denver to Glenwood Springs to record opportunistic wildlife sightings (alive or dead) by drivers along the corridor (<http://www.I-70WildlifeWatch.org>). The website was created and promoted as a part of the I-70 Eco-Logical Project and the data collected complemented the other data layers informing the identification of Linkage Interference Zones along this segment. While the site is still live, there is no longer funding available to encourage citizen participation or to analyze the data.

Wildlife Linkages and Prioritization in Colorado

In 2005, a statewide connectivity assessment, *Linking Colorado's Landscapes*, was completed by the non-profit organization Southern Rockies Ecosystem Project with funding from FHWA and CDOT. The effort 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, 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. For these analyses, CSP accident reports were considered at a finer scale to pinpoint specific roadway segments with the greatest WVC problems. At the time of the assessments, the CDOT maintenance roadkill database was not yet available.

In 2008, the state received an FHWA Eco-Logical grant to conduct an in-depth analysis of wildlife linkages along the I-70 mountain corridor. 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.

The primary steps for the GIS-supported analysis included:

- Identifying primary and secondary parameters for prioritizing road segments based on their potential contribution to habitat connectivity for terrestrial wildlife.
- Ranking and tallying the presence/absence of primary parameters for each 1/10th mile segment along the corridor.
- Applying decision rules for delineating discrete connectivity zones within each bioregion and applying secondary criteria as appropriate.

Milepost-specific mitigation recommendations provide CDOT with preliminary information for considering terrestrial and aquatic wildlife movement needs during planning, design, construction, and operations and maintenance. These mitigation recommendations provide an initial guide for incorporating connectivity needs in to transportation projects that will be further developed during Tier 2 planning processes.

While data and analysis are critical elements in informed, ecosystem-based decision-making, so too are the stakeholder processes that provide a framework for integrative planning. The I-70 Eco-Logical Project built an existing inter-organizational committee tasked with addressing wildlife concerns in the corridor. The agencies and stakeholders engaged in the ALIVE Committee informed the general project approach, tasks and outcomes. In this way, the I-70 Eco-Logical Project advanced the development of mechanisms for integrating connectivity concerns into transportation planning for the I-70 mountain corridor, as outlined in the ALIVE Memorandum of Understanding. These mechanisms are designed to facilitate early incorporation of terrestrial and aquatic connectivity in each life cycle phase of the planning process, improve predictability in the environmental review process, and avoid delays in project development and delivery.

To support the objectives of ecosystem-based planning and collaboration the project team facilitated a sub-committee of agency and local government stakeholders to create an Implementation Matrix to highlight specific considerations for wildlife at each phase of potential infrastructure improvements. The resulting ALIVE Implementation Matrix lends structure and guidance in addressing connectivity concerns as projects move into Tier 2 planning and design. The Matrix outlines specific inputs (e.g., wildlife and land use data), considerations (e.g., what opportunities exist to improve, protect or restore permeability

and habitat components?), and outcomes (e.g., avoidance and mitigation strategies). Notably, the matrix is designed to be adaptable to changing and updated data and information while taking into consideration specific stakeholder resources and concerns at each life cycle phase of a transportation project.

At the outset of a transportation project along the corridor, the CDOT project manager identifies and initiates a Project Leadership Team (PLT), consisting of local agency and community representatives and other key parties specific to that project area. The establishment of PLTs is a major step towards integrative transportation planning in Colorado, demonstrating a commitment to a more inclusive and transparent process that is widely supported, manages expectations, and demonstrates best practices – a model for transportation projects across the state and the region.

Ontario, Canada

Reported by Kari Gunson of Eco-Kare International

Background Information

Ontario is a large province and has the highest biodiversity of wildlife in Canada. In its southern region (where the majority of the human population lives) there is a large need for conservation for many of Ontario's smaller endangered wildlife species, such as amphibians and reptiles. In the northern region (north of the Canadian Shield) where roads and human density are less, many larger animals such as black bear (*Ursus americanus*), moose (*Alces alces*), elk (*Cervus canadensis*), white-tailed deer (*Odocoileus virginianus*), bobcat (*Lynx rufus*), lynx (*Lynx canadensis*), and gray wolf (*Canis lupus*) are more abundant. Although more large animal-vehicle collisions that occur in northern region, collisions with deer are an issue through-out the province.

A recent report has shown that on average collisions with large animals has increased by 9.47 percent from 1994 to 2001 in Ontario and by 14.5 percent with deer (1994 to 2004) in Ottawa, Ontario alone.⁽²⁾ As WVC rates rise, so does the safety risk for motorists on Ontario's roads, prompting government authorities to investigate mitigation solutions for the problem. In the past few years, the Ontario the Ministry of Transportation (MTO) has begun to integrate road ecology science into its planning and policy procedures. Currently, the MTO is developing a strategy to prioritize where short- and long-term mitigation for small and large animals is most required on provincial roadways in the Province. This is 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.

Short-term mitigation will include implementing taxa specific wildlife warning signs at prioritized locations, with the intention of improving mitigation measures with upcoming and routine road upgrade procedures.⁽³⁾ Longer-term solutions include integrating wildlife underpasses, overpasses, and fencing. In addition to prioritizing where and what mitigation is required, the MTO is looking for information technology solutions for better WVC data collection and for increasing public awareness about the issue.

WVC Mapping and Prioritization Methodology for Large Animals

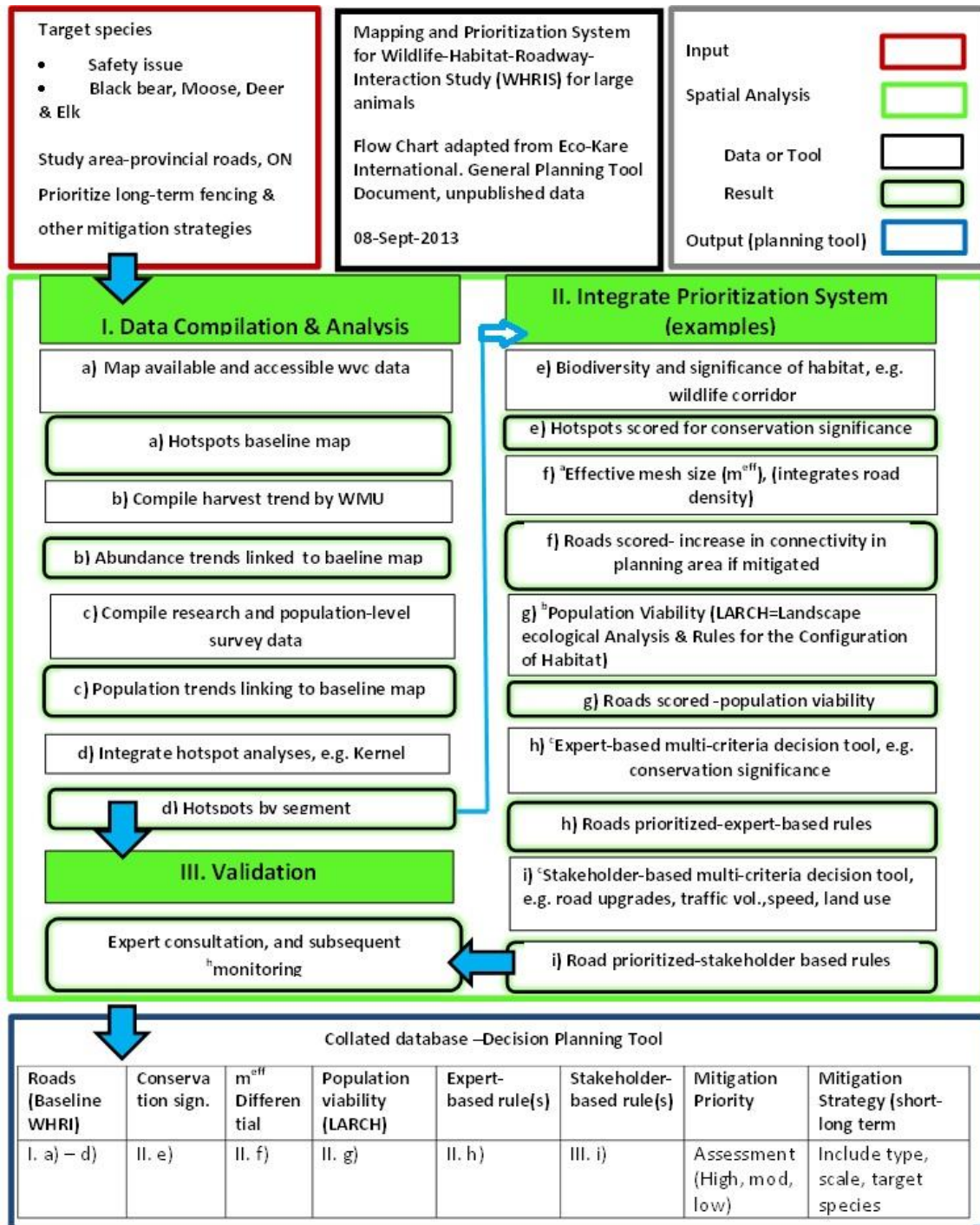
An expert workshop was held on October 29th, 2013 that hosted academic and government transportation and wildlife experts to determine the best available and accessible data, its limitations to predict where mitigation should be prioritized, and the best approach to meet the goals and objectives of the assignment. The mapping methodology will focus on using large animal-vehicle collision (AVC) data, and (specifically crash data reported by the Ontario Provincial Police (OPP). The crash data is not species specific and it may have up to 2 km of spatial error. The crash data is first referenced to the nearest landmark by the OPP and is then sent to the MTO for translation to their linear highway referencing system (LHRS). Crash data will be used for from 2001 to 2010 to account for temporal variability. There will be several metrics calculated at specific highway segment lengths; these will include number of WVCs per year, and proportion of crashed involving wildlife. Once data is compiled, it will be mapped on provincial roads and spatial hotspot analyses will be conducted to determine WVC hotspots. Spatial hotspot analyses will consist of using graduated symbols to denote WVC rates on 2-4 km road sections. Hotspot analyses will only be conducted on the provincial road network; however the approach can be applied in a municipal context across the province. These spatial hotspots will be considered baseline hotspot mapping for mitigation based on safety criteria only. Obvious limitations to these hotspot analyses are the lack of species-specific information and inaccuracy of locations when transcribed from the crash location to the MTO LHRS.

Other pieces of information used for the prioritization process include population and abundance data, severity of accident to motorist, and traffic volume. Abundance data is limited in the province, only available by wildlife management unit (WMU). When abundance data is lacking harvest data may be a surrogate to measure projected abundance trends within Wildlife Management Units, especially for Deer. Traffic volume (TV) will be integrated by first regressing traffic volume on the number of baseline collisions per hotspot to rank classes of TV that most contribute to AVCs.

Criteria will be implemented and integrated in a geographic information system spatially and by matching data attributes to each “hotspot” location. A final database will be compiled for each baseline hotspot with its associated attribute fields (Figure 14). This process will also assist in providing information for the type of mitigation strategy required. An example criterion for mitigation importance may be a threshold value for an acceptable proportion of total collisions that involve wildlife on a specific road stretch within a specific MTO district. There will be opportunities through a final meeting in March 2014, on-line tools and email surveys for experts and stakeholders to comment and validate the final database and map(s) for inclusion as final deliverables to the MTO. All future recommendation to increase functionality of the system, and its current limitations will be documented and reported and for continual upgrades and iterations of the decision planning tool

All criteria and metrics will be compiled into a decision planning tool database. Final weighting of criteria will be based on expert and stakeholder opinion and will subsequently inform mitigation priority, e.g. high, medium or low and a preferred mitigation strategy. Mitigation strategies will be based on a compilation of a list of relevant mitigation strategies in Ontario. A cost-benefit analysis can be used to

justify more costly mitigation in areas where WVC have surpassed a specific threshold. Field surveys and ground trothing will be action items and next steps to inform each “hotspot” location. Field surveys will focus on improving the data gathered in a GIS such as informing permeability of the current length of highway with bridges, and assessing retro-fit opportunities at each “hotspot.”



Spatial analysis tools are not exhaustive and are relevant examples to meet specific goals and objectives that integrate current published science and wildlife habitat mapping principles for multiple species (e.g.; ^aJaeger 2007, 2006, ^bVan der Grift and Pouwels, ^cClevenger 2012).

Figure 14. Flow Diagram of Proposed Wildlife Mitigation Action Prioritization Process for Ontario, Canada

Note: Eco-Kare International. 2013. Wildlife Habitat-Roadway Interaction Mitigation Strategy. Proposal submitted to the Ontario Ministry of Transportation. St. Catharines, Ontario

A. WVC Mapping and Prioritization Methodology (this will be expanded on as the Ontario Prioritization Project progresses):

Currently there are two main data sources in Ontario:

- a. Maintenance Crews (carcass data)
 - Spatial accuracy varies: sometimes use GPS in trucks, however sometimes only descriptive location that is geo-referenced by student
 - 2006 to current.
 - Only collect in northeast region.
 - Mostly species specific.
 - Better than crash data but still does not include carcasses that die away from roads.
- b. Ontario Provincial Police (OPP) (crash data)
 - Spatial Accuracy Varies: referenced to municipality, highway and possibly nearest km marker.
 - Only reported if collisions are more than \$2,000.
 - MTO receives data in 5-year increments (2002-2006) and is not species specific.
 - Only 10 - 50 percent of the carcass data.

B. Compiling large animal abundance data in Ontario

Currently there are two main sources of population abundance data in Ontario:

- a. Harvest Data and Trends: available by WMU in Ontario for all large game species (deer, moose, black bear and elk); temporal and spatial units are still being discerned.
- b. Research Specific: telemetry data projects, aerial surveys, genetic analyses for black bear, and pellet and tracking surveys (specific to eastern Ontario, Algonquin Park and Northeast and Northwest region).

In summary there were four main questions that came from this discussion and so I have grouped bullet points under each:

1. How do you deal with limitations in your WVC data (crash vs. carcass)?
 - Washington State looked at crash data and found 95 percent of those reported were with ungulates.
 - Can interview highway maintenance personnel to find out the “correction factor” for crash vs. carcass data.
2. How do you define large animal road mortality “hotspot” locations for mitigation (in this case fencing)? New Brunswick DOT determines WVC rate per km for a 5-year period, and what type of road (access points)
 - It is beneficial to have historical as well as present data if possible.
 - Recommended to take an average over a period rather than per year.

- When defining a “hotspot” you need to take “barrier effect” as well as connectivity into consideration, WVC rate may not be telling the entire story, barrier effect could also be a function of traffic volume.
 - Should not consider fencing as the only mitigation strategy, especially when justifying it to be used based on a cost-benefit analysis.
 - The benefit of fencing is that it possibly reduces collision rate, if there isn’t a fence end issue, but it also has a cost, it increases landscape fragmentation.
3. What criteria can be used to prioritize a large animal hotspot for mitigation?
- Require other criteria to supplement WVC rates, this would put less emphasis on WVC rate which may not be accurate because data is lacking, opportunistic, or not accurate.
 - Population viability.
 - Important criteria will vary among which stakeholder you talk to.
 - Prioritizing where mitigation should go could be based on safety (WVC reduction, or a conservation angle (restoration of Endangered and Threatened species, and increase in connectivity)).
 - Conservation angle would have high weight if a population is depleted at a specific location and mitigation is a recovery effort, this would have significantly high benefit especially if there are regulations such as an Endangered Species Act.
4. What constitutes a cost and what constitutes a benefit when using this analysis for convincing transportation professionals to mitigate a road at a specific location?
- Cannot rely on cost-benefit analyses to justify locations for mitigation especially when based on WVC data, cost-benefit analyses are more to justify using mitigation in the first place, e.g. it can convince transportation agencies that it will save you money.
 - If conducting a cost-benefit analysis then need to consider costs associated with lawsuits, and also need to be careful how you define a benefit, a benefit to a DOT may not necessarily be the same benefit to a motorist or taxpayer.
 - Mitigation measure could be to trade a piece of land that a DOT owns with the fish and game regulatory agency, can put a price tag on this especially if can be developed. Price tag can also have indirect value if land is part of wildlife corridor. This helps to “value” the benefit, and decide on the type of mitigation measure to use, what has more value or benefit to the wildlife?
 - DOT’s and MOT’s need to develop a usable method for estimating the dollar value of fragmentation/connectivity relating to roads, however flawed or limited that method may be.

Prioritization of Wildlife-Vehicle Collision Treatments

Sandra Jacobson, USDA Forest Service, Pacific Southwest Research Station, Davis, CA

Sandra Jacobson of the USDA Forest Service was a member of the team who has experience with different prioritization processes to help put wildlife mitigation actions in place. She created a step by step prioritization process that was used to develop the overall WVC Prioritization Process in this research. While the sections of the report described the process, it did not go into detail as to why each step was important. This appendix section gives credence to the methods used in the WVC Prioritization Process.

Introduction

Prioritization of mitigation for sites with known WVC issues has not been standardized, although virtually all states in the Union have a serious problem. Generally, DOTs use sites of frequent or recurring carcass pickups to identify “hotspots” as the first locations to mitigate. However, there are many other factors to consider over the long term to prioritize efficiently.

We considered several model approaches. We rejected the simple prioritization of sites based exclusively on carcass data for the following reasons. Using carcass data alone masks the effect of increasing traffic volume on the severity of the mortality and habitat fragmentation issues because very high traffic volume highways such as Interstates may have very low mortality from WVCs with concurrent high avoidance (indicating a high level of habitat fragmentation) or a long term population reduction.⁽²⁷⁾ Carcass data is frequently intermittently collected or unstandardized, making comparisons across the state difficult. Carcass data indicates where WVCs have occurred but it does not consider ecological values. Using carcass locations does not consider the temporal trends in human or animal populations, nor does it consider opportunities associated with interested stakeholders or planned highway improvement projects.

Value analyses that weight criteria and options in a prioritization matrix can consider multiple criteria of importance to ITD, IDFG and the citizens of Idaho. A prioritization matrix is a decision tool that narrows options by systematically comparing choices through the selection, weighing, and application of criteria. An example of a value analysis/prioritization matrix is the following, from a simplified 25-mile stretch of SR-89 in northern California (credit Highway 89 Stewardship Team)⁽¹⁾

**Table 16. California's Highway 89 Stewardship Team Prioritization
Process Checklist for Wildlife Mitigation Action
SR 89 in northern CA (credit Highway 89 Stewardship Team)**

Criteria	Definition	Value	Description
Aesthetics	How Will the Project Influence Visual Quality.	0	Visually Distractive
		3	Noticeable But Not Intrusive
		5	Not Intrusive
Cost	Absolute cost, < or = \$720K	0	> \$720K
		3	= \$350K
		5	< \$100K
Cost Effectiveness	Best value for the money spent – should a project be implemented because it is affordable, but doesn't necessarily serve the species, the purpose or need	0	Low Value for the Money Spent
		3	Medium Value for the Money Spent
		5	High Value for the Money
Environmental Impact	Adverse effects to the environment such that it may be publicly undesirable, the mitigation may be prohibitive etc.	0	Permanent Impact With Mitigation
		3	Temporary Impact That May Require Mitigation
		5	No Impact
Feasibility	Can the project/concept actually be built with a general idea of potential limitations?	0	No Feasible Way to Be Built
		3	Feasible With Limitations
		5	Can Definitely Be Built
Habitat Quality	Will the proposed project improve access to quality habitat or is it just a convenient location. Is there the potential for the facility to be used by multiple species?	0	Low Species Use, Limited Habitat Availability
		3	Few Species Most Of The Time
		5	Multiple Species, Important Habitat
Human Use/Influence, Human Proximity	Amount, duration & time of potential human interaction	0	Proximity to Permanent Human Development or Well Established Facility
		3	Proximity to Temporary/Seasonal Human Disturbance
		5	None or Rare
Land Ownership	Ownership complexity. The current project has no right-of-way dollars – does the proposed project have right-of-way issues.	0	Private Property Only
		3	Public & Private Property
		5	Public Property
Maintainability	Maintenance frequency requirements	0	High Frequency (Annual), High Cost
		3	High Frequency/Low Cost
		3	Low Frequency/High Cost
		5	Low Frequency/Low Cost
Multiple Species	Effectiveness of the facility to serve multiple species	0	Few Species, Limited Crossing Success
		3	Few Species Most of the Time or More Species Seldom
		5	Most Species, Most Time
Safety	What is the projects influence on public safety	0	No Improvement
		3	Moderately Improved
		5	Improved Safety
Urgency	Owner or manager activity may lead to a lost opportunity – i.e. planned development, increased traffic, losing ability for landscape level planning	0	No Urgency (No Foreseeable Lost Opportunity)
		3	High Priority/Low Opportunity
		5	Urgent (Lost Opportunity)

Methods

The Highway 89 Stewardship Team then placed these criteria in a weighted prioritization matrix according to the values the group identified (Table 17). The higher the value, the more the group valued that criterion. The total column indicates the number of times the criterion was selected in a two-way choice. The percent column expresses it in percentage. For example, in this project stakeholders chose Feasibility over Maintainability (A over C), and Maintainability over Aesthetics (Column and Row B). Aesthetics was never chosen as more important than another criterion, so it received 0 percent of the choices.

Table 17. California's Highway 89 Stewardship Team's Weighted Criteria Matrix for Selecting Actions to Address Wildlife-Vehicle Collisions

		Feasibility	Aesthetics	Maintainability	Environmental Impact	Cost-effectiveness	Land Ownership	Urgency	Habitat Quality	Multiple-Species	Safety	Human Disturbance		
Criteria		A	B	C	D	E	F	G	H	I	J	K	Total	Percent
A	Feasibility		A	A	A	A	A	A	A	A	A	A	10	20
B	Aesthetics			C	D	E	F	G	H	I	J	K	0	0
C	Maintainability				C	E	F	G	H	I	J	K	2	4
D	Environmental Impact					E	F	G	H	I	J	K	1	2
E	Cost-Effectiveness						E	G	H	I	J	K	4	8
F	Land Ownership							G	H	I	J	K	3	6
G	Urgency								H	I	J	G	6	12
H	Habitat Quality									H	H	H	9	18
I	Multiple-Species										I	I	8	16
J	Safety											J	2	4
K	Human Disturbance												5	10
		Total											50	100

Our approach uses a modified framework derived from Joseph et al., Figure 15, to organize questions and data needs for Idaho's prioritization process.⁽⁴⁾ Further prioritization and risk assessment processes from the Army Risk Matrix informs the approach.



Figure 1. Graphical representation of Joseph et al.'s (2009) nine steps to prioritization beginning with defining objectives.

Figure 15. Flow Diagram of the Nine Steps to Prioritization
First Step is to Define Objectives⁽⁴⁾

For most steps in the cycle, a table can be prepared with weighted levels. Although some questions are qualitative, the entire process when completed will provide a quantitatively derived prioritization of sites throughout Idaho. The qualitative questions will help to confirm or caution results derived from the quantified process.

This process is organized as an iterative circle, adaptively moving around to the beginning after one cycle. The order is:

1. Define Objectives.
2. List Biodiversity Assets.
3. Weight Assets.
4. List Management Projects.
5. Estimate Costs.
6. Estimate Benefits.
7. Estimate Likelihood of Success.
8. State Constraints.
9. Choose Projects.

As the process of determining priorities proceeds in Idaho, a few issues could be kept in mind. First, recognition that mitigation of WVC's is a very long term, ongoing challenge and an integrated, practical solution is likely to take many decades. Second, prioritization of WVC mitigation is about not only safety but also about the health of Idaho's game populations; without healthy, connected herds and their natural ranges, Idaho will suffer economically as well as culturally.

1. Define Objectives

Defining objectives is the first step in prioritization of WVC reduction. Defining objectives is the purview of management, and this step must be carefully completed in order for the following steps to be properly conducted. The authors of this research report suggest at least three categories of objectives: Safety, Economy, and Ecological Considerations. Other categories can be added. Possible candidates include: Opportunity, Urgency, Stakeholder Interest (including political or social cost), Esthetics, Cost-Effectiveness (including engineering feasibility), or some other. The following questions suggest considerations in determining the objectives of the prioritization process.

A. Safety

The primary objective of this measure is to define effectiveness of mitigation measures in terms of human fatalities, injuries and property damage from WVCs. The definition of an effective mitigation measure for reduction of WVCs may be a simple before/after mitigation deployment, for example a reduction in WVCs of 85 percent. Studies show that a combination of fencing, wildlife crossing structures, and escape structures can reduce the incidence of large animal/vehicle collisions by 80 - nearly 100 percent, assuming proper design features and maintenance are employed. If a lower level of risk and effectiveness is acceptable at a given site, then typically a lower cost mitigation measure can be deployed.

B. Economy

The primary objective in this measure is to keep costs as low as possible while meeting the likelihood of success that is set in the other two objectives. This measure answers the basic question of "How much does a given mitigation measure cost?" A low relative cost project would rank 10 on the Economy scale; whereas a very high cost project would rank 0 (such a project may be a stand-alone overpass on a level terrain). A low cost project such as a retrofit to an existing culvert, such as removing a barrier of a livestock fence at the entrance of an otherwise suitable structure might be 10.

Considerations include more than the absolute cost of a mitigation feature. What is the net cost of an added feature that provides wildlife passage relative to a standard design? For example, if a bridge is being rebuilt, how much is the net extra cost to design an additional dry surface for animals to walk on, or to install interlocking concrete blocks instead of large boulder armament? What other benefits of those features can be inferred to other resources; for example, an expanded bridge may provide long term protection against pulse storm events.

C. Ecological Considerations

Sustainability of Idaho's large animal populations is an ecological objective as well as a cultural value. Idahoans value the legacy of harvestable levels of big game as well as the financial values that come with watchable wildlife.

In addition to a reduction in mortality from reduced WVCs, an important ecological objective is to maintain the ability of animals to move across the landscape. Movement is important at several scales, including genetic interchange, demographic movements, and movements to meet daily or seasonal life requisites. The scale of population impact informs the urgency of deploying mitigation measures and how effective the measures must be in order to solve the problem.

Ecological considerations, including animal behavior relative to varying levels of traffic volume and highway functional classes, are important in interpreting carcass and road kill data. Most large mammals show increasing avoidance of highways as traffic volume and lane width increases, so the level of mortality is actually lower on high volume roads such as interstates than on moderate volume roads such as 2-lane, rural 55 mph highways. An implication of this fact is that carcass data must be carefully interpreted to reveal whether a highway has an advanced problem of habitat fragmentation, such as with an interstate, or a less advanced problem of habitat fragmentation, such as with a low volume (up to about 2,500 AADT) highway. Both highways may have similar levels of carcasses, but a higher volume highway with low mortality indicates an advanced problem while a very low highway with low mortality indicates a lower priority problem.

Areas managed especially for wildlife are important to consider in objective setting, partly because the management of wildlife is a primary mission objective for several cooperating agencies of ITD. Where highways cross wildlife management areas, national or state wildlife refuges, national parks, or national forests, the objective of reducing WVCs includes a strong element of habitat connectivity as well as mortality prevention.

2. List Biodiversity Assets

Data needs include connectivity assessments; herd winter, summer and transition ranges; carcass data; location of rare species ranges (to enhance efficiency of prioritization); trend of herd populations. Species may vary by location, for example, moose do not occur all over the state but are a serious safety consideration where they occur. Moose, elk, bighorn sheep, mule and white-tailed deer, and pronghorn are likely to be the minimum species to consider in WVC safety and ecological issues. Black bear and mountain lions also pose a rare safety issue such that their presence can be considered coincident with their prey species.

Biodiversity assets include land ownership where habitat for target species is likely to remain good. Public lands, trusts and other lands managed for natural resources are important to spatially identify with the previous biodiversity assets. Most public lands have land management allocations that indicate the degree that parcels are managed for wildlife habitat; indicating these will assist in the location of high potential WVC areas as well as high value mitigation sites.

At this step, it is important to assess the data gaps and how to address them in the short or long term.

3. Weight Assets

Weighing assets includes temporal considerations such as the population trend of a herd as well as spatial considerations such as a high WVC incidence. An example may be where a herd traditionally wintered in a valley fully developed as a subdivision, with little available habitat remaining. This herd may have an urgent need and high weight for immediate action to be accommodated, or alternatively a triage action may be considered to allow the herd to become extirpated.

Based on objectives determined in the first section, consider the following to determine weighting values. Suggested weighting of assets scales the 3 categories of objectives as follows:

Safety - 10 points.

Economy - 10 points.

Ecological Consideration - 10 points.

A perfect project would weight 10 in all scales; the worst project would rate 0 in all scales.

A site with very high collision frequency (Safety = 10 points), low cost for fencing to divert animals to an existing suitable bridge structure (Economy = 10 points), and on a highway through a wildlife management area (Ecological Considerations = 10 points) would rank high priority. Alternatively, a site with a low volume highway through level terrain and no recorded carcasses (Safety = 0 points), challenging terrain for underpass, overpass or fence construction (Economy = 0 points), and marginal habitat value (Ecological Consideration = 0 points) would rank lowest priority.

Consideration needs to be given to the cost of no action and foregone opportunities as well as positive actions. For the future, some decisions will be precluded if no action is taken.

This step will result in a table of considerations and relative weights.

4. List Management Projects

Listing management projects provides an indication of the opportunities for mitigation in the next 5 to 10-years. If a highway stretch has an urgent need to be mitigated but has no project currently in the project pipeline, funding sources may need to be sought for implementation. Otherwise, a project already in planning has a high opportunity value, and probably most rural highway improvement projects have some opportunity to reduce WVCs.

Data needs for highway management projects include the following items:

- A. Bridge Replacements Planned.
- B. Structurally Deficient Bridge Locations.
- C. Culvert Replacement Needs and their Schedule.
- D. Undersized Culvert (of at least 12 ft. span) Locations.
- E. Aquatic Organism Passage Planned Mitigation (for integrating projects).
- F. Planned Highway Upgrades, Including Smaller Projects such as Resurfacing, and STIP Dates.

- G. Road/Stream Intersections and Adjacent Barriers (Such as Lakes, Cities, Train Tracks).
- H. Parallel Infrastructure (Such as Utilities, Canals, or Train Tracks).
- I. Traffic Volume Current and Projected In 10, 20 and 30 Years.
- J. Width of Highways (and Number of Lanes).
- K. Responsible Agency for Highway Maintenance.
- L. Existing Wildlife Crossing Structures and/or Fencing.
- M. Retrofitting Opportunities.

Data needs for land management projects include the following items:

- A. Planned Winter Range Habitat Improvements.
- B. Planned Landownership Changes from Private to Public Lands.

An additional approach in this step that may provide useful information is to model highway stretches with adequate biodiversity information (carcass data, linkage zones, winter range, etc.) for fencing and/or fencing with wildlife passages using simulated stretches of fencing.⁽⁵⁾ Modeling provides an experimental approach that, when used with conservative assumptions of effectiveness, can identify segments of highways to mitigate in a cost-effective manner. Modeling fence segments has shown that short segments of fence are most cost-effective ecologically and economically when target species' movements are clearly identified and channeled, whereas larger fence segments are more cost-effective ecologically and economically when target species' movements are diffuse and irregular.⁽²⁹⁾ This approach does not consider many of the factors we suggest are important, but it can provide a starting point for relative effectiveness on a large scale when combined with other qualifiers.

5. Estimate Cost

For each of the projects listed in Section 4, a cost associated with improving them to accommodate wildlife (primarily deer, moose or elk) passage can be assigned. The cost will be an estimate based on the minimum working structure at the site. At some sites, multiple mitigation options may be available, with a different cost and benefit associated with each. For example, an existing structure such as a minimally-suitable culvert may be present that could be retrofitted by installing diversion fencing at modest cost but with no planned STIP project to fund it. The same site may have a bridge replacement planned in 5 years that could be modified to create a much better passage structure than the retrofitted culvert but with a delay in implementation time.

6. Estimate Benefits

Two major benefits are considered in our prioritization approach. First is the benefit of reducing human fatalities, injuries and property damage due to WVCs. Second is the value of wildlife to Idaho citizens and their way of life.

Quantification of cost/benefits in WVCs can be found in Huijser et al.⁽⁶⁾ Huisjer's approach considers the cost of human lives, injuries and property damage, and does not take into account the value of wildlife, thus we add an additional measure to the analysis through these questions.

- A. Urgency. Is the current situation at urgent risk of impacting the population level of the target species?
- B. Opportunity. Is funding available currently, is a project in the project planning pipeline, or if a bridge is present, is it structurally deficient?
- C. Expected Future Condition. What is the projection for the target species population in the next 10 to 50 years based on future human development and land use, and traffic volume?
- D. Current versus Future Benefits. How greatly will mitigation done in the near term benefit the target population compared to a greater benefit in the future? An example of this is a retrofit of a marginally suitable culvert compared to construction of a bridge with specially designed wildlife features.
- E. Multiple Species. Will a project benefit multiple species? This is a particularly important benefit if the other species benefitted are federally or state listed species.
- F. Mitigation Banking. Will a project provide a wetland restoration or other potential mitigation banking opportunity?
- G. Social Considerations. What are the benefits to a local human population in terms of sustainability of hunting customs, or sustainability of wildlife values for hunting, wildlife watching, or other social needs?
- H. Cumulative Effects. Are cumulative effects, such as high road density, reduced habitat quality from invasive species or intense fires, or other factors affecting the possibility of improving conditions on the highway?

7. Estimate Likelihood of Success

Studies in the last 15 years have confirmed that several mitigation measures to reduce WVCs have a high probability of success when applied using good designs and locations. Although fencing alone has a high benefit/cost in reducing WVCs, it does not promote animal movement, which is necessary for most of the target species in Idaho to survive and thrive. A combination of well-designed wildlife crossing structures, diversion fencing, and escape structures has been shown in multiple studies to be effective in reducing WVCs as well as facilitating animal movement.

In the previous steps, mitigation options were identified by site. Unfortunately generally speaking, the more expensive mitigation options tend to produce the greatest amount of gain in effectiveness.

However, depending on the objectives identified in Step 1, a small reduction in the incidence of WVCs may be adequate to meet management objectives at a given location. In other locations, particularly sites of high ecological value, the standard for success is higher.

Thus the likelihood of success is tied to the stated objectives in Section 1. For sites in which Safety is the overriding consideration with a scale value of 10, and lowest scale values for Ecological Considerations and Economy, a fence project would rank high on the probability of success. However, for sites with high values in all three scales, the likelihood of success would need to include considerations for animal movement as well, so would likely be a project that included a suitable passage structure.

8. State Constraints

The primary constraint associated with prioritization of mitigation of WVCs is cost. The second is related, involving time and foregone opportunities associated with the passage of time. It is clear that mitigation for WVCs across the state will require a multiple-decade effort, during which some of the assumptions made in this analysis will be rendered obsolete. Thus, an update of any analysis is recommended every decade or so.

The constraint of cost can be managed to some extent by carefully considering all funding mechanisms appropriate for each mitigation measure. For example, bridge replacements were considered a separate funding item in SAFETEA-LU but not MAP-21, and if they become separate in a future bill it may be a special opportunity as structurally deficient bridges gain momentum.

Time constraints include both urgent opportunities, such as funding windfalls, as well as urgent high impact situations where no action can cause irreversible damage to target species populations or high human fatalities. These constraints cannot always be planned, but a prioritization process that enables high risk situations to be identified will capture more opportunities as they arise.

9. Choose Set of Projects

This step is the decision stage of the previous information gathering stages. Once a set of projects is chosen, and implementation occurs, then monitoring can also inform the process for the next set of projects.

Prioritization implies a series of choices in sequence. As the first choice of projects is implemented, the next set of projects can be online, such that a continuous series of projects is moving forward. At some pre-determined point in the process, new data will need to be analyzed to determine if previous priorities are still in line with management objectives. This begins the iterative process and the cycle repeats.

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Appendix C

Wildlife Mitigation Action Strategies

Treating Areas Near Road

Vegetation Management

Vegetation both draws animals near the road to feed and may impeded the line of sight that drivers and wildlife use to be wary of one another. The two most predominant treatments are:

1. Mow vegetation, trim trees so drivers and wildlife can better see one another.
2. Plant unpalatable vegetation so mule deer, elk, and other ungulates are not drawn to the road. Rea reviewed vegetation management techniques for reducing moose-vehicle collisions in British Columbia.⁽¹⁾

Supplemental Feeding Away from Road

Large herbivores (ungulates) in Idaho can be drawn to or away from areas with supplemental feed or water, depending on the limiting resource. In Idaho supplemental feeding of mule deer and elk was reported to have occurred in southern Idaho, to draw the animals away from the road. This appears to be done when large fires in the area leave few food choices for animals dependent on those areas. For example, Craig White, Regional Wildlife Manager for IDFG was quoted in the [Idaho Statesman](#) as saying that in Southeast Idaho, specially formulated feed is put out in select sites to keep animals off the highway. This may be an emergency short-term solution. Supplemental placement of salt and mineral blocks away from the road have been a potential solution for drawing bighorn sheep away from the road, because they lick de-icing salts off the road (Washington Fish and Wildlife contact). ITD funded a synthesis research project on alternatives to de-icing solutions that do not attract wildlife to the road edge.⁽²⁾

Influencing Drivers

Static Warning Signs and Message Boards

Traditional static deer warning signs are ubiquitous across North America. They are largely inefficient at reducing WVC.⁽³⁾ They do however, alert motorists to the danger of colliding with the specific animal on the signs. Ontario is creating taxa specific static warning signs for different areas. Variable message boards are used temporarily in areas where animals migrate seasonally through an area. These then alert motorists to the specific danger and during specific times of year. Hardy et al. found that motorists were most likely to pay attention to these signs when they updated the number of animals killed weekly, and were in operation for weeks or a month at a time.⁽⁴⁾ Variable message boards are used regularly in Idaho. They have been used on I-15 near Inkom for mule deer migration. They were also

held up as a potential action in winter of 2013-2014 south of Boise along I-84 for mule deer and elk movements along highway in response to the 2013 Elk Complex and Pony Complex Wild Fires results which blackened crucial winter ranges.

Wildlife Crossings Zones

Reduced speeds in wildlife crossings zones are based on the premise that if drivers are moving slower in a wildlife area, they are better able to detect animals and react with evasive manners in the case the animals are on the road, thus helping to decrease WVC. Kloeden et al. estimated small reductions in speed, as little as 5 km/hour could decrease crashes by 31 percent.⁽⁵⁾ In these wildlife crossings speed reduction zones motorists are instructed to slow down during a specific period the calendar year and during certain hours, typically in darkness. Idaho recently enacted such a speed reduction zone near Hailey (See Case Study Below). These zones are specific in space and limited in time to when large herbivores and species of interest are most likely to cross the road. In 2010 Colorado established 14 wildlife crossing zones in mountainous areas where wildlife, particularly mule deer need to come near roadways to wintering grounds. Speeding fines were doubled during night hours during winter. An initial study of the efficacy of this method was sponsored by CDOT, and was found to be inconclusive.⁽⁶⁾ A second study was to be initiated.

Compliance High on First Night of Reduced Speed Limit

Sheriff reports 75 percent of drivers obeyed 45 mph posting
<http://www.mtexpress.com/index2.php?ID=2007149096#.UnkrbRCzLuh>

By TERRY SMITH
Express Staff Writer

Blaine County Sheriff Gene Ramsey said Thursday that motorist compliance was unusually high on the first night that a reduced speed limit went into effect on a stretch of state Highway 75 north of Hailey.

The new limit, put in place by the Idaho Transportation Department to reduce the number of vehicle and wildlife collisions, went into effect Wednesday evening. New flashing electronic signs were installed by ITD sign technicians earlier Wednesday to advise drivers that the nighttime speed limit is now 45 miles per hour rather than 55 mph.

The new speed limit applies to a 2.5-mile stretch of Highway 75 between McKercher Boulevard in northern Hailey and Zinc Spur Road. The stretch of highway is one of the most notorious areas in the county for vehicle collisions with elk or deer.

Ramsey said deputies patrolled the stretch of highway for several hours Wednesday night, measuring speed limits and issuing warnings to motorists who were driving too fast.

"We had a 75 percent compliance rate," Ramsey said. "The compliance rate on this new speed limit was amazing. Seventy-five percent compliance on the first day—that's unheard of.

"The majority of the cars were within five miles per hour of the posted 45, with most being between 43 and 46," the sheriff said.

Ramsey chose not to have tickets issued, but said his officers pulled over four vehicles, three driven by local people and one by a man from out of state.

He said the local people said "they knew it was coming; they just weren't sure when we were going to start enforcing it." Ramsey said the out-of-state driver, who was going 56 mph, said he didn't see the signs.

"I didn't want to initiate any citations yet because I wanted community buy-in," Ramsey said. "We don't want it to be a negative where people think we're just out there writing tickets to make money. We're out there to protect people and wildlife."

Ramsey said his deputies may start issuing citations next week.

"The word's out there and at some point we have to start enforcing the law," he said.

Ramsey noted that many motorists knew the reduced speed limit was coming, or knew that the stretch of highway was a hot spot for wildlife collisions, and had been driving at lower speeds even before Wednesday evening.

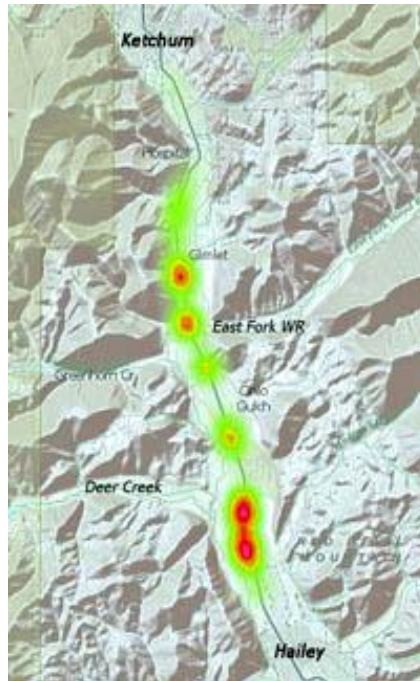
“This is a perfect example of a community buying into a problem and working together to come up with a solution,” he said. “This was our first kind of short-term thing, showing that we want to be proactive. Just lowering the speed limit, that’s not the final solution.”

Ramsey and ITD representatives are members of a Wildlife Crossing Committee, which serves as a subcommittee to the Blaine County Regional Transportation Committee. The subcommittee will continue to seek solutions to wildlife collisions, not only immediately north of Hailey but in other areas of Blaine County.

Ramsey noted that driving at the reduced speed limit only adds about 35 seconds to the drive on the 2.5-mile stretch of highway.

“That’s 35 seconds well spent,” the sheriff said. “In the grand scheme of things, that’s nothing. Just hit an elk and you’ll see thousands of dollars of damage. Even if you’re not injured, the animal will probably be killed and you’ll be without a vehicle for a while.”

Terry Smith: tsmith@mtexpress.com



This Idaho Transportation Department map shows “hot spots” between Hailey and Ketchum where vehicle collisions with elk and deer most often happen. The largest one to the south is the area where a new nighttime speed limit was put into effect Wednesday. ITD courtesy map.

Animal Activated Warning Signs for Motorists

Washington State has radio collars on several cow elk in a herd outside of Sequim on the Olympic Peninsula. Since 2000 whenever these animals, which typically travel in herds, approach the roads near these signs, the radio collars activate warning signs that alert motorists to elk approaching the roadway. Washington reports that it has reduced elk-vehicle collisions, but it also creates false positive triggers when elk are near the road but not attempting to cross it.

<http://www.wsdot.wa.gov/Environment/Biology/FAQwildlifeCollisions.htm>.

Animal Detection Systems

Animal detection systems are electronically based systems placed in or near a road right-of-way that detect a larger bodied animal approaching the road and then set off a warning sign for motorists to be cautious of the approaching animal.⁽⁸⁾ These systems, while less expensive than wildlife crossing structures can be costly, over \$100,000. The systems have mixed results.^(8,9) The best example of these warning systems is one near Payson, AZ along SR-260.⁽⁹⁾ There was a similar system temporarily placed near Ketchum and Sun Valley, ID by the Western Transportation Institute. Currently the Arizona driver warning system is the best example of a working system that has been in operation for a period of years, and has been found by the wildlife and transportation agencies to work satisfactorily for reducing elk vehicle collisions from 11.7 per year on average pre-treatment, to an average of 1 per year with this system.⁽⁹⁾

Thermographic Cameras

In 2013 Zhou created and tested thermal based cameras in Minnesota that detected deer in roads and in zoo settings fairly accurately.⁽¹⁰⁾ This research is a step along the way to mounting these cameras on vehicles for detection of warm bodied animals and people ahead of the driver of a motor vehicle's range of view, thus helping to prevent WVC. Idaho has begun using these in the panhandle, ITD District 1 in the winter of 2013-2014. ITD District 6 was scheduled to use these types of cameras in the future.

Public Awareness Campaigns to Affect Motorist Behavior

States and Canadian provinces have created public awareness campaigns to warn motorists of the dangers of wildlife on the road. These are most numerous in the fall months when wildlife are on the move and most large herbivores are moving in response to the breeding season. Saskatchewan's campaign "[*Moose on the Loose*](#)" is well known within Canada.

Influencing Wildlife

Wildlife Deterrent Devices

A reflective and noise device called DeerDeter has been marketed to western DOTs as a way to prevent deer and other wildlife from entering the road if a vehicle is approaching in a dark setting. The device reflects car headlights into the wild area, and plays a sound recording of the users' choice. Jafa Technologies the distributor claims the devices have reduced deer-vehicle collisions in Austria and in New Jersey on roads with speed limits under 65 mph, but could not produce scientific evidence. As a result, DOTs have been funding studies of these devices. UDOT tested the device on a 2 lane, 2,000 AADT road in southeastern Utah, US-191 near Monticello, but the study results were inconclusive as the deer-vehicle collisions were not reduced in the study area.⁽¹¹⁾ Currently Wyoming DOT is testing the same devices with Teton Science School's Conservation Research Center conducting the experiment.⁽¹²⁾

Deer Mirrors, Reflectors, and Whistles

Animal reflectors, whistles, sound deterrents have been studied in various locations across North America, and none have proven effective in multiple studies. For a review of warning reflectors, see D'Angelo et al.⁽¹³⁾ See Huijser and Kociolek for an overall review of studies and devices.⁽⁷⁾

Wildlife Fencing, Guards, and Escape Ramps

Wildlife fencing is typically 8 ft (2.4 m) high and placed on both sides of a road to prevent deer, elk, moose, and other large animals from entering the roadway. Fence type can be the page-wire mesh fence typically used along road right-of-ways, a V-mesh fence is the standard in Utah, or chain link fence has been used extensively in Utah and other locations. Fencing keeps wildlife off the road, but does not ensure that populations of animals can move across the landscape to survive. It can be very effective. Clevenger et al. showed these types of fences reduced WVC with ungulates by 80 percent.⁽¹⁴⁾ Wildlife fencing was investigated under a National Cooperative Research Program funded study in 2013-2014 at the time of this writing, titled: NCHRP 25-25 Task 84: *Construction Guidelines for Wildlife Fencing and Associated Escape and Lateral Access Control Measures*. The primary investigator of this study (Dr. Cramer) worked in conjunction with the researchers at Western Transportation Institute in 2014 to learn of all types of wildlife fencing and the concurrent cattle guards, wildlife guards, electric mats, escape ramps and escape gates that make up the wildlife mitigation along roads. The study was being completed at the time this report was being written; readers are encouraged to seek the study results in the future.

Wildlife guards and cattle guards are positioned along wildlife fencing to prevent wildlife access to the road at ingress and egress points. The different types of guards were studied from 2013 – 2015 by this study's primary investigator to determine success rates and cost-effective retrofits of single cattle guards to prevent mule deer and elk access to Utah highways.⁽¹⁴⁾ While several studies with small sample sizes (less than 5) have been conducted throughout the west (Allen et al. for instance), the best knowledge at this time is that double cattle guards and wildlife guards are 60 to 90 percent effective depending on the situation.⁽¹⁵⁾ Single cattle guards and painted white lines are almost completely ineffective at preventing mule deer, elk, and moose access to roads.^(16,17)

Wildlife escape ramps are mounds of earth piled on road side of the wildlife exclusion fence and are as high as the top of the fence to allow wildlife trapped on the road to jump to the wild side. These are rarely used if a mitigation system is working properly. These ramps are the standard in the U.S. and Canada, replacing one-way gates from the past. Siemers et al. found that of 784 visits to 11 ramps by mule deer, 318 (41 percent) resulted in the animals jumping to the wild side to safety, and just 3 intrusions into the road right-of-way by mule deer jumping up the ramps to the road area.⁽¹⁸⁾ These ramps are standard when installing wildlife exclusion fencing, and in Utah the standard is roughly 4 escape ramps per mile.

Fence ends constructed of boulders, at least three feet high and wide, is another option to help keep hooved animals off the road. There are situations where typical wire mesh fencing is not desired, and boulders are placed near wildlife crossing structures or at the end of traditional fencing to repel large herbivores from entering the roadway. Such a system was placed US-95 north of Sandpoint, ID at the Copeland wildlife crossing culverts, and in Arizona along SR-260 near Payson. These systems have not been studied but have been breached repeatedly by elk in both cases. This approach could be considered still experimental.

Wildlife Crossing Structures with Wildlife Fencing, Escape Ramps, and Guards

Wildlife crossings structures are built specifically for wildlife and are the most effective means to reduce WVC and to promote permeability of the landscape for wildlife.^(19,20) These structures are classified as underpasses and overpasses. Underpasses can be culverts or bridges that allow the animals passage below the road and traffic. Overpasses can be bridges or culverts that allow the vehicular traffic to flow beneath the path of the wildlife. Wildlife crossing structures are always installed with wildlife exclusion fencing to motivate the wildlife to use the structures. Most mammalian species in North America have been documented using wildlife crossing structures or existing culverts and bridges on the landscape. Studies from states closest to Idaho and with species present in Idaho offer the best approximations of structural dimensions best suited for Idaho's ungulates and bear species. Cramer found in Utah that:

1. Bridges had higher success rates in passing mule deer than culverts.
2. The length of culverts was the most important factor in determining mule deer success rates through wildlife crossing structures and existing culverts. The shorter the length the higher the success rate.^(16,17)

The study supported the assertion that culverts should be 140 feet or less to help ensure success rates of 60 percent or better for mule deer. Mule deer are also using recently constructed overpasses in Nevada, and Montana.^(21,22) White-tailed deer readily use culverts and bridges along US-93 south of Missoula, and even adapted to bridges below 5 ft. high.⁽²³⁾ Elk were very skittish toward any kind of structure in the Utah study and other studies in the United States. The crossing structure types with the best chance of success in passing elk in Idaho are bridges with at least 20 feet of space total to the left and right of the animal's passage (width), and as short as possible. Moose were shown in Cramer to regularly use 2 culverts in a northern Utah mountain range, but were rarely photographed anywhere else in the state.^(15,17) Arizona and Wyoming studies found pronghorn antelope reluctant to use culverts and bridges.^(24,25,26) Wyoming constructed 2 bridged overpasses for pronghorn in 2012 in western Wyoming and hundreds of pronghorn have used them every fall and spring since construction.⁽²⁵⁾ Desert bighorn sheep were studied in Arizona and were found to avoid culverts and bridged underpasses. Arizona constructed 3 overpasses on US-93 for this species and the bridges are regularly used by animals.⁽²⁶⁾ Black bear and grizzly bear have been documented using structures. In Montana on US-93, Cramer et al. find regular black bear use of both culverts and bridges.⁽²³⁾ Grizzly bear were documented using culverts on US-93 north of Missoula.^(P. Basting, MDT, personal communication)

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Appendix D

Step 1 Methods Used to Create Wildlife-Vehicle Collision Priority Road Segments Maps

Overview and Purpose

A mapping process based on geospatial (GIS) data was used as the first step for the creation of a prioritization process. The TAC came to a decision with the research team to:

1. Make a priority map layer based on traffic-ITD related data, called the “Safety Map.”
2. Priority map layer based on ecological data, called the “Ecological Map.”
3. A final map layer which was creating by bringing the two maps together.

The overview of this process is presented in Figure 16, below. Each road segment had a score based on the ratings of each GIS layer. The scores for each road segment were tallied, and each road segment was compared with any roads within a five mile radius. Thus four mile segments were analyzed to view areas with scores compared against different threshold values for different map model runs. The road segments that met defined score thresholds were included in various priority maps.

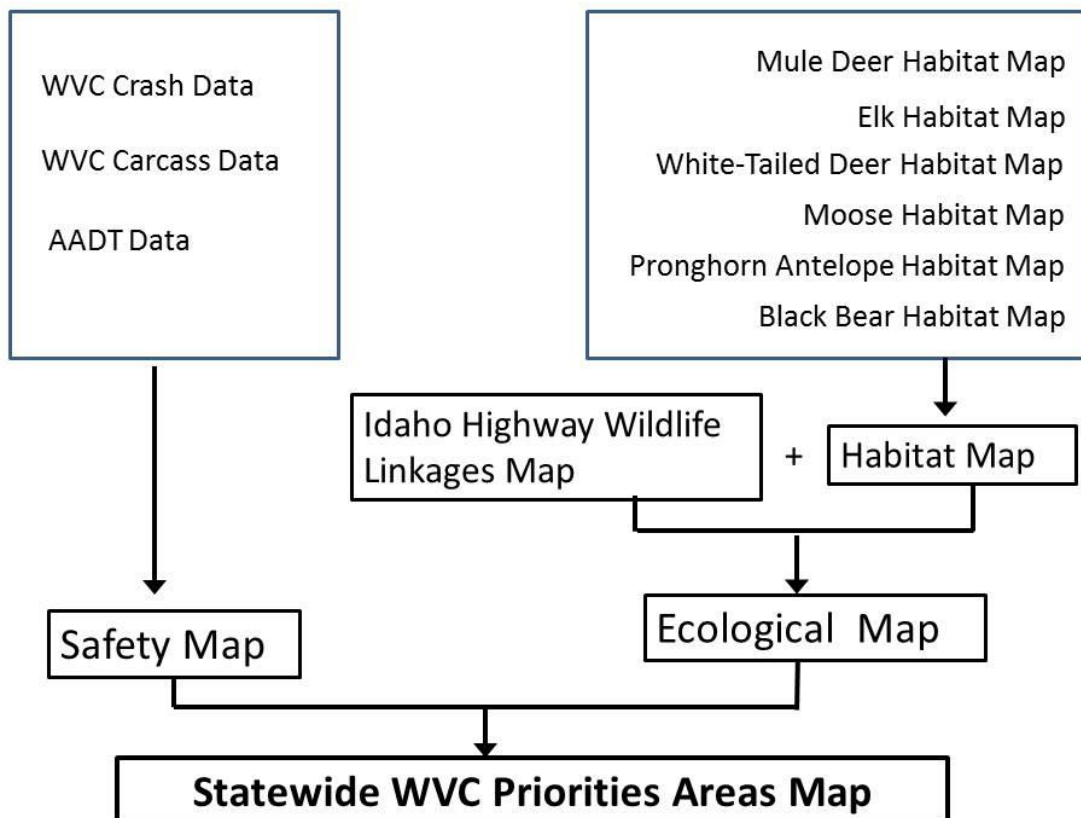


Figure 16. GIS Mapping Process for Final Wildlife-Vehicle Collision Priorities Map

The resulting GIS map of WVC priority road segments is the first step in the prioritization process. This map is not to be used as a final map for state and district priorities. It is a springboard from which to locate problem areas for WVC overall in the state, and within each ITD District.

Methods Introduction

The prioritization process developed in this project was adapted from WSDOT's method (Kelly McAllister, of WSDOT personal communication) of creating connectivity priorities into a GIS Layer. It is also very similar to a process Arizona DOT proposed to create for prioritization. ^(Norris Dodd of AZDOT, personal communication) It takes aspects of prioritization processes used in California (as described by Sandra Jacobson of the research team, in Appendix B) and in Colorado (as described by Julia Kintsch of the research team, Appendix B). Table 18, below, presents the GIS data used in this process, the ranking of the classes of data, and the maximum score that data layer received out of the total 100 points for the mapping process.

**Table 18. Scoring System for Determining Which Road Segment
Were Wildlife-Vehicle Collision Priorities**
Analyses Were Conducted On Each Mile Segment of Each Road

Explanation	Rankings	Maximum Score/ Total Points For This Entry	Maximum Score This GIS Map
Crash Data Where Code Indicated a Wild Animal Involved in Each Mile Segment	Weighted Kernel Density Estimate: 0 = No Crashes 1 = Property Damage 2 = B Injury Accident 8 = A Injury Accident 10 = Fatal Accident True Zero Values; Jenks Natural Breaks to Categorize Values >0 0 = 0 6 = 0.2 - 0.6 13 = 0.6 - 1.9 20 = 1.9 - 4.3	20	
Carcass Data Number of Large Animal Carcasses Reported from 2008- 2013 for Each Mile of Road	Unweighted Kernel Density Estimate. True Zero Values; Jenks Natural Breaks to Categorize Values >0 0 = No Carcasses 6 = 0.04 - 1.01 13 = 1.01 - 3.21 20 = 3.21 - 10.78	20	
Average Annual Daily Traffic 2012	3 = 0 - 2,000 6 = 2,001 - 10,000 10 = 10,000+	10	
Safety GIS Layer Total			50
Idaho 2007 Wildlife Linkages Each Linkage was Assigned a Value in the Original Mapping Process.	0 = No Linkage 10 = Low Priority 20 = Moderate 30 = High	30	
Linkage GIS Layer Total			30
Wildlife Habitat Maps			
Mule Deer	0 = Not Present 1 = Limited Range 2 = Summer, Winter 3 = Year-Round, Winter Concentration or Other Important Habitat	3	
Elk	0 = Not Present 2 = Summer, Winter 3 = Summer Critical, Winter Critical, Year-Round	3	
White-Tailed Deer	0 = Outside of Range 2 = Within Range	2	
Moose	0 = Outside of Range 2 = Within Range	2	
Pronghorn Antelope	0 = Outside of Range 1 = Within Range	1	
Black Bear	0 = Outside of Range 1 = Within Range	1	
Habitat GIS Layer Total			20
Total Combined GIS Map			100

The GIS mapping process used the Kernel Density Estimate (KDE) statistical programs available on ArcGIS software, to translate and analyze the different data. Kernel Density analyzes a neighborhood of cells within a pre-defined radius and calculates the density of features in that neighborhood for those features. It can be calculated for line, point, and polygon features. In ArcGIS this is exactly what was done in this process: line data that represented roads was brought together with point data that represented individual crash and carcass locations. Polygon data that represented wildlife habitat and wildlife linkages were added to the process. The density at each final raster cell was the sum of the tally of the values of all GIS layers at that cell (Figure 17).

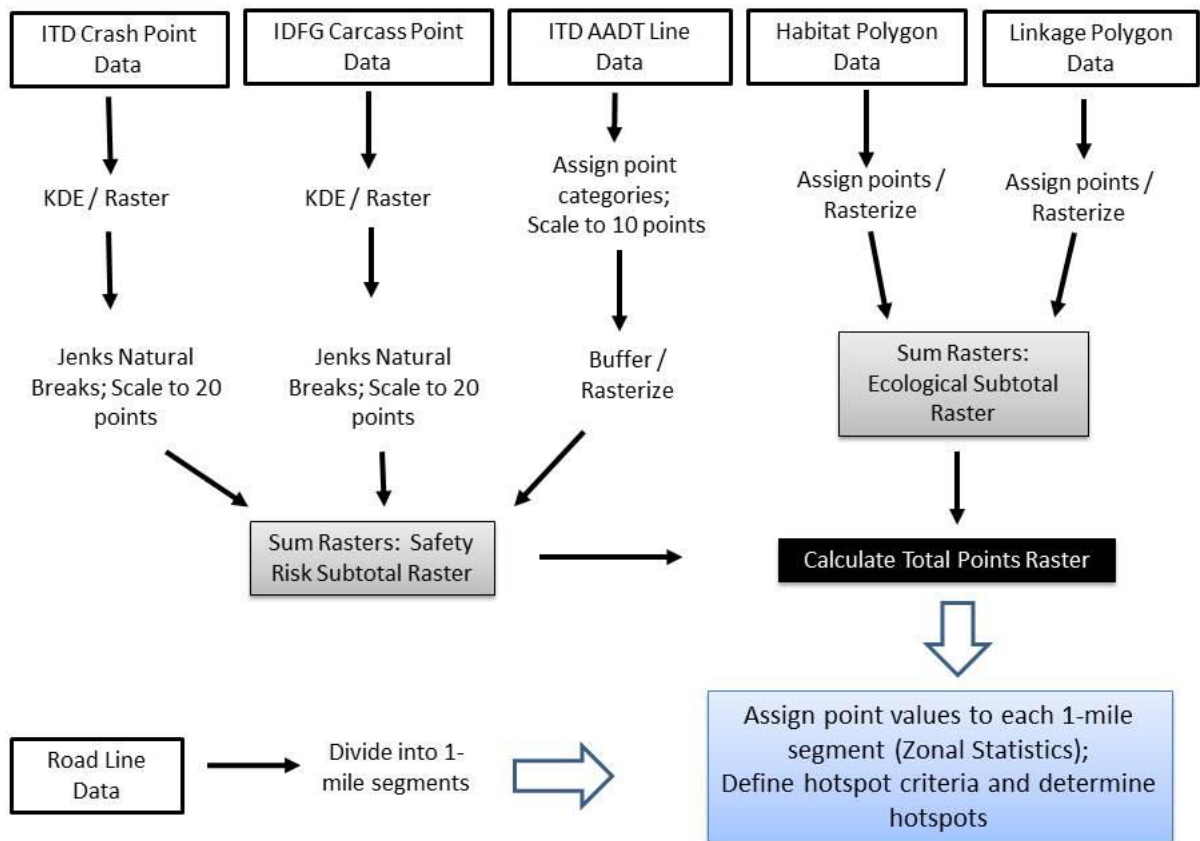


Figure 17. GIS Process of Bringing Together Data and Maps, Rasterizing All Data, Applying the Kernel Density Estimate (KDE) Process, Scaling Points per Cell, and Calculating Total Points per Cell for Final Point Assignment for Each One-Mile Road Segment

With the Kernel Density functions, each 1 mile segment of road was selected and a search radius of 4 miles was conducted to look at values of all the GIS layers in other road segments within that 4 miles. The final values of these raster cells were evaluated to detect areas of high priority. The Kernel Density function helped with smoothing and the generalization of data that was in one dimension, and created a two-dimensional map of the roads with areas of high point values highlighted. Segment length for a WVC “hotspot” was not predefined: the process allowed for the data to present the results rather than

the researchers. As a result, the resulting priority hotspots could be as little as 1 mile and as much as 13 miles.

The GIS research team used Jenks Natural Breaks classification of the raster cells. Classes were based on natural groupings inherent in the data. Therefore there was no prior assignment of how the different classes of both the GIS data itself and the final map classes would be arranged: it depended on the data classes that resulted from the mapping procedure. ArcMap identified the break points by selecting the class breaks that best grouped similar values and maximize the differences between the classes.

While the length of road segments was not pre-defined, a hotspot was defined by:

1. Point requirement for the inclusion of mile segments, with Jenks Natural Breaks it was decided that the count used 74 points and greater.
2. The road segment had to be connected to other road segments for those to become a longer “priority hotspot.” This connectivity had to be within 5 miles.

With these rules, top priority WVC segments of road were selected. Longer segments were included as one if the individual mile segments within the larger one were all of values over the 74 point criteria for top priorities.

Specific Methods and Details in the GIS Map Modeling Process

The GIS map modeling process is detailed below with specific steps for future GIS professionals to carry out the next time this mapping process is created.

Projection

All data to be projected to NAD 1983 Idaho Transverse Mercator (Meters)

Defined Study Area

1. StateHwys.shp (ITD) plus Banks to Lowman road (supplied by Tom Marks)
2. Buffer Roads (126 meters, flat ends)

Created Raster File for Each Input

Safety Map

AADT:

Downloaded from ITD

http://inside.uidaho.edu/webapps/search/iso_browse.aspx?filter=Transportation

Assigned categories and point values:

3 Points: AADT 0 - 2,000

6 Points: AADT 2,001 - 10,000

10 Points: AADT 10,000 +

Buffered (126 meters) and rasterized. Reclassified based on above point scheme.

Carcass:

Downloaded most recent 5 years of data on relevant species from IDFG website:

<https://fishandgame.idaho.gov/ifwis/core/view/roadkills>

Edited:

Most recent 5 years of data

Delete records without spatial info or outside of Idaho

Delete records which are not relevant to species of interest

Kernel Density:

Ran “Kernel Density” tool in ArcGIS (Spatial Analyst):

Not Weighted, Output Cell Size = 250 m, Search Radius = 4 miles (6,437 meters),

See Figure 18.

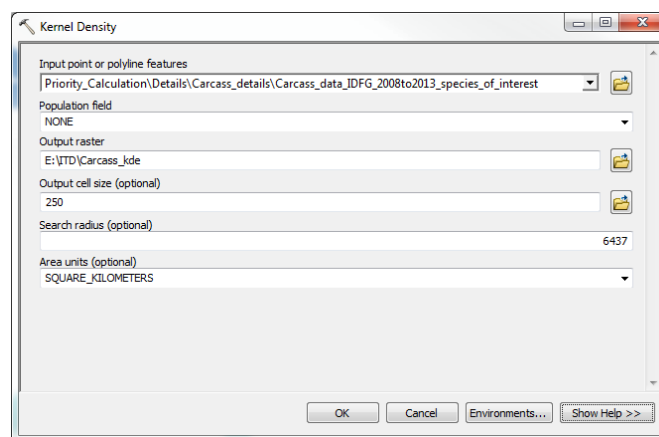


Figure 18. Screen Clip of KDE for Carcass Data Translation

Clip to buffered roads (Extract by mask)

Classified: Jenks Natural Breaks, 3 classes with exclusion of zero values,
Figures 19 and 20.

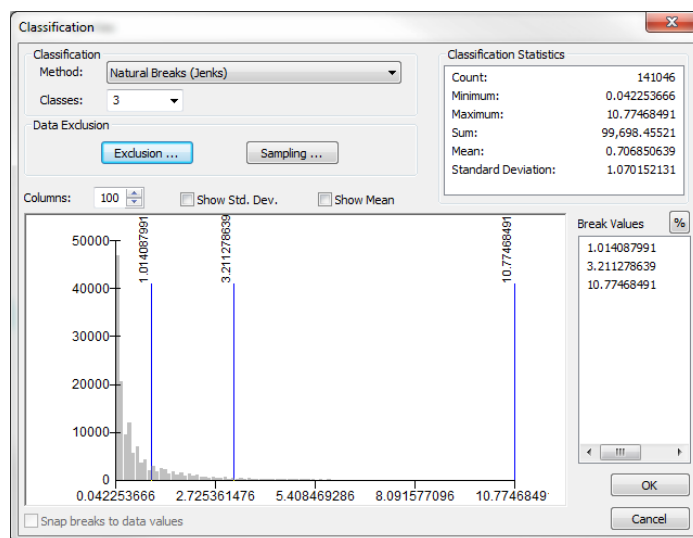


Figure 19. Screen Shot of Jenks Natural Breaks Function Applied to Carcass Data to Determine Classes of Data

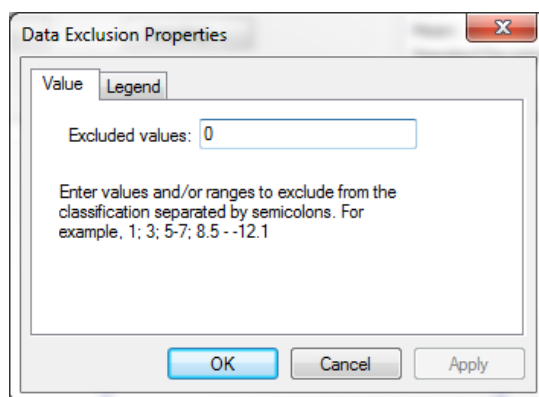


Figure 20. Screen Shot Jenks Natural Breaks for Data, Excluding Values of 0

Rasterized

Reclassified based on classification scaled to 20 points:

0 Points: 0

6 Points: 0.04 - 1.01

13 Points: 1.01 - 3.21

20 Points: 3.21 - 10.78

Crash:

Obtained wild animal crash data from ITD

Edited:

Retained only the most recent 5 years of data (January 2008 – December 2012)

Excluded Records which had no spatial information and Excluded Records Outside of Idaho

Added Field with Weighting (based on crash severity; “Pop1” in included shapefile):

Category	Weight
Property Damage	1
C Injury	2
B Injury	4
A Injury	8
Fatal	10

Kernel Density:

Ran Kernel Density Tool with Weighting (Figure 21)

Population field = “Pop1,” 250 meter cell size, 4 mile (6,437 m) search radius

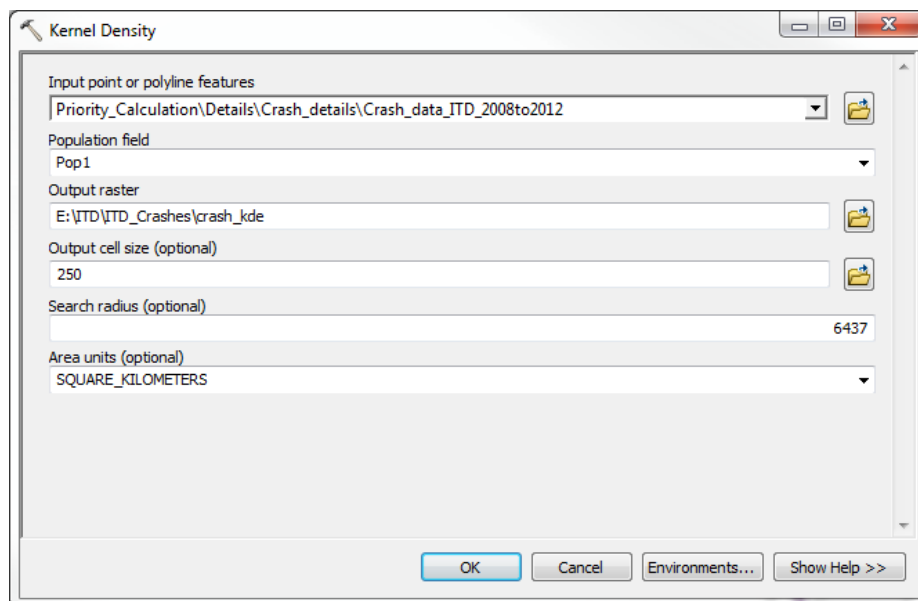


Figure 21. Screen Shot of KDE Run on Crash Data

Clipped to Buffered Roads (Extract by Mask)

Classified: Jenks Natural Breaks, 3 classes with exclusion of zero values
(as above for carcass data)

Rasterized

Reclassified - values to 0, 6, 13 and 20 point categories:

0 Points: 0

6 Points: 0.0168 - 0.604

13 Points: 0.6040 - 1.878

20 Points: 1.8780 - 4.276

For Safety Subtotal Map

Summed AADT, Carcass and Crash Rasters for “Safety subtotal,” up to 50 points.

Species Habitat Maps

Downloaded Habitat Maps from:

Mule Deer:

[USU RS/GIS Lab Mule Deer Mapping Project](#)

Elk:

Idaho Fish and Wildlife Information System
[Elk Habitat \(Rocky Mountain Elk Foundation\)](#)
RMEF_ElkHabitat.shp

White-Tailed Deer, Moose, Pronghorn, Black Bear:

Idaho Department of Fish and Game
GameDistributions.shp

Grizzly Bear:

Not available at the time of our analysis

From GameDistributions.shp: We exported the polygons for white-tailed deer, moose, pronghorn, and black bear

Assigned Points:

Mule Deer:

- 0 = Not Present
- 1 = Limited Range
- 2 = Summer, Winter
- 3 = Year-Round, Winter Concentration or Other Important Habitat

Elk:

- 0 = Not Present
- 1 = (1 Is Not Used)
- 2 = Summer, Winter
- 3 = Summer Critical, Winter Critical, Year-Round (Summer/Winter Overlap)

White-Tailed Deer:

- 0 = Outside of Range
- 2 = Within Range (Chose 2 Rather Than 1 Due to the High Number of White-Tailed Deer Collisions)

Moose:

- 0 = Outside of Range
- 2 = Within Range (Chose 2 Rather Than 1 Due to High Severity of Moose-Vehicle Collisions)

Pronghorn:

- 0 = Outside Of Range
- 1 = Within Range

Black Bear:

- 0 = Outside Of Range
- 1 = Within Range

Rasterized and Reclassified Rasters Based On Above Points

Added Rasters Together; Total Possible = 12 points

Scaled from 12 to 20 Points by Reclassifying the Totaled Raster → Habitat Map

Linkages

Downloaded Polygon Data File from [IDFG Website](#):

Excluded Linkages Which Were Outside the Study Area of Roads of Interest

Excluded Linkages Which Were Not Relevant to the Species of Concern

Assigned Point Values Scaled to 30 points:

No Linkage = 0 Points

Priority Not Identified = 10 Points

Low or Moderate Priority Linkage = 20 Points

High Priority Linkage = 30 Points

Rasterized, Reclassified

Created Shapefile of Relevant Roads in Mile-long Segments with Unique Identifier

Roads of Interest Were StateHwys.shp (Download from ITD) plus Banks to Lowman Road (Per Committee).

Cut Roads into 1-Mile Segments Based on Mileposts (ITD Milepost Data File).

Assigned Mile Number to Each Segment.

Created Segment Identifier (Road Name\Mile Number).

Assigned Calculations to Road Segments

1. Buffered Segmented Roads 126 meters, Flat Ends (ensures inclusion of center point of at least one 250 m raster pixel).
2. Calculated Zonal Statistics as Table (MEAN) on each of the Input Rasters (Crash kde, Carcass kde, AADT, Habitat, Linkage).
3. Joined Each Table Output (mean) to Road Segment Shapefile's Attribute Table Based on Road Segment Identifier.
4. Changed Attribute Table Field Names to Label Input Data Source and Maximum Points (e.g., "Habitat_20").
5. Added a Field "Sum_100" and Used Field Calculator to Total the Inputs for Each Mile Segment for a Maximum of 100 Points Possible.

6. Additional Fields in the Final Shapefile Give Results with Different Weighting Scenarios or with Exclusion of Some of the Inputs:

Safety_sub: Is the Safety Subtotal.

Ecol_sub: Is the Ecological Subtotal.

noLink_sub: Is a Subtotal without Considering the Linkages.

2crash_AH: Was a Post Hoc Analysis Requested by Dr. Cramer Which Counted the Crash Data Twice and Left out the Carcass and Linkage Data.

7. Start_E and Start_N: Are the Easting and Northing at the Start of the, Mile Segment.

End_E and End_N: Are the Coordinates for the End of the Mile Segment.

(NAD 1983 Idaho Transverse Mercator).

Determined Hotspots

Statewide

1. Symbolized the mile segment shapefile based on Sum_100.
2. Top 10 hotspots statewide were mile segments with point totals ≥ 79 points. Segments were lumped into a hotspot when they were adjacent or within 5 miles.
3. Top 15 hotspots in the state were mile segments with point totals ≥ 74 points. Segments were lumped into a hotspot when they were adjacent or within 5 miles.

District Hotspots

- a. Clipped mile segment shapefile with point totals by maintenance district boundaries.
- b. Lowered criteria for minimum Sum_100 until 4 hotspots are determined in each maintenance district.

Results

The resulting maps are presented in this section.

Safety Map Based on ITD Data

Crash Data

Crash data is important in two areas, first it documents the severity of collisions documented with wildlife and second, it helps identify problem areas for WVC where little carcass data is recorded. It is consistently collected across the state, making it an important predictor based on scientific data collection. Categories presented above in Table 19. The Kernel Density Estimate function was conducted for a 4 mile search radius. There were 4 classes of data, from the low class (0 points) for no WVC crash data, to the top Class given to crashes with WVC where there was a human fatality (20 points) (Figure 22).

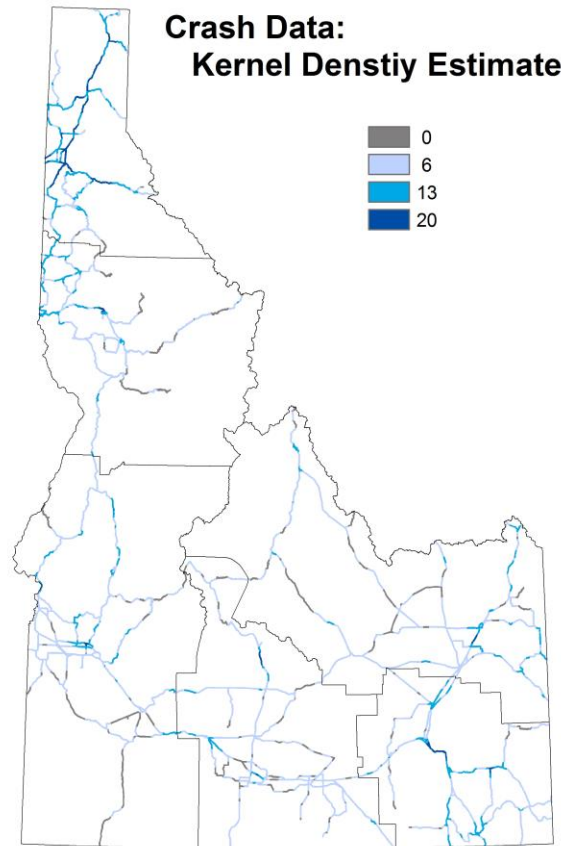


Figure 22. Wildlife-Vehicle Collision Crash Data January 2008-December 2012

Wildlife-Vehicle Collision Carcass Data

Carcass data is important in that it provides WVC data where no crash was reported, and it gives a more complete picture of the animals that are dying on roads. For this analysis, all animals that are not ungulates or bears were taken out of the database because the large ungulates (except for bighorn sheep) and bear are most often the species reported in WVC and are most dangerous to motorists. The carcass data therefore represented mule deer, white-tailed deer, elk, moose, pronghorn antelope, and black bear. Bighorn sheep were not listed in the original Request for Solicitation (RFS) but were included in a map for special consideration in Step 2 of the process. All mammal species listed in the WVC carcass database were tabulated and are presented in Appendix E. Maps of white-tailed deer and mule deer, the number one and two most often reported species in carcass data are also presented in Appendix E.

Carcass data were not organized into weighted categories in contrast to the crash data. A kernel density estimate of big game carcasses over a 4 mile search radius was calculated. We assigned true zero values and divided values > 0 into 3 categories using Jenks Natural Breaks, see Table 19. The final map is presented in Figure 23.

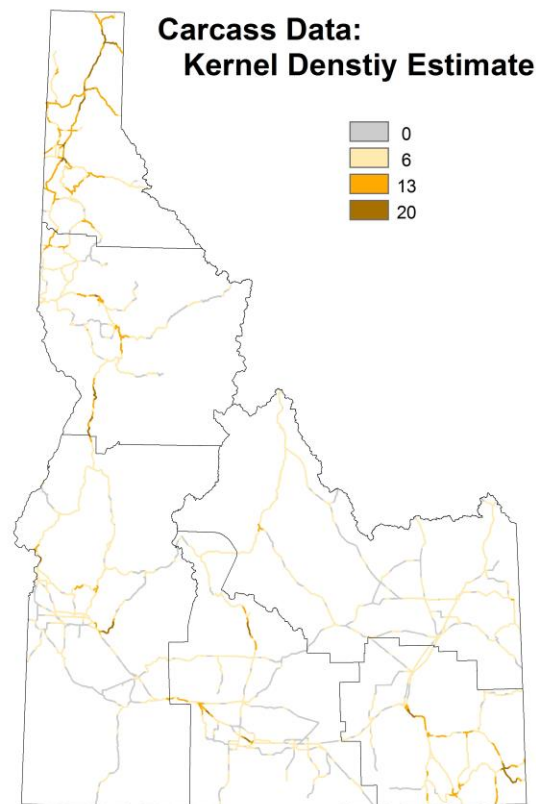


Figure 23. Wildlife-Vehicle Collision Carcass Data April 2008-March 2013

It is important to note that ITD District 1 holds carcass recording as a daily priority, thus accurate records and high numbers of carcasses.

Carcass data for animals other than the large herbivore and black bear included above were also mapped. The resulting maps can be viewed in Appendix E. Seasonal carcass data locations for mule deer, and maps of mule deer carcasses from 1967 to 2013 can also be viewed in Appendix E.

Average Annual Daily Traffic

Average Annual Daily Traffic (AADT) data are very important for wildlife movement because traffic volumes can have an effect on the ability of animals to cross the road safely. Three categories of data

based on wildlife and roads research and effects of traffic on wildlife movement were created, see Table 19, above, and Figure 24.

This ranking is very basic and negates the subtleties of what research reveals about traffic volume in connection with different situations. For instance, Sandra Jacobson of our research team states, “Traffic volume effects on collisions are not linear.... So if ITD is primarily interested in reducing Deer-Vehicle Collisions, then the focus on the overlap between highly motivated migrant deer and 2,000 - 8,000 AADT 2-lane rural roads is going to be the highest priority over interstates.” This statement lends credence to the idea that traffic volume rankings should be up for discussion based on multiple inputs. The trouble is, with this project, a traffic volume ranking is taken from ITD AADT files and does not interplay with mule deer migration areas, and it is just a value we can map.

Also, once traffic volume reaches a level of approximately 20,000 AADT, wild animals may not as often attempt to cross the now moving barrier of continuous traffic. The bottom line is this ranking is up for discussion and re-adjustment.

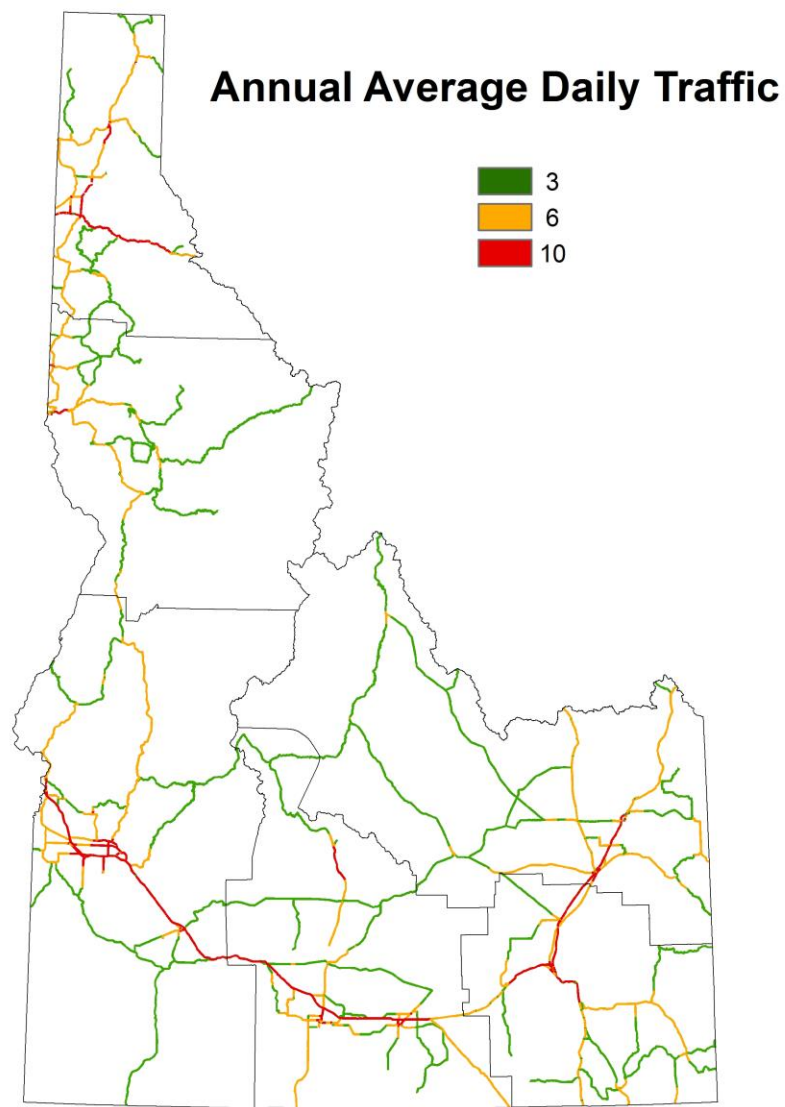
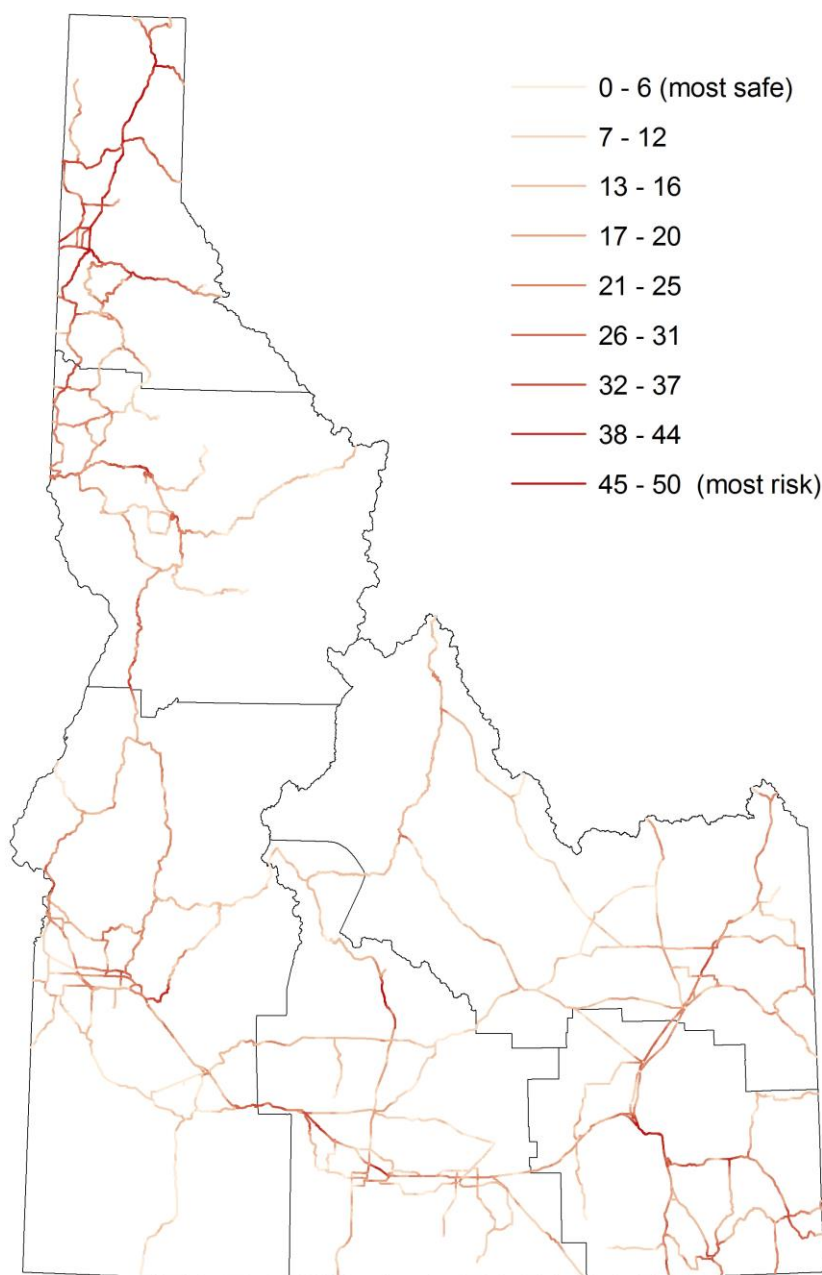


Figure 24. Average Annual Daily Traffic Map
Category 3 = Up to 2,000 Vehicles Per Day
Category 6 = 2,001 to 10,000 Vehicles
Category 10 = 10,000 or More Vehicles per Day

The fully combined Safety Data Map is presented below (Figure 25).

Safety Subtotal: 50 points



**Figure 25. Wildlife-Vehicle Collision Safety Map with 50 Points Total
Combined for WVC Crash, Carcass Data and AADT**

ITD District GIS layers will be used in this mapping process for the ease of observing priority areas within each district.

Ecological Data – Based on Idaho Fish and Game Data

The Ecological Map was developed to include habitat maps of big game species, and the 2007 Maps of the wildlife Linkages relevant to the species of concern. The 2007 Maps of Wildlife Linkages and the ITD District 6 Maps of Wildlife Linkages each gave up to 30 points to a road segment. The wildlife habitat maps were created by various agency, academic, and non-profit entities and added a maximum of 20 additional points to the Ecological Map. Habitat is defined as the ecosystems that can and do support populations of the species. The range of the species is considered a much larger area, such as a several state region, and can include pockets of habitat that are not suitable, such as rock mountain tops or lakes.

Mule Deer, Elk, White-Tailed Deer, and Moose

These four species are the animals most reported in WVC and whose carcasses are most often reported along the side of the road. As a result, the ratings for these species were slightly higher than the other species in this map building process. Mule deer are numerous in Idaho and the species second most often involved in WVC. The mule deer maps were created with greater accuracy than the white-tailed deer maps (Figure 26). Between these two facts, the total points for this species was assigned as a high of three. Elk are not as numerous as mule deer, but collisions with this animal are more dangerous than mule deer due to their size. Elk habitat maps also gave three categories of data, so this species also received a top ranking of three (Figure 27). White-tailed deer was the species most often involved in WVC in Idaho, based on WVC carcass data collected. Since their presence in an area can pose a higher probability of WVC than other species, this deer species was given a value of 0 in areas where it is not known to be present, and 2 in areas where it is believed to be present. White-tailed deer data was not as accurately mapped as the mule deer maps were, with only a presence or absence indicated on the maps, thus the map received one point less than mule deer maps (Figure 28). Future developments in the prioritization process could change these values. Moose are a formidable threat to human life when involved in a WVC. Moutrais and Gunson found that 33 percent of moose collisions resulted in human injury or fatality, as compared to only 7 percent of white-tailed deer collisions in Vermont.⁽¹⁾ As a result, any areas in Idaho where moose habitat was present were ranked a 2 in the habitat maps, rather than a 1 as is done for other species that are ranked with only presence(1) or absence (0) (Figure 29).

Other species

Pronghorn antelope and black bear habitat maps were gathered from the IDFG website for use in this mapping process (Figures 30 and 31). These species are rarely involved in WVC, as taken from the WVC carcass data. Their presence in an area does not result in numerous (as in White-tailed deer) or lethal (as in moose) WVC for motorists. As a result, the maps were coded with either a 0 for absence for each species, or 1 for presence. No other species was included in the habitat mapping process.

Once each map was created, the total points per cell were tallied and an Idaho species habitat map was created, Figure 32.

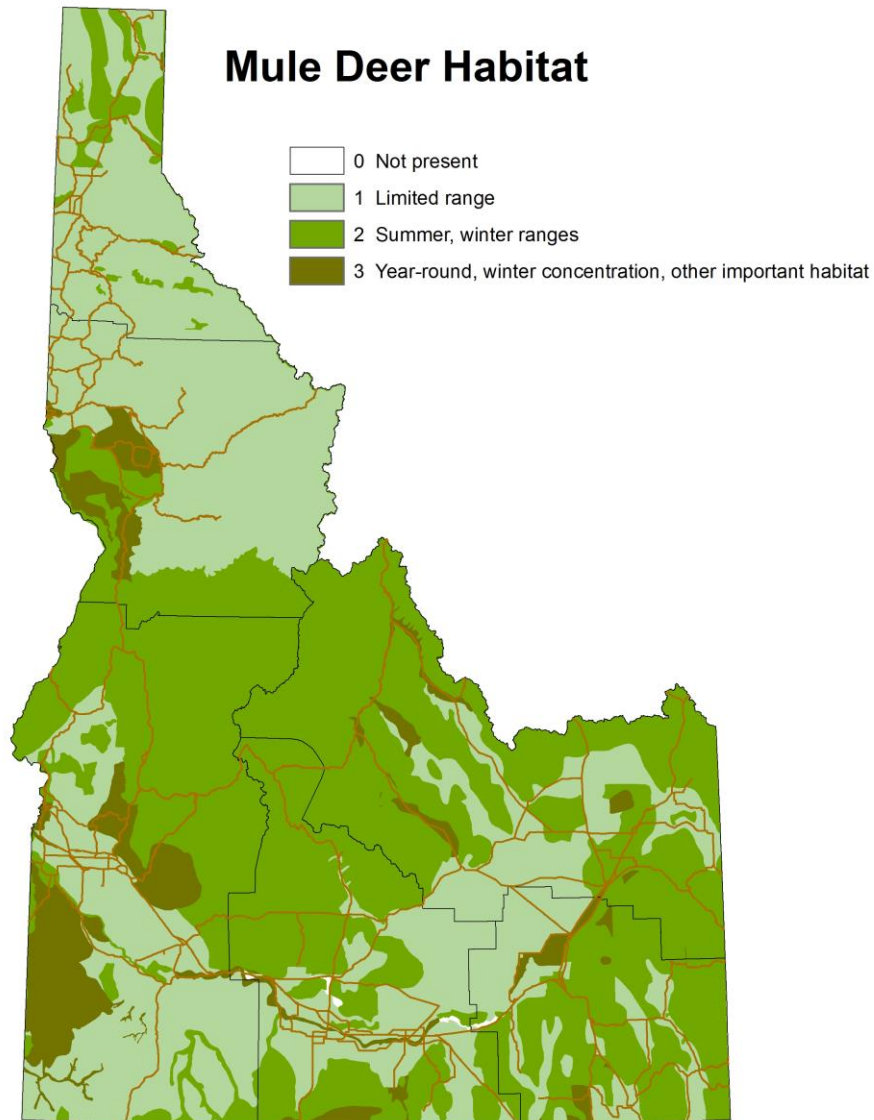


Figure 26. Mule Deer Habitat Map

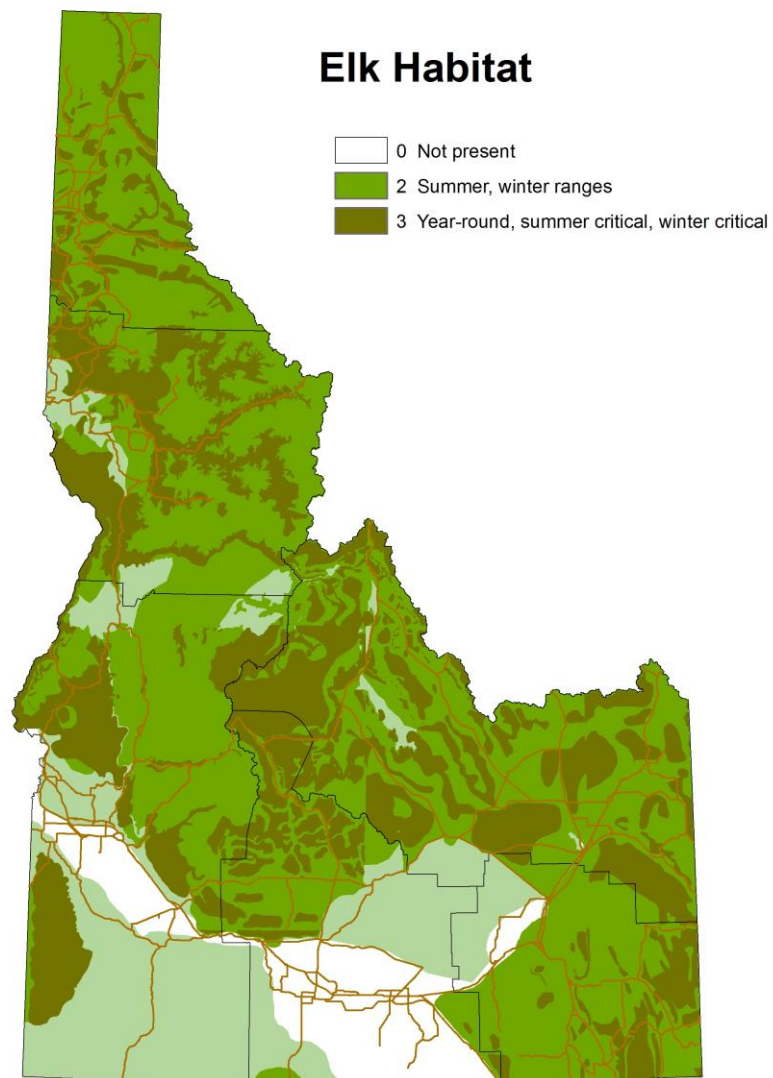


Figure 27. Elk Habitat Map

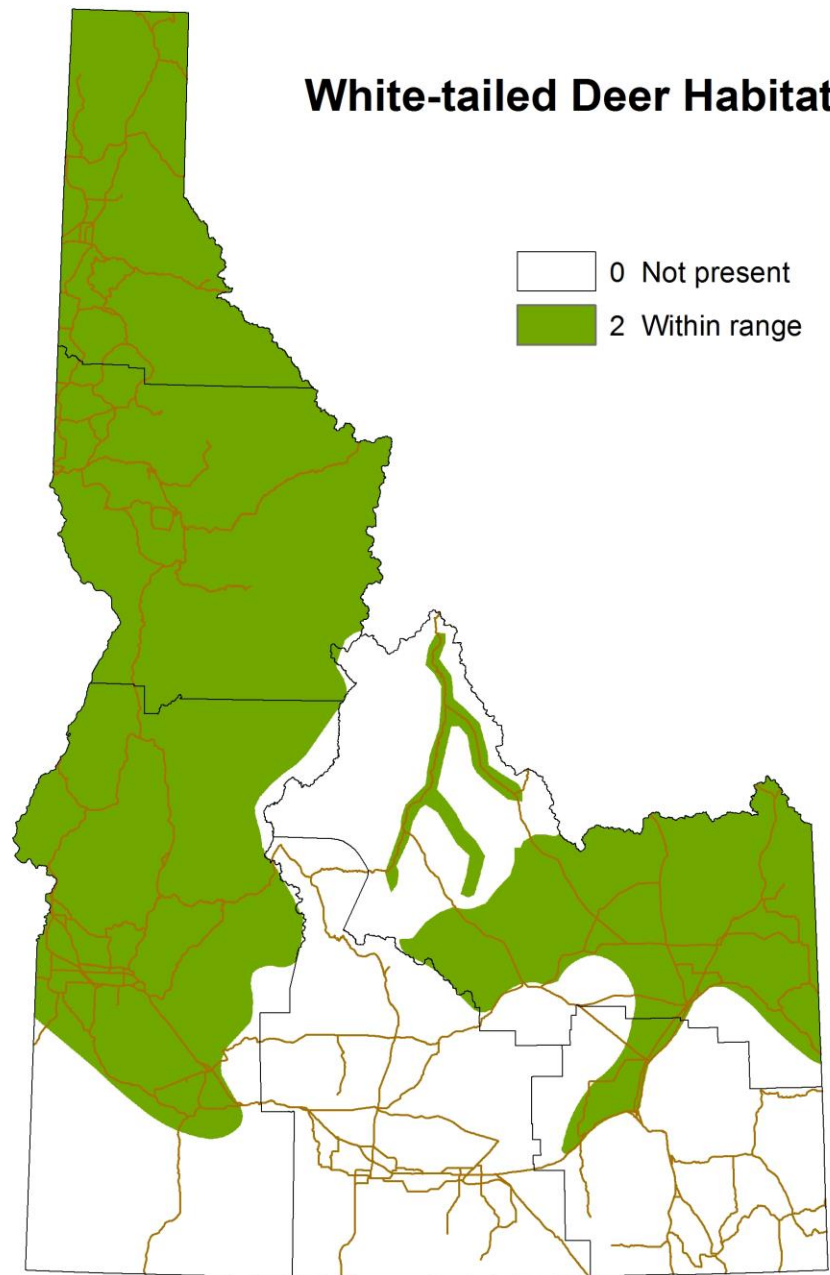


Figure 28. White-Tailed Deer Habitat Map

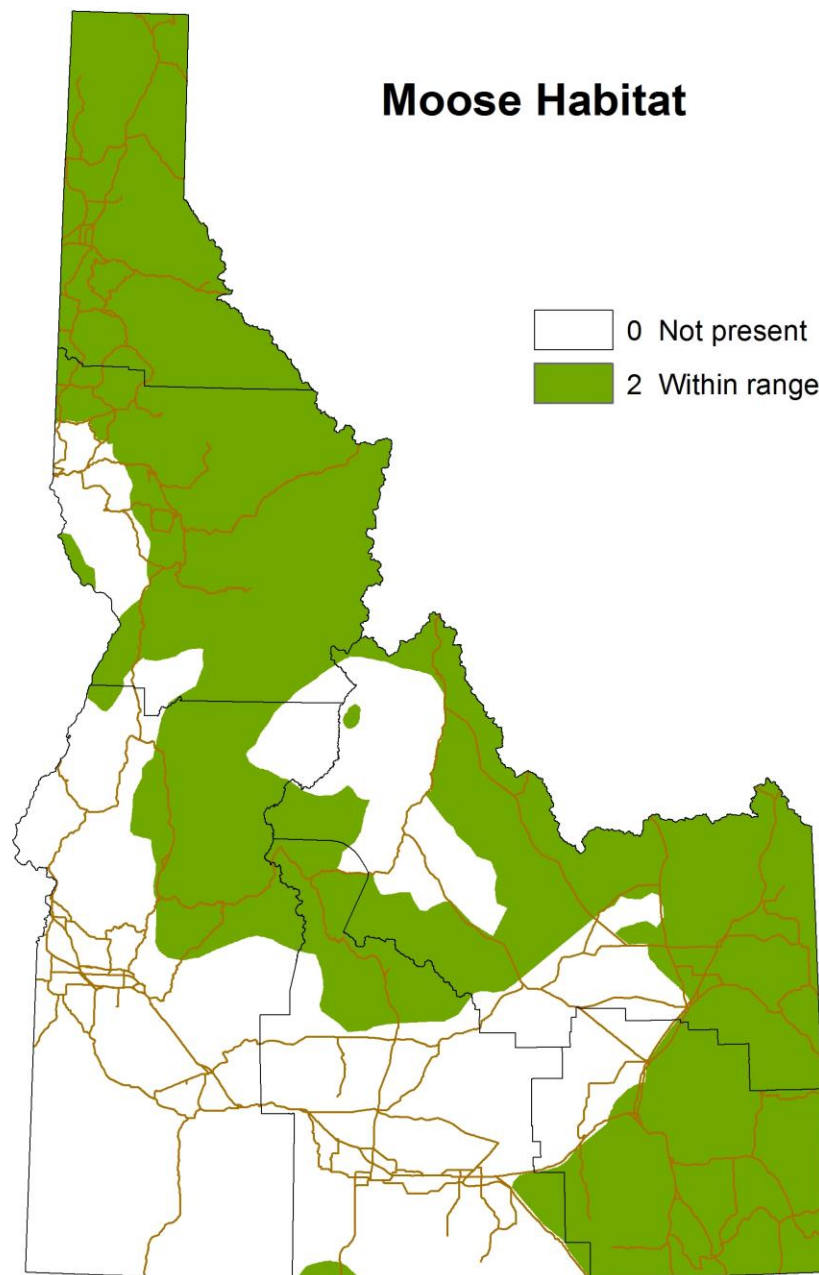


Figure 29. Moose Habitat Map

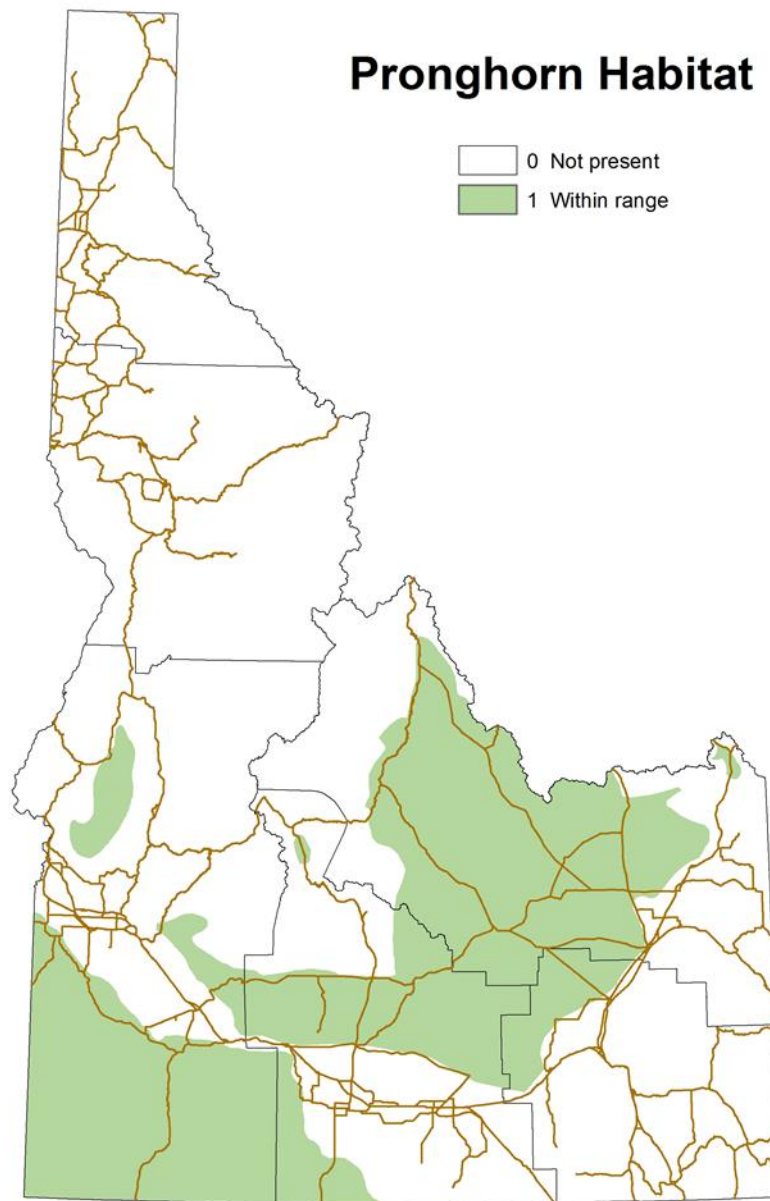


Figure 30. Pronghorn Antelope Habitat Map



Figure 31. Black Bear Habitat Map

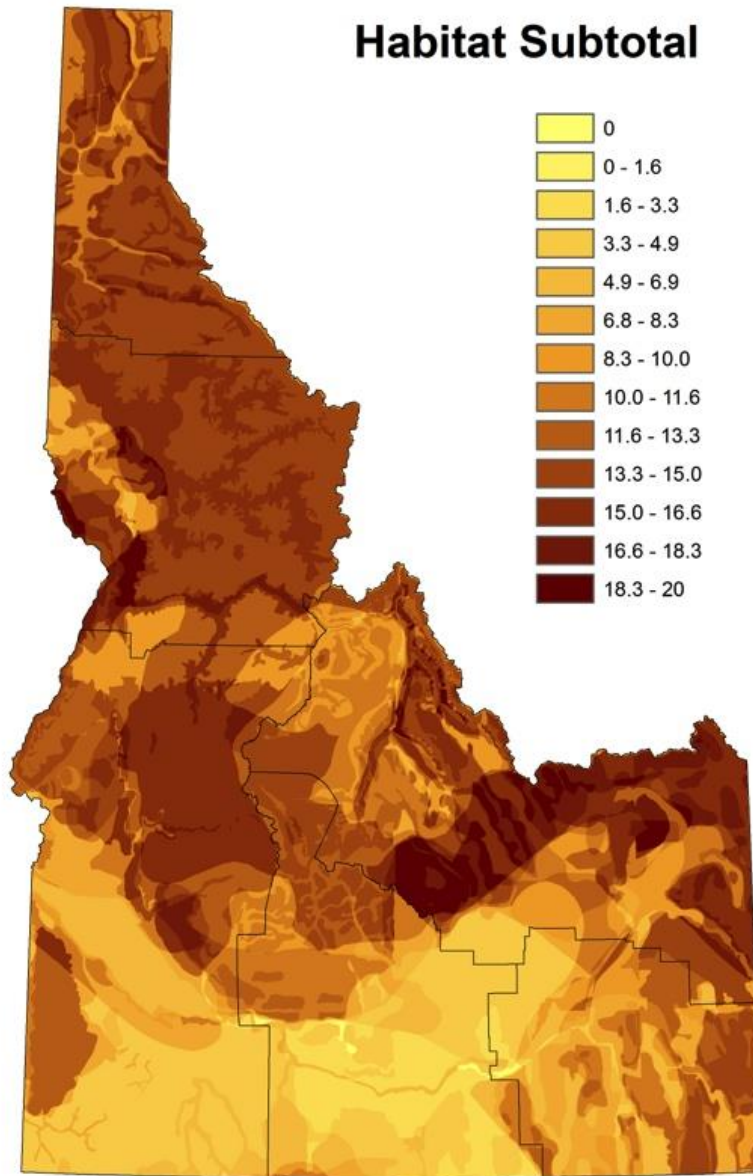


Figure 32. Wildlife Habitat Map

Lighter colors equate to areas with less species present, darker areas denote areas with more of the species modeled present.

Grizzly Bear Habitat

The GIS research team received a file of data points for grizzly bear road crossings locations from GPS collar data in ITD District 6 in the Yellowstone Ecosystem. This file was received after initial set up of the prioritization method, and since it was restricted to one area of one district, were brought together in the map labeled, “Areas of Special Consideration.” This map was not included in the statewide prioritization map but is referred to in Step 2 of the prioritization process.

In research teams meeting with the TAC it was decided that the overall habitat maps received just a 20 percent rating of the total points for the prioritization maps, in part due to their coarse nature.

Idaho Highway Wildlife Linkages

The Idaho 2007 Wildlife Linkage Analysis rated segments of ITD highways based on high, moderate or low priority for wildlife: <https://fishandgame.idaho.gov/ifwis/portal/opendata/idaho-highway-wildlife-linkages>. These ratings were used as the classes for linkage map. Two years prior to the statewide wildlife linkages maps, ITD District 6 in Idaho Falls conducted a separate linkage analysis. Both linkage analyses rankings for highway segments were included in the maps for linkages statewide. Since these linkages were vetted through a peer review process, and the TAC and research teamed approved these maps, the Idaho Wildlife Highway Linkages data were deemed a tremendously important part of the final mapping process, the points for these linkage areas counted for 30 percent of the total point calculation of the final WVC priorities map. See Figure 33.

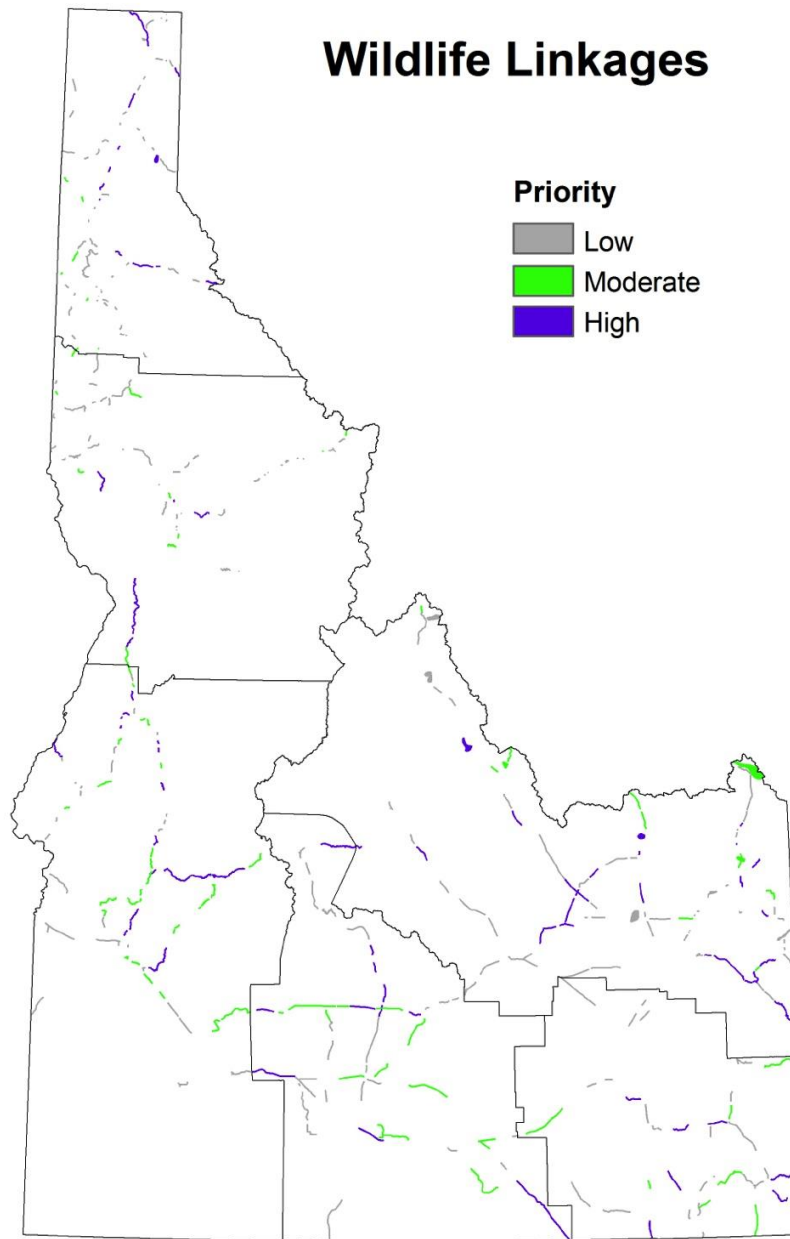


Figure 33. Idaho Wildlife Highway Linkages Map
Roads Are Not Included In Map but Can Be Distinguished as the Colored Lines or “Caterpillar Lines” on Map

The ecological map subtotal with habitat maps and wildlife linkages is presented below (Figure 34). Darker colors indicate areas of higher ecological importance along Idaho roads.

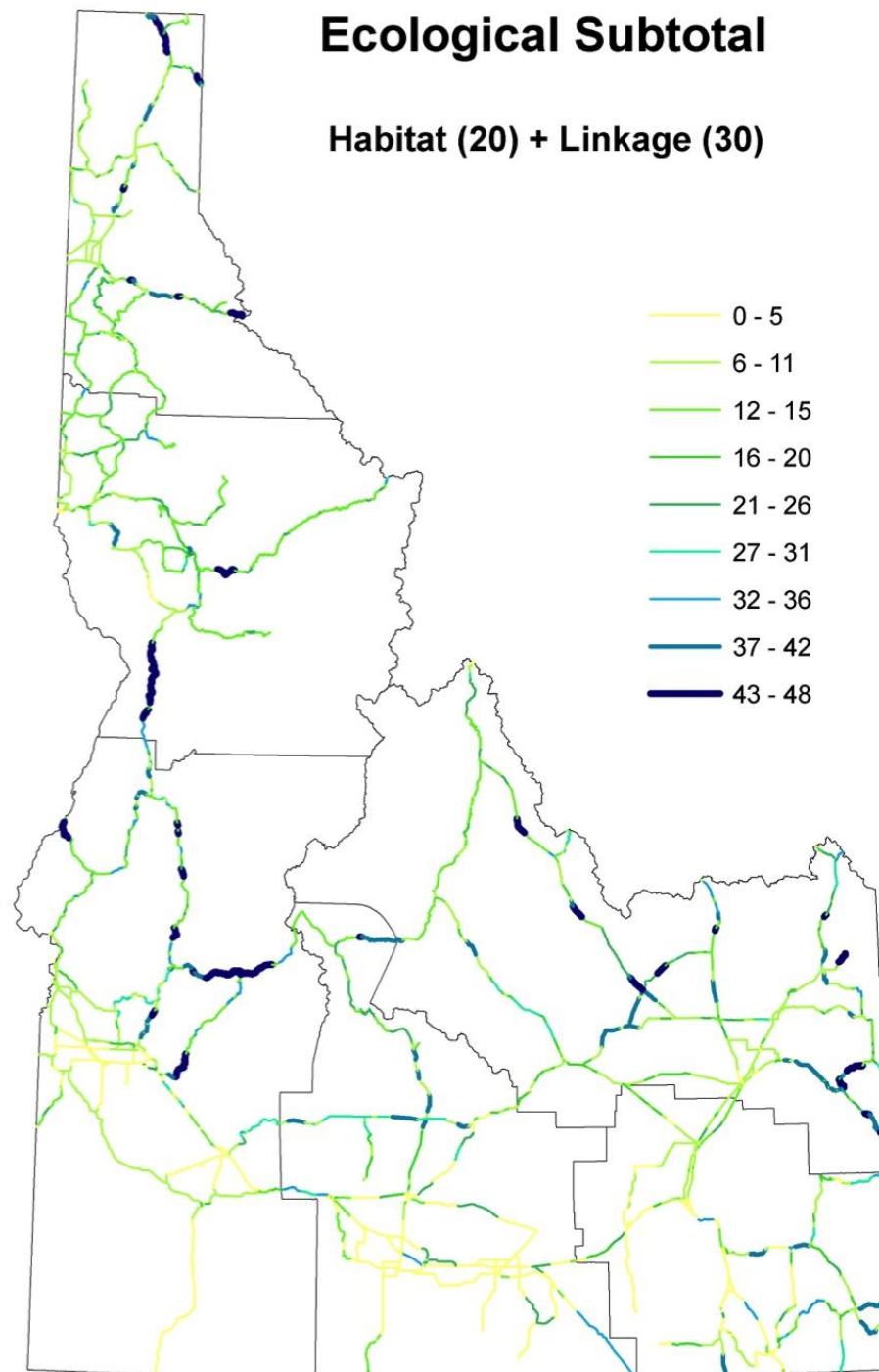


Figure 34. Ecological Map

The Final WVC Priority Areas Map

The safety map and ecological maps were brought together to create the final WVC Priorities Map, with segments of road with the highest priority values allocated with colors closest to red, Figure 35 below. The areas in the warmer colors of orange and red have higher ecological and safety values from the combined maps.

The attribute table for this map was abbreviated as an example and is presented in Table 20. The table presents the top 10 WVC priority segments, and one of the miles within the segment. This table helps users to understand how each road segment was ranked.

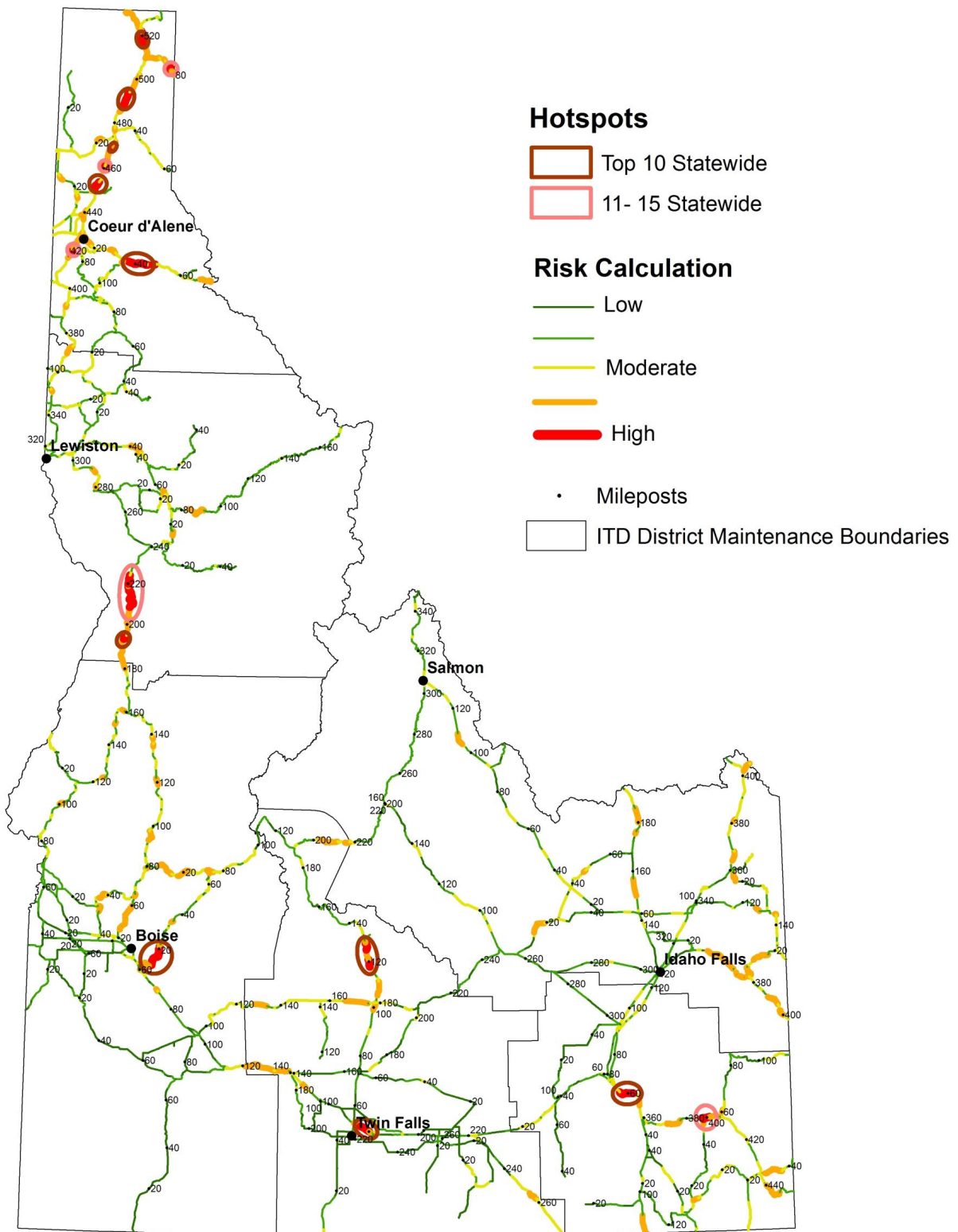


Figure 35. Idaho Top 15 WVC Priority Road Segments Based on GIS Data

**Table 19. Abbreviated Attribute Table from GIS Map Modeling to Determine
Top 10 Wildlife-Vehicle Collision Priority Road Segments in Idaho**

Ranking (Added)	Name (Added to Attribute Table Here)	Hwy_Mile	District	Habitat_20	Linkage_30	Crash_20	Carcass_20	AADT_10	Sum_100
1	US-95 Cocolalla/Westmond/Algoma	US095\469	1	12	30	20	20	10	92
2	SH-75 Ketchum/Big Wood River	SH075\118	4	10	30	20	20	10	90
3	US-95 Indian Reservation/Kootenai River	US095\516	1	13	30	16	20	6	85
4	US-95 Pack River/Elmira	US095\488	1	8	30	20	20	6	84
5	SH-21 Lucky Peak/Boise	SH021\18	3	15	30	13	20	6	84
6	I-90 Kingston	I-90 R 039 E ON\0	1	10	30	20	13	10	83
7	I-15 North Inkom/Portneuf	I015\63	5	3	30	20	20	10	83
8	US-95 Granite/Cocolalla	US095\453	1	12	30	20	13	6	81
9	I-84 Snake River Rim Special Recreation Management Area	I084\176	4	2	30	19	20	10	81
10	US-95 Riggins/Salmon River	US095\194	2	17	30	6	20	6	79

Experimenting with Different Search Radii

The search radius with the KDA/KDE for the carcass and crash data for statewide analysis was four miles. Since the resulting maps are affected by the search radii, GIS research team members experimented with decreasing this by one mile for several different model runs. A comparison of KDE results using different search radii on the carcass data is presented below, Figures 36 and 37. When search radius is reduced to one mile, individual milepost hotspot areas begin to appear rather than stretches of road with such hotspots. The viewer can observe increasing number and length of darker road segments as the search radius is increased.

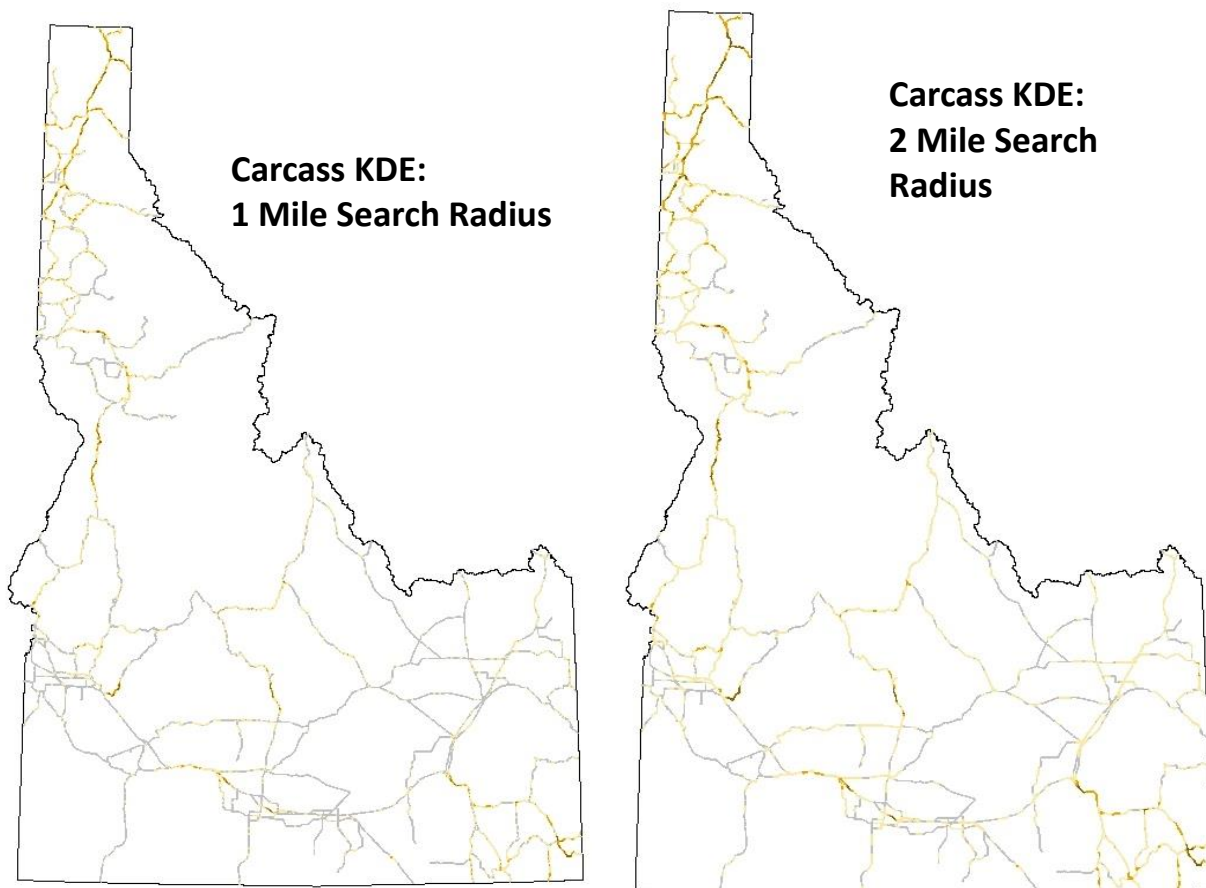


Figure 36a. GIS Modeling of WVC Data with a 1 Mile Search Radius

Figure 36b. GIS Modeling of WVC Data with a 2 Mile Search Radius

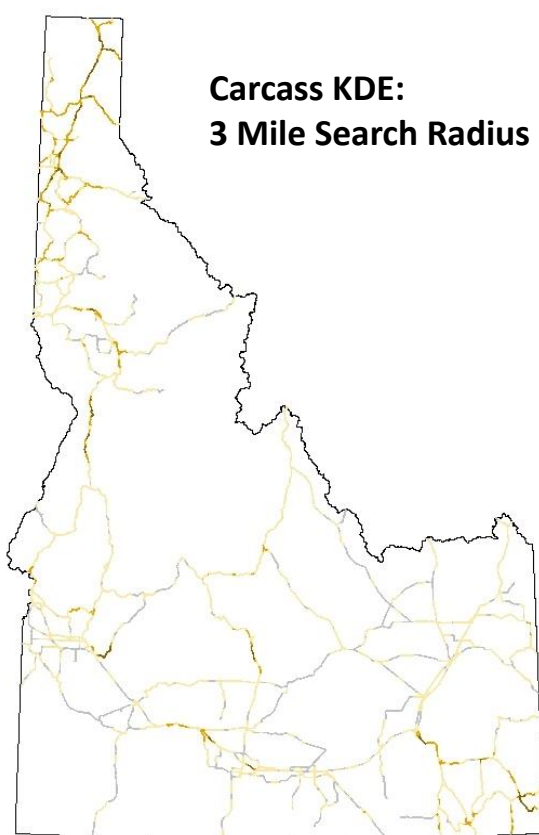


Figure 37a. GIS Modeling with a 3 Mile Search Radius

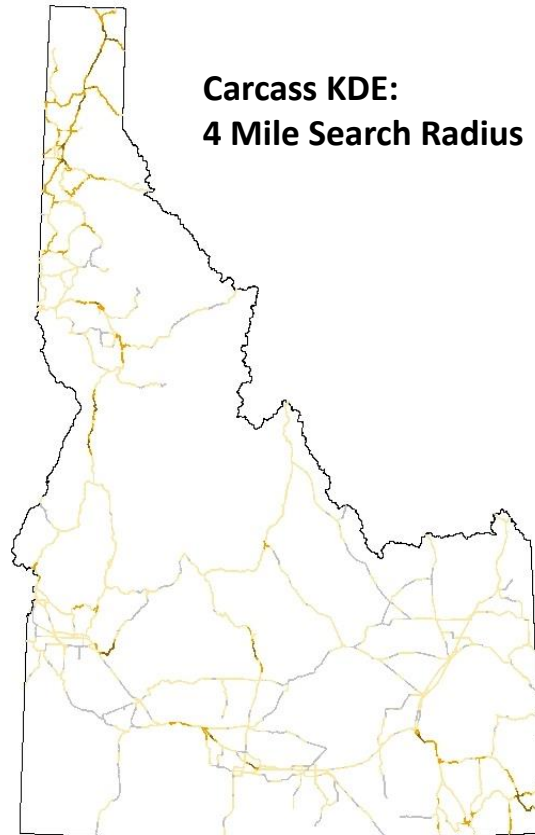


Figure 37b. GIS Modeling with a 4 Mile Search Radius

Validation Process

An important component of the map making is validating the model used to identify WVC priority areas. It was difficult to test the model because so many of the inputs were inter-related. Our GIS research team worked on creating different maps with different weightings and inputs of the layers of information throughout the mapping process. Validating a model of maps is difficult because the very data that could be used to test the maps for accuracy is either included in the model or not available at this time. In Barnum's 2012 paper, multiple methods to identify deer-vehicle crash hotspots, from simple approaches such as visual analysis of maps, to models and spatial statistics were analyzed.⁽²⁾ The results of the research found there was no single "best" method to identify deer-vehicle collision hotspots, but that the model based approaches and spatial statistics appear to offer advantages because meeting the assumptions that are required for their implementation reduces the subjectivity of results interpretation.

Model validation was conducted through two processes:

1. Changing different values in the mapping model.
2. Through a comparison review of priority areas by TAC members Scott Rudel and Tim Cramer.

Map Validation with Different Map Inputs

Map validation through changes in class values was conducted through map modeling. To better determine which GIS maps had greatest bearing on the locations of WVC priority segments across Idaho, the GIS research team modeled WVC priority area with and without different map layers to see if the WVC priority segments changed with different map inputs. Four different scenarios were mapped:

1. The final WVC priority map with WVC crash, WVC carcass, AADT, Wildlife Habitat, and Wildlife Linkages data and maps.
2. A map with all but the wildlife linkage data included.
3. A map with all but the carcass data included.
4. A map without the linkage and carcass data included.

The initial priorities map, developed with just 2 classes of priority is presented in Figure 38. The initial priorities map developed with gradations of 9 colors is presented in Figure 39. Figures 40 through 42 demonstrate the maps created under the 4 scenarios. Table 20 presents each of the 20 WVC priority areas identified in any and all of the 4 scenarios created by different runs of the map models. Those 20 priority areas are then evaluated with respect to other model runs to see if the priority area was indicated in other map scenarios. This table allows the viewer to view which WVC priority areas are affected most heavily by the wildlife linkage data, or the WVC carcass data, or a combination of the 2, or if the area consistently is ranked as a priority in every scenario. Of the 20 priority areas 10 were priority areas in every model run of the different map scenarios. Of these priority areas that consistently ranked as priorities in all model runs, 7 were in ITD District 1.

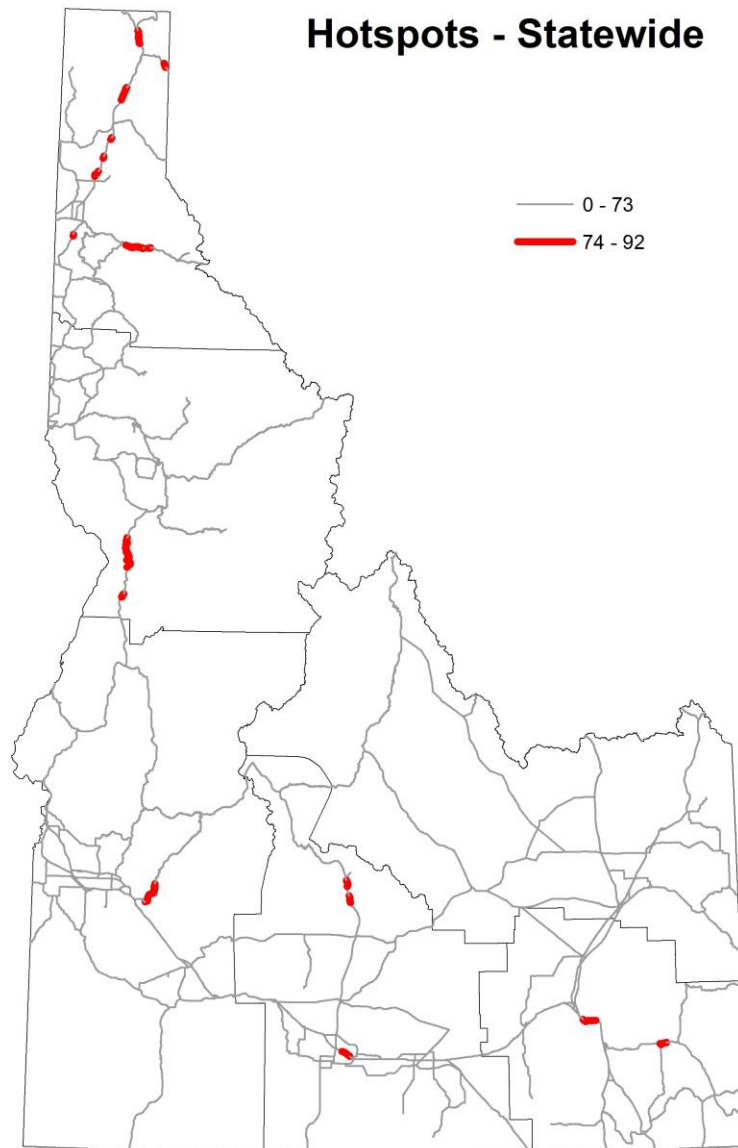


Figure 38. General Map of Idaho's Top 15 WVC Priority Segments Based on GIS Data and Displayed in Two Colors

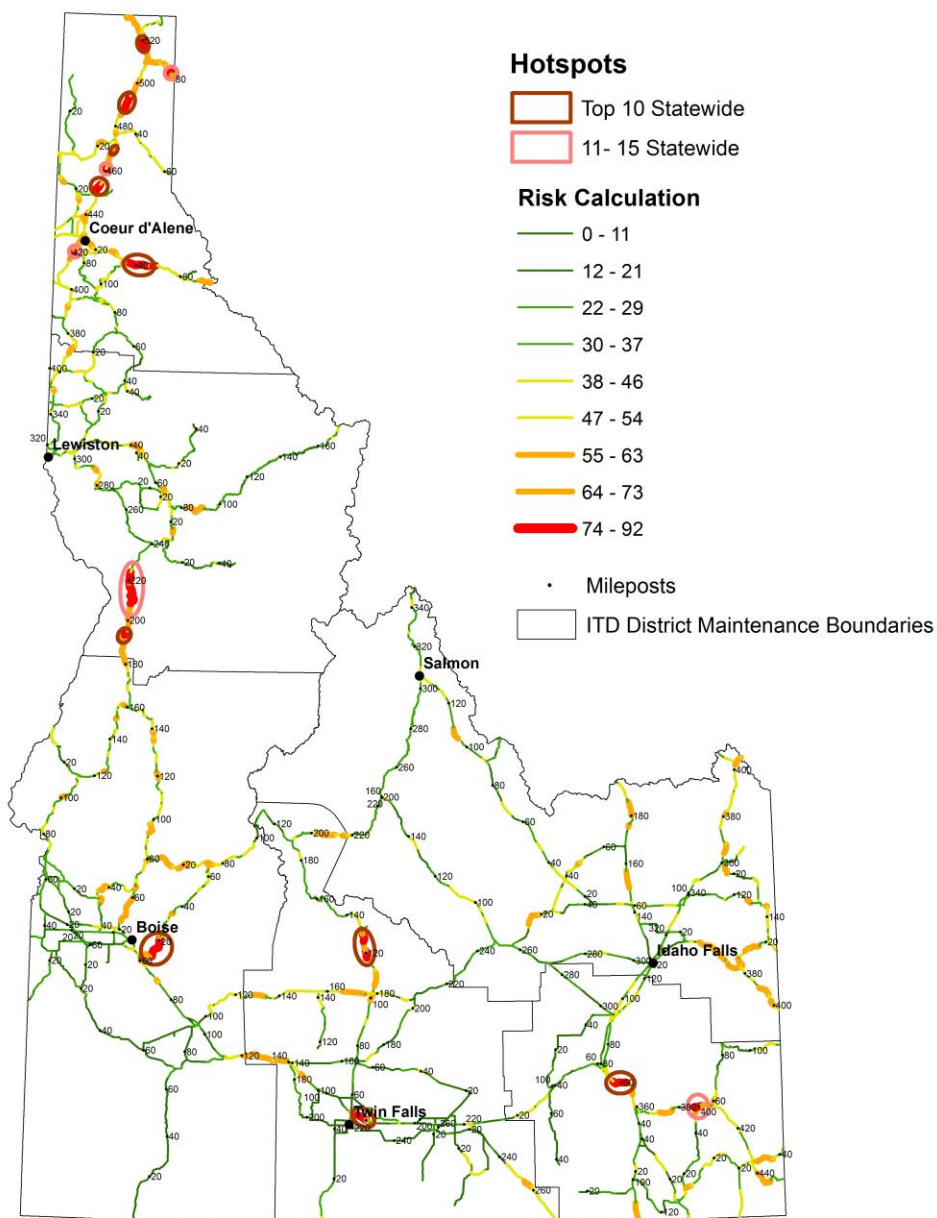


Figure 39. Scenario 1, Idaho Top Wildlife-Vehicle Collision Priority Segments and Different Colored Road Segments Based on Rankings
Risk Calculations Are the Ranked Values and Represent Risk of Wildlife-Vehicle Collision

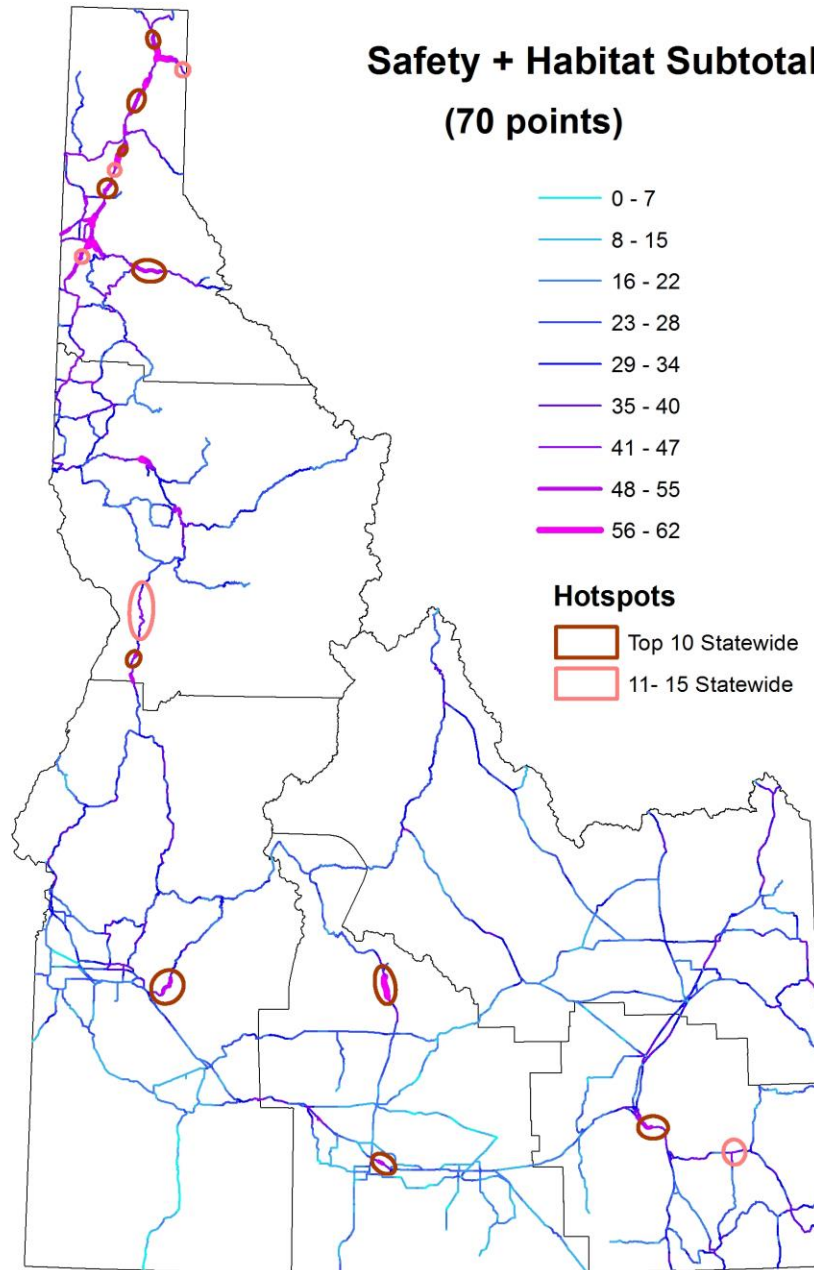
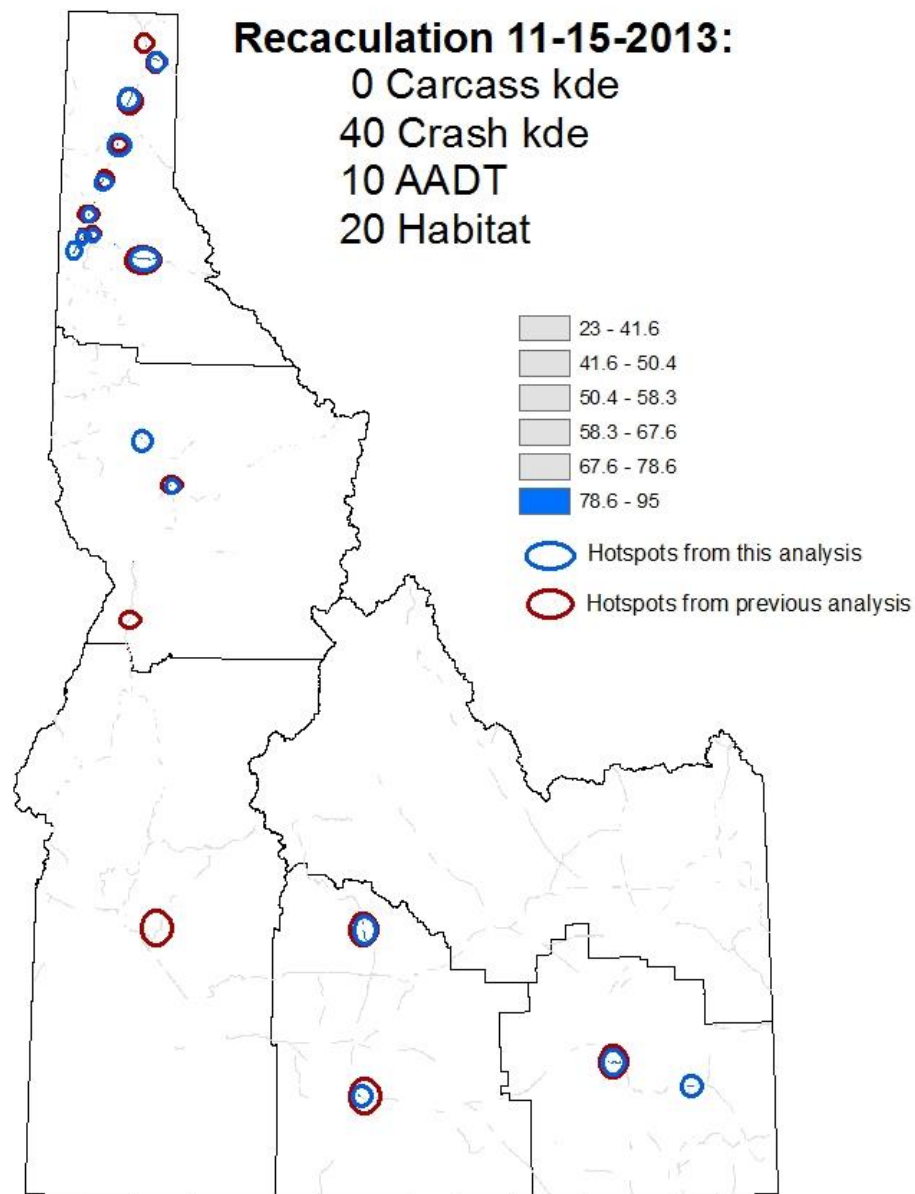


Figure 40. Scenario 2, GIS Map of Safety Data Plus Habitat Data, Without Linkage Data



**Figure 41. Scenario 3, Idaho GIS Map of Model Run of Crash Data
 Plus AADT, With Habitat Maps, and Linkage Map
 No Carcass Data. Top Priority Areas from Original Model Run in Red Circles, this Model Run Blue Circles**

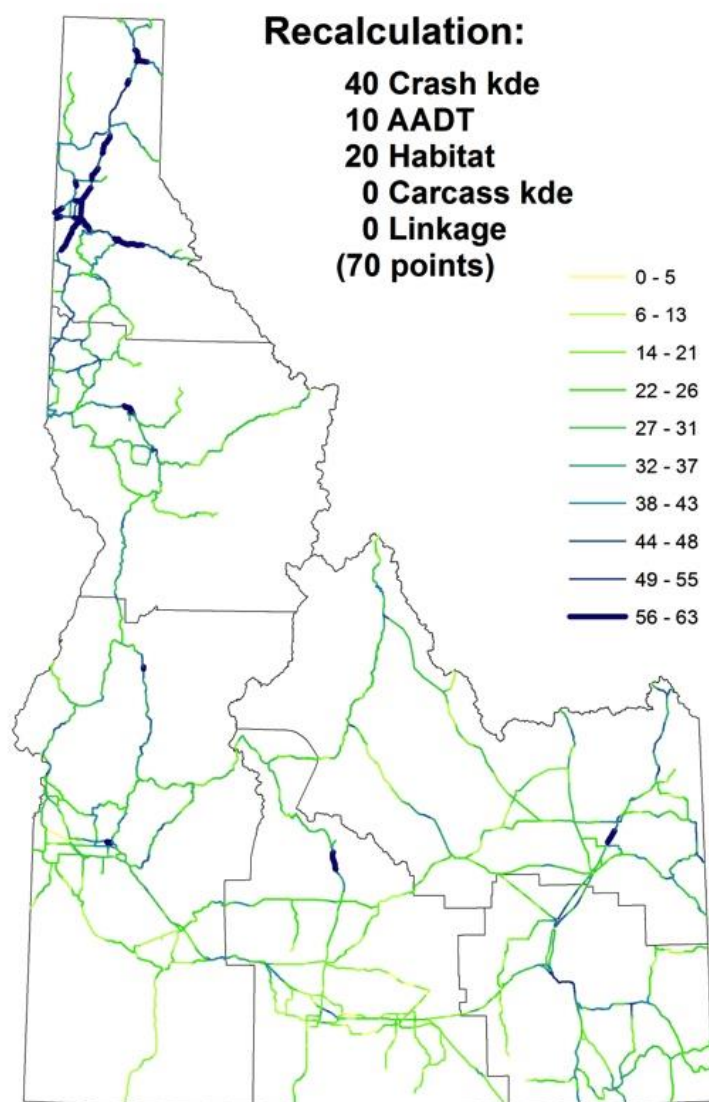


Figure 42. Scenario 4, Idaho Map of Model with Only Crash, AADT, and Habitat Maps
No Linkage Maps and No WVC Carcass Data Used

Table 20. Wildlife-Vehicle Collision Priority Areas within Each ITD District Identified Under Different Mapping Models with Different Map Inputs

Priority Area	Final Map = Crashes, Carcasses, AADT, Habitat, Linkages	Crashes, Carcasses, AADT, Habitat, No Linkages	Crashes, AADT, Habitat, Linkages No Carcass Data	Crashes, AADT, Habitat, No Linkages & No Carcass data
District 1				
1. US-95 Kootenai River & Indian Reservation	✓	✓	?	✓ Part of Larger Hotspot
2. US-2 Katka	✓	✓	✓	✓ Part of Larger Hotspot
3. US-95 McArthur Lake	✓	✓	✓	
4. US-95 South of Sand Point	✓	✓	✓	✓
5. US-95 Sandpoint	✓	✓	✓	✓
6. US-95 North Coeur d'Alene	✓	✓	✓	✓ Part of Larger Hotspot
7. I-90 Coeur d'Alene	✓	✓	✓	✓ Part of Larger Hotspot
8. US-95 South of Coeur d'Alene	✓	✓	✓	✓ Part of Larger Hotspot
9. US-95 South of Coeur d'Alene			✓	✓ Part of Larger Hotspot
10. I-90 Pinehurst	✓	✓	✓	✓
District 2				
1. US-12 Orofino			✓	✓
2. US-12 Kamiah	✓		✓	
3. US-95 Riggins	✓	✓		
District 3				
1. SH-21 Lucky Peak/IDFG Boise River Wildlife Management Area	✓	✓		
2. SH-44/SH-55 Star to Eagle, Near Boise River			✓	✓
District 4				
1. SH-75 Ketchum	✓	✓	✓	✓
2. I-84 Twin Falls	✓	✓	✓	✓
District 5				
1. I-84 Inkom/Pocatello	✓	✓	✓	✓
2. US-30 Soda Springs			✓	
District 6				
1. US-20 Rigby/Thorton				✓

Validation ,through Comparison of ITD Environmental Planners' Priorities

The top 15 priority areas of the original map model were also cross checked by ITD District 3 Environmental Planner Scott Rudel and ITD District 6 Environmental Planner Tim Cramer. They selected "High," "Medium," and "Low" priority areas for each district to compare the WVC Priority GIS model run maps to help examine if the GIS data were in concordance with what they knew to be on the ground. The ITD environmental planners rated select road sections as "Low," "Medium," and "High" priority. The rankings taken from the WVC Priority GIS Map were rated as "Low," "Lower Mid-Range" "Mid-Range," "Upper Mid-Range," and "High." These added classes of ranges for the WVC Priority GIS model runs

made comparing priority rankings a bit more difficult, but point values were inserted into those classes so viewers could see how the quantified ranking process of the GIS ranked those road segments (Table 21).

**Table 21. Priority Areas in Each ITD District as Selected by TAC Members S. Rudel and T. Cramer:
How Those Areas Were Ranked by These Two and How the Rankings Compared to Map
Modeling Rankings for WVC Priorities Statewide**

Priority Area	Road	Mileposts	Species of Interest								Ranking*	Ranking of Map Models
			White-tailed Deer	Mule Deer	Elk	Moose	Bear (in general)	Grizzly Bear	Black Bear	Pronghorn Antelope		
District 1												
Pack River/McArthur Lake corridor extending north to just past Bonner's Ferry. Area was identified as a high priority ecosystem level linkage by ITD, USFS, IDFG, NGO's & others in 2007-08 linkage analysis study. The USU assessment identifies it as high WVC priority area. Known as a Critical grizzly bear, lynx, wolverine & other endangered species linkage between the Selkirk & Cabinet-Yaak Mountains. The Pack/Kootenai River corridors have healthy moose populations & the highway corridor traverses through the river valleys. Mule deer, white-tailed deer, elk, large/mid-sized carnivores, & other wildlife are present in large numbers.	US-95	483 - 520	X		X	X		X	X		High/Top	Upper Mid-Range - High Orange to Red (61 - 92)
Red Hog to Micah. Identified as moderate priority by both the 2007-08 linkage analysis and USU WVC study assessments. White-tailed deer, elk, moose & bear are primary concerns. Tend to be local populations. Traffic Notes: Major Truck Route	US-95	411 - 429	X						X		Medium	Upper Mid-Range Yellow to Orange/Red (61 to 82)
Priest River to Priest Lake Corridor. Area ranked low in both the linkage analysis and USU studies. Corridor does contain critical wildlife linkages but due to low traffic volumes ranks as a low priority because they are functioning without risks. Moose, white-tailed deer, elk, bear & other wildlife are present in large numbers. Low Traffic	SH-57	0 - 38	X		X		X				Low	Low Yellow (0 to 55)

Table 21 (cont.) Priority Areas in Each ITD District as Selected by TAC Members S. Rudel and T. Cramer

Priority Area	Road	Mileposts	Species of Interest								Ranking*	Ranking of Map Models
			White-tailed Deer	Mule Deer	Elk	Moose	Bear (in general)	Grizzly Bear	Black Bear	Pronghorn Antelope		
District 2												
Salmon River. Identified as a high priority by both the 2007-08 linkage analysis & USU WVC study assessment. Species of concern are mule deer (1 of the largest mule deer areas within D2; MP 215 - 220 has high concentration of mule deer WVC), black bear near John Day Creek, elk tend to congregate around MP 212 - 216 & white-tailed deer are present throughout. This travel corridor traverses through a known migratory linkage for mule deer & elk & is situated in critical wintering range along the Salmon River. US-95 Major Truck Route.	US-95	203 - 234		X	X				X		High/Top	Upper Mid-Range - High Orange to Red (69 - 79)
Kamiah & Heart of The Monster. Identified as a moderate to high priority by both the 2007-08 linkage analysis & USU WVC study assessments. Species: Lots of white-tailed deer with some mule deer. US-12 has some truck traffic & heavy recreational traffic.	US-12	16 - 53	X	X	X						High/Top	Mid-Range Orange (43-54)
Harpster Grade. Identified by both the 2007-08 linkage analysis & USU WVC assessment as a moderate priority. Species of concern included a large local white-tailed deer herd with some elk, moose & black bear in the area. SH-13 has relatively low traffic volumes.	SH-13	5 - 10	X		X						Medium	Mid-Range Orange (43-54)
Camas Prairie to Grangeville to Winchester. Identified as low priority by both the 2007-08 linkage analysis & the USU assessment. Species: Deer. US 95 is a major truck route.	US-95	240 - 280	X	X							Low	Low Green to Yellow (0 – 42)

Table 21 (cont.) Priority Areas in Each ITD District as Selected by TAC Members S. Rudel and T. Cramer

Priority Area	Road	Mileposts	Species of Interest								Ranking*	Ranking of Map Models	
			White-tailed Deer	Mule Deer	Elk	Moose	Bear (in general)	Grizzly Bear	Black Bear	Pronghorn Antelope			
District 3													
Boise River Wildlife Management Area (BRWMA). Portion that bisects Boise Front & BRWMA. Identified as a high priority in both the 2007-08 linkage analysis & in the USU WVC assessment. Well known as a travel corridor that bisects a critical migratory linkage & wintering range for mule deer (7,000 - 8,000 winter on the WMA but can vary +/-) & elk (500 – 1,500 winter on the WMA but can vary +/-). Also known as critical linkage for birds of prey/raptors. In addition, a few hundred pronghorn live year round within the WMA. Also present are white- tailed deer, black bear, mountain lions, mid-sized carnivores, badger & other wildlife. The mule deer & elk that winter on the BRWMA are tied to larger overall populations that winter across the Boise/Danskin Front & make up a total herd size of 22,000 - 26,000 mule deer & 5,000 - 7,500 elk. The migration of deer & elk traverses from as far as way as the Sawtooth Mountains some 60 to 70 linear miles away. The SH-21 corridor serves Idaho’s largest & fastest growing population center & has exhibited trends of increased traffic over the years.	SH-21	7 - 22	X	X	X					X	High/Top	High Red (69 - 84)	
Spring Valley to Horseshoe Bend Hill. Identified as a medium to high priority in the 2007-08 linkage analysis. In the USU WVC assessment the highway has a high assessment near Horseshoe Bend Hill. The corridor has residential mule deer & elk. Elk tend to stay in the upper elevations of Spring Valley Creek & the Boise Front. During hard winters elk & mule deer come down slope sometimes traversing the highway corridor. Traffic has increased modestly with high increases in weekend recreational traffic. This segment of SH 55 could see increases in AVC with the proposed amount of residential development and increased volumes of traffic that will subsequently occur if build out occurs (i.e. correspondingly lead to a wider highway corridor in the future).	SH-55	47 - 63		X	X						X	Medium – Medium- High	Mid-Range -High Orange/Red - Red (50 -70)
Walters Junction to Grandview. Identified as a low priority in the 2007-08 linkage analysis & in the USU WVC assessment. SH-78 has low traffic volumes.	SH-78	20 - 60		X								Low	Low - Mid-Range Green to Yellow (0 to 41)

Table 21 (cont.) Priority Areas in Each ITD District as Selected by TAC Members S. Rudel and T. Cramer

Priority Area	Road	Mileposts	Species of Interest								Ranking*	Ranking of Map Models
			White-tailed Deer	Mule Deer	Elk	Moose	Bear (in general)	Grizzly Bear	Black Bear	Pronghorn Antelope		
District 4												
Moonstone ID4-4. Identified as a high priority linkage because of mule deer, elk, moose, wolf, mid-sized carnivores, badger, red-band trout, & resident trout in the adjacent Wood River. In addition wintering bald eagles, nesting golden eagles & other raptors were also identified.	US-20	166.5 - 174.5		X	X	X					High	Upper Mid-Range Yellow to Orange (48.0 - 66.1)
Little Camas. Identified as moderate priority because of mule deer, elk, black bear, wolf, & mid-sized carnivores. The linkage analysis put this area in the moderate priority category while USU priority process rated this area mid-range.	US-20 US-26 US-93	109.5 - 125.0		X	X				X		Low	Lower-Mid Range Green to Yellow
Raft River. Identified as a low priority linkage area. The linkage area is listed for moose, pronghorn, mid-sized carnivores, & barn owls. The USU priority rating for this area is slightly below the mid-point between mid-range & high priority.	I-84	233.5 - 237.5				X				X	Low	Lower-Mid Range Green to Yellow (30.3 - 48.0)
District 5												
Red Rock Pass. A series of valley wetlands interspersed with upland mountain ridges & a busy highway. Agricultural uses of wetlands with many species of birds including water-fowl, golden eagle. Linkage area designated for mule deer, elk, mid-sized carnivores, amphibians/waterfowl production. The linkage analysis rated this area as a high priority but the USU priority system rated it upper mid-range.	US-91	23.0 - 32.5		X	X						High	Mid-Range Yellow (41.6 - 48.9)
Tin Cup. Typical of montane eastern Idaho with mixed conifer forest with valley streams/marsh complexes. Good wildland habitat with some high elevation connecting between the Wasatch & Teton Ranges. Very much a death trap for wildlife moving through the natural drainage of Tin Cup Creek & ending up being pushed onto the roadway. Need a precast arch culvert with room for wildlife. The linkage analysis prioritized this area as moderate & the USU priority analysis shows this area with mid-range & upper mid- range values.	SH-34	98.5 - 112.5		X	X	X					Moderate	Lower - Mid- Range Green to Yellow (33.7 - 41.6 & 41.6 - 48.9)
China Hat. Mountain sage valleys surrounded by mixed conifer mountains & hills. Heavy truck traffic on this road & recreation & agricultural traffic. The linkage analysis had this location as low priority but the USU priority process rated this in upper mid-range, higher than the linkage analysis priority.	SH-34	66.3 - 71.0			X	X		X	X		High	Mid-Range Yellow (46.5 - 51.8 & 51.8 - 56.8)

Table 21 (cont.) Priority Areas in Each ITD District as Selected by TAC Members S. Rudel and T. Cramer

Priority Area	Road	Mileposts	Species of Interest								Ranking*	Ranking of Map Models
			White-tailed Deer	Mule Deer	Elk	Moose	Bear (in general)	Grizzly Bear	Black Bear	Pronghorn Antelope		
District 6												
Palisades Dam. This linkage includes the southern end of the Teton Mountain Range & areas directly connected to Wyoming. Includes valleys, agricultural fields, & recreational properties, montane, riparian, & lacustrine habitat. Linkage area was identified for elk, moose, black bear, grizzly bear, mountain lion, lynx, wolverine, bighorn sheep & mountain goats. Linkage analysis prioritized this area as high. USU priority analysis rated this area about mid-way between mid-range & high.	US-26	387.4 – 402.5			X	X		X	X		High	Mid-Range Yellow (46.5 - 51.8 & 51.8 - 56.8)
Targhee Pass. High elevation pass on the border between Idaho & Montana. The area includes approximately 4 miles in Idaho & is an important corridor for elk migration below the Pass between the Madison Range in Montana & Yellowstone National Park. The linkage analysis was identified as an important area for elk, black bear, wolverine, & a multiple-species linkage including carnivores, bears, & ungulates. The linkage analysis prioritized this area as moderate while the USU priority process rated this area in the upper mid-level to lower high level.	US-20	402.2 – 406.0			X				X		Moderate	Upper Mid-Range Orange (51.8 - 56.8 & 56.8 - 63.5)
Salmon North. Riparian areas of several drainages crossing US-93 & the Salmon River to the West of the highway. The area is interspersed with agricultural lands, mostly hay fields & pastures interspersed with rural home sites & riparian drainages. It also includes valley bottoms & mountains adjacent to & away from US-93. The linkage analysis described this area for bighorn sheep, pronghorn, mule deer, bald eagle & peregrine falcon. The importance of this area comes from the proximity to the Salmon River & the drainages crossing the highway & to the headwaters of Deriar, Fenster, Bob Moore, & Jessie Creeks. The linkage analysis established this area as a low priority but the USU priority rating for this area is slightly below the mid-point between mid-range & high priority, which is higher than the linkage analysis priority rating would suggest.	US-93	306.2 – 311.0		X						X	Low	Mid-Range Yellow (46.5 - 51.8)

Results of Validation Processes

The results of the two step validation process allow the viewer to assess each priority area as developed by various mapping techniques and selections by TAC members. The validation process did not develop a method to quantifiably evaluate how well a WVC priority segment selected an area based on all the different map inputs, and TAC member knowledge of situations on the ground. However If the viewer examines Table 21, the results of the multiple GIS models of prioritizing road segments with different data layers can be considered the most quantified method in this validation process. It appears from Table 21 that 7 priority areas in ITD District 1, 2 priority areas in District 4, and 1 priority in District 5 (10 in total) consistently stayed top priorities with different GIS modeling techniques. These areas were almost certainly the most validated WVC priority areas with the GIS modeling techniques.

A second step in this validation process was to examine the GIS attribute table to determine why ITD District 6 consistently did not have any or at best 1 priority segment of road in the different prioritization methods. For all map values District 6 had rankings comparable with other Districts, except for carcass data. All other Districts had dozens of road segments with carcass ratings of 14 through 20. The highest any District 6 road segment had was a rating of 13 points out of 20. This low data reporting of carcasses handicapped all road segments in the entire District in the overall prioritization process. When the GIS maps were run without carcass data, District 6 still did not receive any priority rankings, so the problem was not solely carcass data. When the model was run without carcass data and linkage data, a single priority “hotspot” on SH-20 appeared for District 6. This may indicate that consistent low carcass reporting in the areas where linkages were mapped with possibly lower linkage scores than other areas in Idaho may be amplifying the District 6 handicap.

The priorities determined by TAC members Scott Rudel and Tim Cramer were a bit more difficult to compare with WVC Priority GIS model run maps. The environmental planners’ classes of “Low, Medium, and High” were 3 gradations compared to the GIS map classes of 5 gradations: “Low, Lower Mid-Range, Mid-Range, Upper Mid-Range, and High.” Of the 7 high priority segments selected by the environmental planners (2 were selected for District 2), 4 were ranked as “Mid-Range to Upper Mid-Range” by the map, while the other 3 were ranked “High” by the map. This may indicate slight differences in the mapping process than expert opinion that could be further investigated for the next iterations of the mapping process. All environmental planners’ road segments rated as “Moderate and Low” were perfectly matched with the GIS map ratings of mid-range values for the moderate priorities, and “Low to lower-Mid-Range” values for the low priorities. This quantified mapping process aligned well with more subjective human priorities, with perhaps some improvements on how higher priorities should be ranked in the mapping process.

This process assists ITD in determining its top statewide priorities for WVC. Alternatively, this process may not pass a peer reviewed standard unless further testing is developed with data that was independent of this mapping process, such as empirical field data gathered from different collared species of animals involved in other studies.

Future Recommendations

The GIS research team coded the GIS data so the ranking of different GIS layers' output was tabulated in a manner that allows rankings to be changed with little effort, see the attribute tables from the GIS data. This presentation of the values of data for each mile allows transparency and can allow future users to repeat the process with different scenarios.

ITD could use the data in Table 21 to further evaluate the GIS mapping process priorities against what District environmental planners view as priorities. If the GIS processes used in this research did not produce maps accepted by ITD personnel, future efforts could use other GIS techniques, possibly more similar to those described by Fraser Shilling in Appendix A.

References for Appendix D

1. **Mountrakis, G. and K. Gunson.** "Multi-Scale Spatiotemporal Analyses of Moose-Vehicle Collisions: a Case Study in Northern Vermont." *International Journal of Geographical Information Science*, Vol. 23, No. 11 (Nov. 2009): 1389-1412.
2. **Barnum, S. and M. E. Gray.** "A Comparison of Methods to Identify Deer-Vehicle Crash Hotspots." Washington, DC: *Transportation Research Board 91st Annual Meeting Compendium of Papers*, 2012. <http://trid.trb.org/view.aspx?id=1130923>. Accessed on May 2, 2014.

Appendix E

Wildlife-Vehicle Collision Carcass Data for Idaho

IDFG website WVC carcass data by species, time of year, and locations on ITD roads. The tables and figures below present the carcass data to allow the reader to discern patterns of interest.

Table 22. IDFG Ungulate Species Road Carcass Data, 2011-2013

Ungulates, IDFG Roadkill Data 2011-2013		
Ungulate Species	Scientific Name	Count
White-Tailed Deer	<i>(Odocoileus virginianus)</i>	3,560
Mule Deer	<i>(Odocoileus hemionus)</i>	2,770
Deer	(not identified to species)	26
Elk	<i>(Cervus canadensis)</i>	508
Moose	<i>(Alces americanus)</i>	288
Pronghorn Antelope	<i>(Antilocapra americana)</i>	24
Rocky Mountain Bighorn Sheep	<i>(Ovis canadensis canadensis)</i>	14

Table 23. IDFG Non-Ungulate Mammal Road Carcass Data, 2011-2013

Non-Ungulate Mammals, IDFG Roadkill Data 2011-2013		
Species	Scientific Name	Count
American Badger	<i>(Taxidea taxus)</i>	145
Coyote	<i>(Canis latrans)</i>	106
Red Fox	<i>(Vulpes vulpes)</i>	41
Striped Skunk	<i>(Mephitis mephitis)</i>	30
Raccoon	<i>(Procyon lotor)</i>	29
Black Bear	<i>(Ursus americanus)</i>	20
Porcupine	<i>(Erethizon dorsatum)</i>	11
Mountain Lion	<i>(Puma concolor)</i>	10
Bobcat	<i>(Lynx rufus)</i>	9
Eastern Fox Squirrel	<i>(Sciurus niger)</i>	7
Gray Wolf	<i>(Canis lupus)</i>	6
Northern River Otter	<i>(Lutra Canadensis)</i>	6
Red Squirrel	<i>(Tamiasciurus hudsonicus)</i>	6
Beaver	<i>(Castor canadensis)</i>	5
Unclassified Squirrel	<i>(Sciuridae)</i>	3
Columbian Ground Squirrel	<i>(Spermophilus columbianus)</i>	3
Snowshoe Hare	<i>(Lepus americanus)</i>	2
White-Tailed Jack Rabbit	<i>(Lepus townsendii)</i>	2
Mink	<i>(Mustela vison)</i>	2
Black-Tailed Jack Rabbit	<i>(Lepus californicus)</i>	1
Yellow-Bellied Marmot	<i>(Marmota flaviventri)</i>	1
Long-Tailed Weasel	<i>(Mustela frenata)</i>	1
Muskrat	<i>(Ondatra zibethicus)</i>	1
Eastern Cottontail	<i>(Sylvilagus floridanus)</i>	1

IDFG Roadkill 2011-2013, top non-ungulate mammals

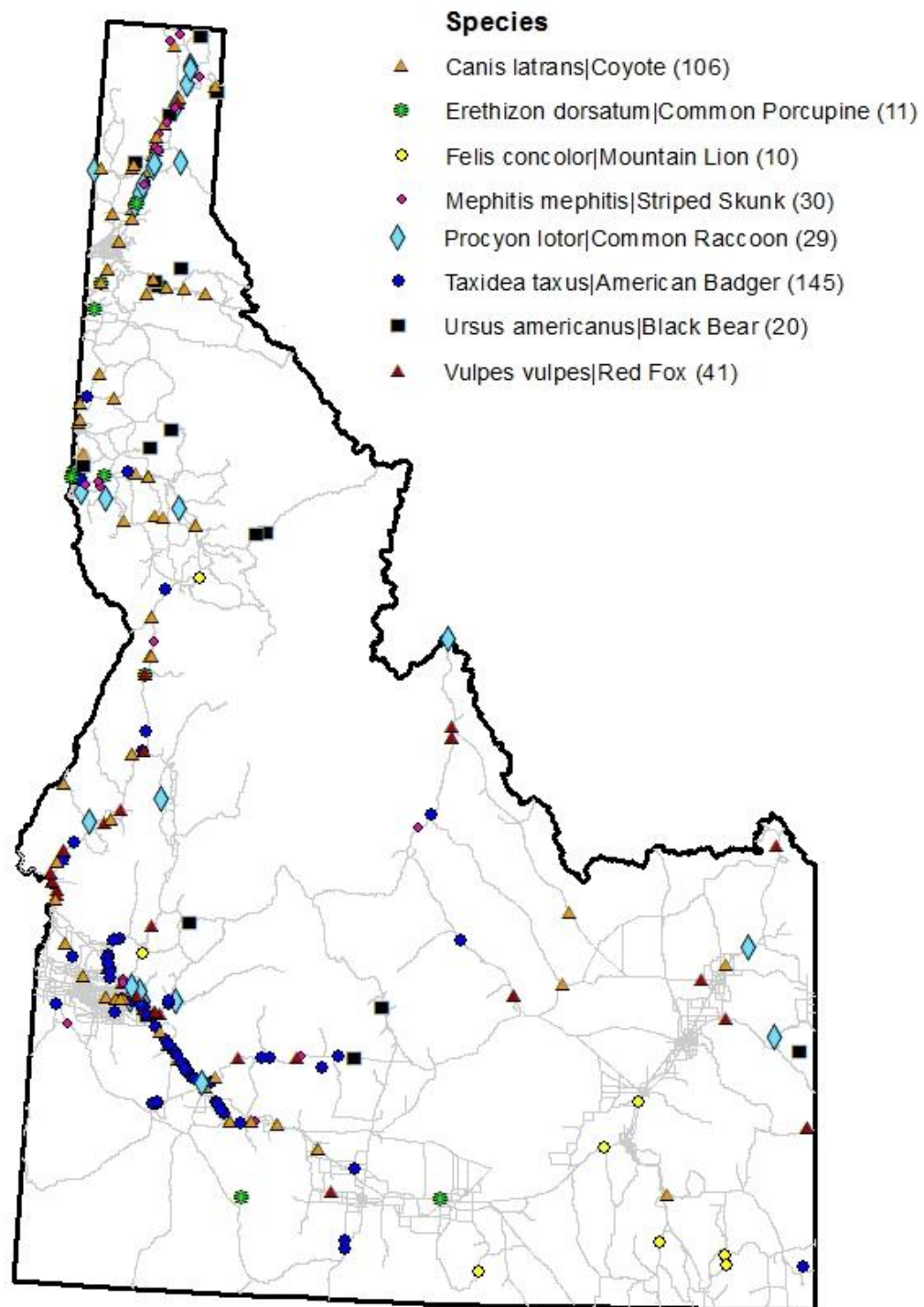


Figure 43. IDFG Roadkill 2011 – 2013, Top Non-Ungulate Mammals

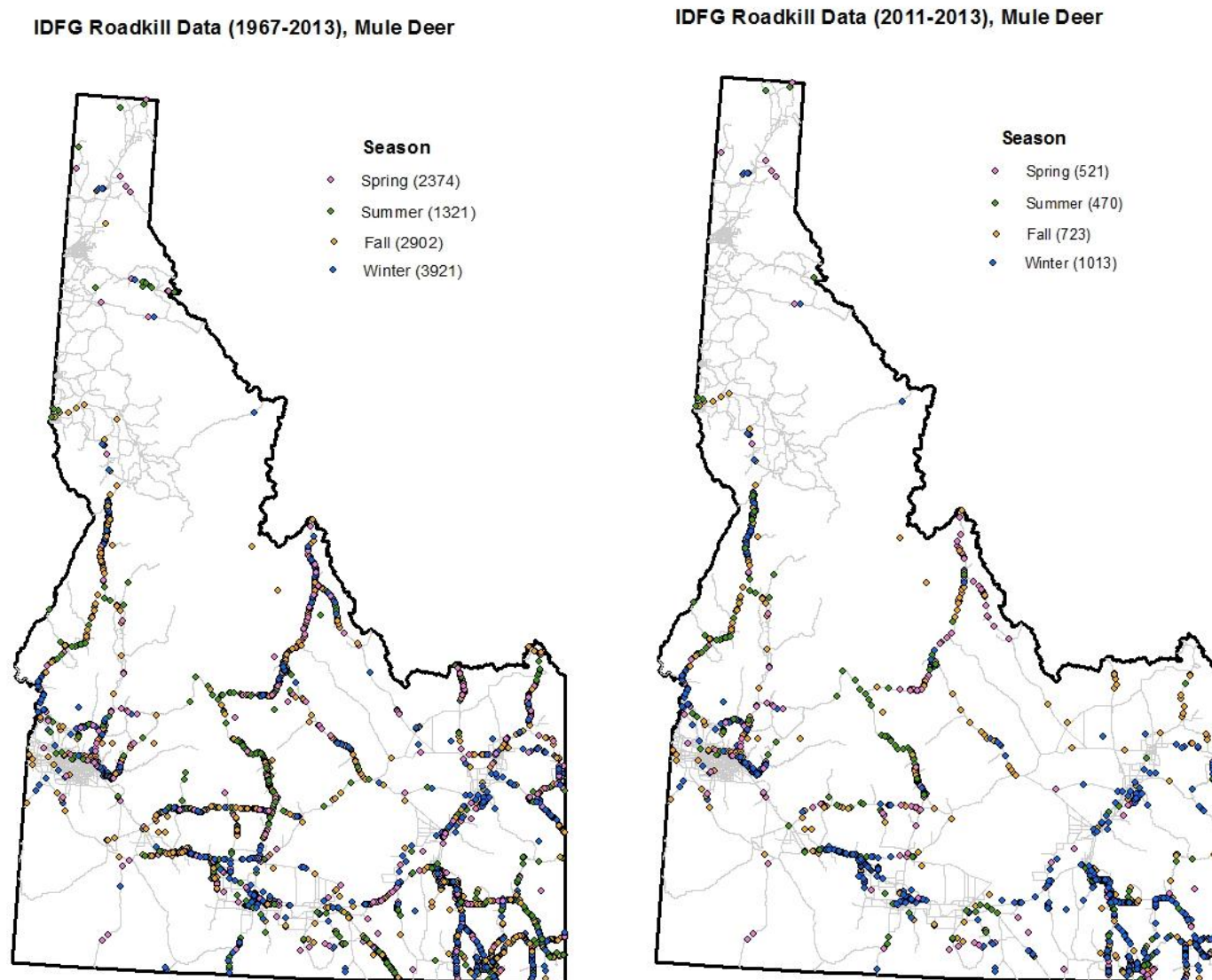
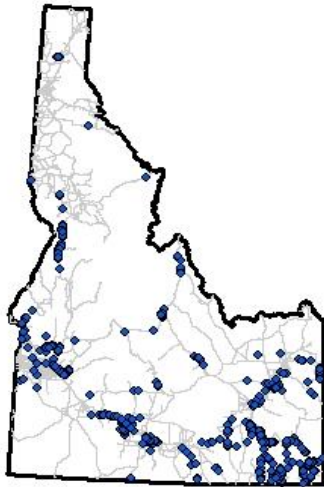


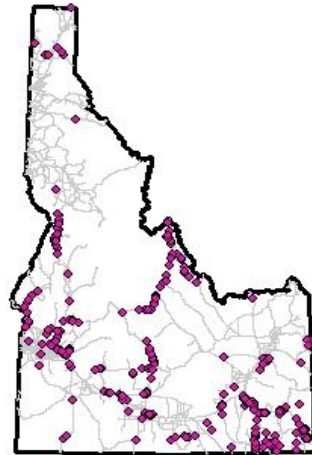
Figure 44. IDFG Roadkill Data (1967-2013 and 2011 – 2013, Mule Deer

IDFG Roadkill Data (2011-2013), Mule Deer

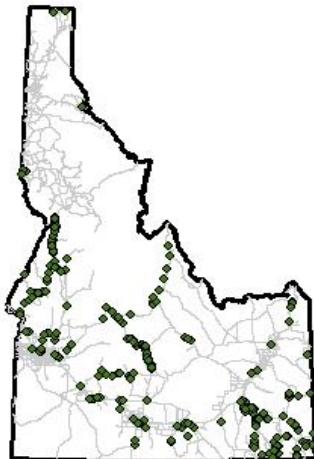
Winter (Dec, Jan, Feb)



Spring (Mar, Apr, May)



Summer (June, July, Aug)



Fall (Sep, Oct, Nov)

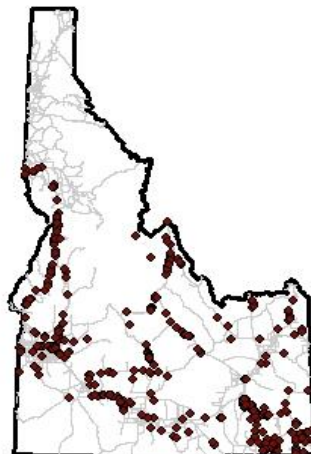


Figure 45. IDFG Roadkill Data (2011 – 2013), Mule Deer By Season

IDFG Roadkill Data (2011-2013), White-tailed Deer

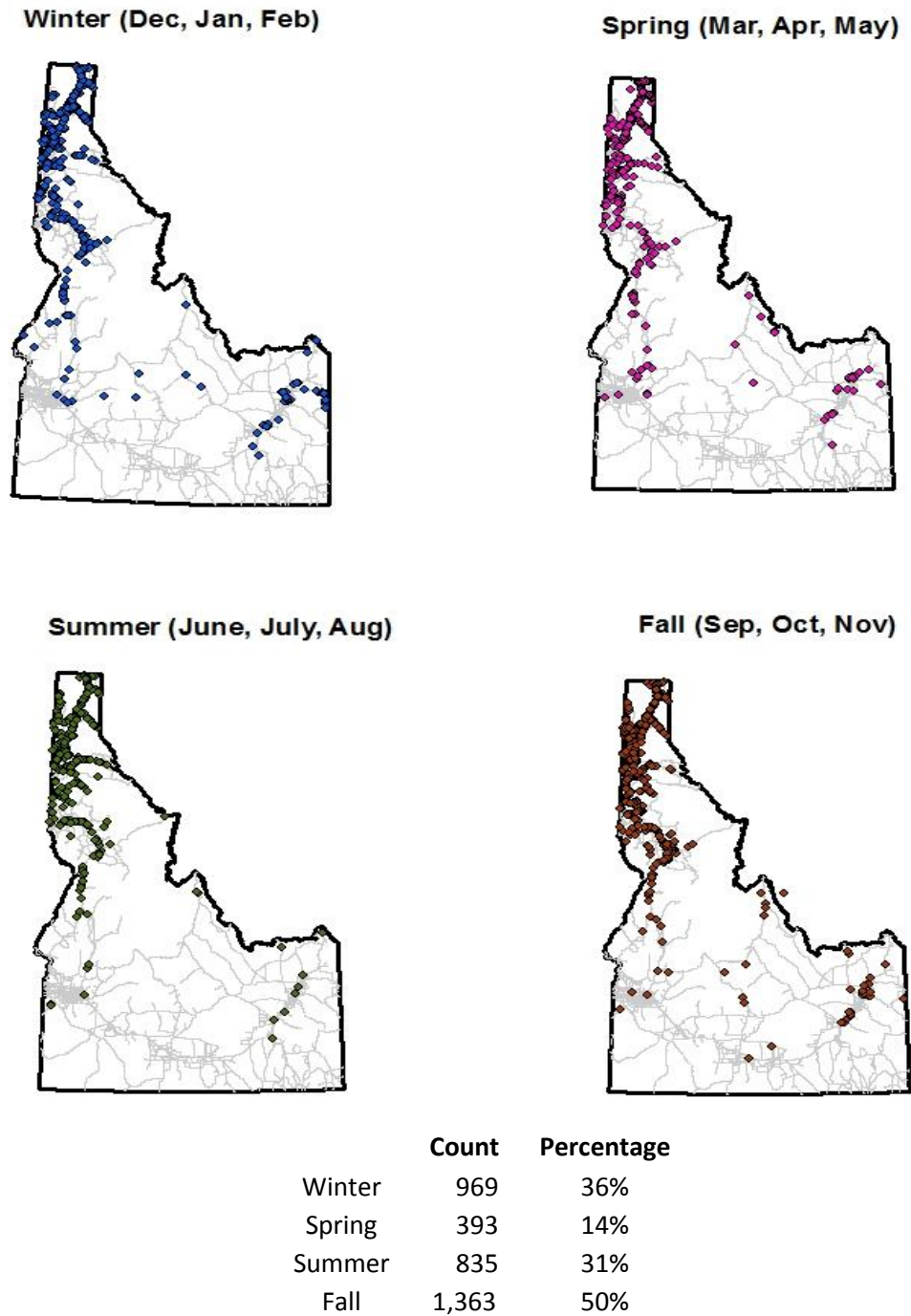


Figure 46. IDFG Roadkill Data (2011 – 2013), White-Tailed Deer By Season

Appendix F

The Passage Assessment System

Taken from Kintsch and Cramer, 2011 and Washington State Department of Transportation

The Washington State Department of Transportation (WSDOT) funded a study by Kintsch and Cramer to evaluate existing infrastructure for potential retrofits (modifications) to allow greater permeability for wildlife species to pass beneath the road.⁽²⁾ This method is to be used by a qualified DOT biologist somewhat familiar with different species preferences for crossing types and other infrastructure. The method was being updated in early 2014 and future users of this system should contact either Patricia Cramer at cramerwildlife@gmail.com, or Julia Kintsch at julia@eco-resolutions.com to learn of how to use the updated and further tested version.

PASSAGE ASSESSMENT SYSTEM: GENERAL QUESTIONS			
<i>Please complete this form for each structure visited.</i>			
Date:			
Location ID:			
Location Code:			
Route #:			
Mileposts:			
GPS ID:			
GPS Latitude:			
GPS Longitude:			
Structure Functional Class:	Class 1: Small Underpass	Class 2: Medium Underpass	Class 3: Large Underpass
	Class 4: Extensive Bridge	Class 5: Wildlife Overpass	Class 6: Specialized Culvert
	Class 7: Canopy Bridge		

Species Movement Guild: (select all that apply)	Low Mobility Small Fauna	Moderate Mobility Small Fauna	Adaptive High Mobility Fauna	High Openness High Mobility Fauna	Adaptive Ungulates	
	Very High Openness Fauna	Arboreal Fauna	Aerial Fauna			
Briefly describe the general environmental conditions at the time of the assessment (e.g., water levels, vegetation):						
Bridge Number:						
Divided or Undivided:		Divided	Undivided			
Highway Direction:		East/West	North/South			
Roadway Photos Numbers:		1:	2:	3:	4:	
General						
Photo Number (route_mp_date_photo#):	1:		2:	3:	4:	
Wildlife Use						
Are there signs of wildlife use in the structure such as tracks?						
Tracks	Scat	Live Animal	None	Other (text)		
If yes, describe						
Are there signs of wildlife within 30' of the entrances?	Tracks	Scat	Roadkill	Live Animal	None	
If yes, describe						

Human Use				
Is there apparent human activity in the structure?	Yes - Frequent/Daily	Yes - Occasional	No evidence Found	
What type(s) of activity? (check all that apply):	Camping/Occupancy	Vehicle/ATV Use	Trail	
	Recreation	Dog	Night Use	Other:
Which description best matches human activities immediately adjacent to the structure?				
	Daily human activity at both entrances		Daily human activity at one entrance	
	Recreational use in a wild setting		Wild setting with infrequent human activity	Other:
Notes:				
<u>Species Movement Guild Rankings</u>				
When ranking the structure, consider how changes in water levels and vegetation growth may affect passage for each Species Movement Guild.				
A = This animal could make it though as is, or with small modifications C = With modest modifications this structure could be functional F = Can't be fixed with a retrofit				
Rate this structure for <i>Low Mobility Small Fauna</i>, e.g., slow-moving animals that require a consistent environmental conditions, such as frogs or salamanders:				
		A	C	F
Comments:				
Rate this structure for <i>Moderate Mobility Small Fauna</i>, e.g., small animals that are fairly adaptable, such as squirrels, skunks, raccoons, fishers and some turtles:				
		A	C	F
Comments:				

Rate this structure for <i>Adaptive High Mobility Fauna</i> , e.g., fairly tolerant medium-sized animals, such as bobcat, coyote and black bear:			
	A	C	F
Comments:			
Rate this structure for <i>High Openness High Mobility Carnivores</i> , e.g., larger animals that prefer larger structures, such as grizzly bear or mountain lion			
	A	C	F
Comments:			
Rate this structure for <i>Adaptive Ungulates</i> , e.g., ungulates that require good visibility through a structure, such as deer, moose or mountain goats:			
	A	C	F
Rate this structure for <i>Very High Openness Fauna</i> , e.g., animals that require large structures with clear lines of sight that are less than 100' long, such as elk, pronghorn and turkey:			
	A	C	F
Comments:			
Which features could be changed to make the structure more functional for each target Species Movement Guild?			
PASSAGE ASSESSMENT SYSTEM: UNDIVIDED HIGHWAY			
<u>Preliminary Questions (i.e., Fatal Flaws)</u>			
Assess each of the following questions relative to the species guild of interest to determine whether the structure is fatally flawed for members of the Species Movement Guilds indicated:			
Is the structure longer than 300'? (fatal flaw for <i>Adaptive Ungulates</i> and <i>Very High Openness Fauna</i>)			No (continue)
			Yes (structure is not suitable for enhancement)

Is the culvert slope > 30° and 100' or longer? (fatal flaw for all Species Movement Guilds)				No (continue)		
				Yes (structure is not suitable for enhancement)		
Is there extensive development/pavement in the immediate vicinity of one or both sides of the structure? (fatal flaw for all Species Movement Guilds)				No (continue)		
				Yes (structure is not suitable for enhancement)		
Can you see through the structure to the other (for divided highways, consider each structure individually)? (if no, fatal flaw for <i>Adaptive Ungulates</i> , <i>Very High Openness Fauna</i> and <i>High Openness High Mobility Carnivores</i>)				Yes (continue)		
				No (structure is not suitable for enhancement)		
Structure						
What is the shape of the structure?		Round Pipe	Squash Pipe	Box Culvert		
	Bridge Underpass - Sloped Sides		Bridge Underpass – Straight Sides		Bridge Overpass	
	Other (Text)		Arch Culvert			
What is the structure material?		Concrete	Metal			
			Plastic/Fiberglass	Other (text)		
If Shape = Box] Are there multiple chambers?			No	Yes - Number of Chambers?		
	**If Yes, select the most appropriate chamber for terrestrial passage to answer the following questions					
If Shape = Bridge Underpass] Is this a single span or multi-span structure?					Single Span	
	Multi-span (1 or more supports)					
	**If Multi-span, select the most appropriate chamber for terrestrial passage to answer the following questions.					
If Shape = Bridge Underpass] What is the material of the abutments on the West/North side?						
Concrete		Concrete/Soil	Soil	Riprap	Gabian Wall	Other (text)
What is the slope ratio? (horizontal:vertical)			0:1		1:1	2:1

If Shape = Bridge Underpass] What is the material of the abutments on the East/South side?						
	Concrete	Concrete/Soil	Soil	Riprap	Gabian Wall	Other (txt)
What is the slope ratio? (horizontal:vertical)				0:1		1:1 2:1
Road Attributes						
Number of lanes of road:						
Is there parallel infrastructure such as railroads, recreational paths, frontage roads, etc?						No
Notes:						Yes - Describe:
INLET SIDE						
Photo Number (route_mp_date_photo#)	1:	2:		3:	4:	
Is there an apron at the inlet?	No	Yes, metal			Yes, concrete	
Does the culvert have wing walls?	No	Yes				
Structure Approximate Dimensions (functional dimensions if partially buried)						
Are the distances measured for the whole structure or for a single chamber of					Whole Structure	
a multi-span structure?			Single Chamber			
For each measurement, indicate "actual" or "estimated" measurement with an 'x' in the appropriate column.						
Height/Rise (ft) – can be marked as graduated				<u>Actual</u>	<u>Estimated</u>	
Width/Span (ft) – across or span of bridge/culvert along road						
Length (ft) – for animal crossing over/under road						
Obstructions						
Is the immediate entrance blocked?	None	Cattle Fence		Boulders humans would have to climb over		
Rocks/Riprap (> volleyball size)		Rocks/Riprap (> baseball size)				
		Some rocks, not continuous				

Thick Vegetation		Gate		Other	
Are there structures that block the entrance within 25'?			No	Cattle Fence	
				Small Mesh Fence	
			Boulder Field	Stream Flow	
			High/Steep Cut or Fill Slope		
Fill Slope					
Is the structure located in a fill slope?			No	Yes, > 20' high	
If yes, how is the structure situated in the slope?			At the base	Near top of fill slope	
				Midway on fill slope	
Approach Vegetation & Cover					
Is there vegetation/cover within 25' of the inlet?			No	Yes, partially	Yes, completely
If yes, select predominant type:			Grasses	Bushes	Bushes/Trees
Is there vegetation/cover within 25 - 50' of the inlet?			No	Yes, partially	Yes, completely
If yes, select predominant type:			Grasses	Bushes	
			Bushes/Trees		
Land Use Within 100' of Inlet:					
Predominant land use:		Forest	Wetlands	Prairie/Grassland	Agriculture
	Shrub/Steppe	Mixed: Human/Natural		Residential	Commercial
Noise					Other:
What does passing traffic sound like at the entrance to the structure?					
			Silent	Low Rumble	Loud and Jarring

Road Attributes									
How wide is zone of maintained vegetation (allowing extra visibility along the road shoulder)?									
0"		0-6'		6-30'		Undetermined			
Is there a guard rail or jersey wall above the structure?				No		Yes, structure only		Yes, extensive	
Notes:									
Inlet Side: Fencing/Walls									
Photo Number (route_mp_date_photo#):		1:		2:		3:		4:	
Is there fencing associated with the inlet side of the structure?						Yes		No	
Select type of fencing to <i>right</i> when facing structure:				Curb (not including wingwalls)					
				Wall (not including wingwalls)					
Chain Link		Wildlife Fence				Sediment Fence		4-Strand Wire	
								Other:	
If curb or wall, does it have a lip?		Yes				No			
What is the height of fencing/wall?		None		≤ 6"		> 6" to ≤ 2'		2' to 4' 4 to 6' 6 to 8'	
What is the mesh size?		None		6x6"		6x6", graduating smaller to 2x3 at base			
Is it connected to the structure?		Yes		No - small gap (≤0.5')					
Does the fencing reach all the way to ground level without gaps?						Yes		No	
Is the fencing entrenched in the ground to prevent animals from digging under it?						Yes		No	
Is the ROW fencing the same as the fencing that is immediately adjacent to the structure?						Yes			
						No			
If no, what is the ROW fencing type:				Curb (not including wingwalls)					
				Wall (not incl. wingwalls)					
Chain Link		Wildlife Fence				Sediment Fence		4-Strand Wire	

Other:									
Minimum distance fence extends from structure:									
≤ 10'	10 – 5'	50 – 100'	>100'	~½ mile	1 mile	_____ Miles			
Select type of fencing to left when facing structure:									
Curb (not including wingwalls)									
Chain Link		Wildlife Fence		Sediment Fence		4-Strand Wire			
						Other:			
If curb or wall, does it have a lip?				Yes		No			
What is the height of fencing/wall?		None	≤ 6"	> 6" to ≤2'	2' to 4'	4 to 6'	6 to 8'		
What is the mesh size?		None	6x6"	Other:					
Is it connected to the structure?		Yes		No -small gap (≤0.5')					
				No - large gap (>0.5')					
Does the fencing reach all the way to ground level without gaps?				Yes		No			
Is the fencing entrenched in the ground to prevent animals from digging under it?						Yes		No	
Is the ROW fencing the same as the fencing that is immediately adjacent to the structure?						Yes		No	
If no, what is the ROW fencing type:				Curb (not including wingwalls)					
				Wall (not incl. wingwalls)					
Chain Link		Wildlife Fence		Sediment Fence		4-Strand Wire			
						Other:			
Minimum distance fence extends from structure:									
	≤ 10'	101'	120 – 250'	¼ mile	½ mile	2 mile	_____ Miles		
What is the general condition of the fencing?				Gaps and areas where fence is down					
				Vegetation needs to be cleared from fence					
Is there an escape ramp(s) within a ½ mile of the structure in either direction?						No			
Is there a one-way gate(s) within a ½ mile of the structure in either direction?						No			
	None	1	2-5	6-10	>10				
Notes:									

INSIDE STRUCTURE						
Photo Number (route_mp_date_photo#)	1:		2:		3:	
Visibility						
Does the inside of the structure appear much darker than the outside lighting?				High Contrast		
Is there a clear line of sight from one end of the structure(s) to the other?				No		Obscured
Water Features						
Is there perennial water flow through structure?			No	< 3' deep	3 - 10' deep	
None	Dry Dirt Pathway		Rock/Dirt Pathway			
	No		Yes		Uncertain	
Substrate						
What is the substrate of the floor at the bottom/center of the structure?				Concrete/Asphalt		
	Plastic	Rocks	Dry Soil	Stream Bottom		
Is there a natural bottom through the length of the structure?				Yes	No	
Is there a natural bottom across the width of the structure?				Yes	No > 6"	
Pathway Floor Substrate						
Does the substrate through the structure appear similar to substrate outside of the structure?					Yes	
If No, what is the floor substrate?						
Concrete	Concrete with Baffles/Stabilizers	Steel	Riprap (> baseball)	Riprap (> volleyball)	Boulders	
If Yes, what is the minimum width of the dry natural pathway all the way through the structure?						
	<2'	2 – 5'	5 – 10'	10 – 20'	20 – 50'	
Vegetation						
Is there vegetative cover and/or woody debris through the structure?				None		
			Some Grass/Brush	Grasses		
Noise						
What does passing traffic sound like from the middle of the structure?						
			Silent	Low Rumble		

Other						
Is there a road or trail through the structure?	None	Paved Road	Dirt Road	Railroad	Paved Trail	
Are there obstructions inside the structure?	None	Debris	Soil	Baffles	Gaps/Trenches	
Is there a sky light in structure?			No	Yes		
Notes:						
OUTLET SIDE						
Photo Number (route_mp_date_photo#)	1:		2:	3:	4:	
Is there an apron at the outlet?	No			Yes, metal		
Is the outlet perched?	No			Yes, < 0.5'		
Does the culvert have wing walls?	No			Yes		
Structure Approximate Dimensions (functional dimensions if partially buried)						
Are the distances measured for the whole structure or for a single chamber of a multi-span structure?					Whole Structure	
For each measurement, indicate 'actual' or 'estimated' measurement with an 'x' in the appropriate column.					<u>Actual</u>	
Height/Rise (ft) – can be marked as graduated						
Width/Span (ft) – across or span of bridge/culvert along road						
Length (ft) – for animal crossing over/under road						
Obstructions						
Is the immediate entrance blocked?	None			Cattle Fence		
	Rocks/Riprap (> volleyball size)			Rocks/Riprap (> baseball size)		
	Thick Vegetation			Gate		
Are there structures that block the entrance within 25'?			No		Cattle Fence	
			Boulder Field		Stream Flow	

Fill Slope				
Is the structure located in a fill slope?		No	Yes, < 20' high	
If yes, how is the structure situated in the slope?		At the base	Midway on fill slope	
Approach Vegetation & Cover				
Is there vegetation/cover within 25' of the outlet?		No	Yes, partially	
If yes, select predominant type:		Grasses	Bushes	
Is there vegetation/cover within 25 - 50' of the outlet?		No	Yes, partially	
If yes, select predominant type:		Grasses	Bushes	
Land Use Within 100 feet of outlet:				
Predominant land use:	Forest	Prairie/Grassland	Agriculture	
Shrub/Steppe	Mixed: Human/Natural	Residential	Commercial	
Noise				
What does passing traffic sound like at the entrance to the structure?				
		Silent	Low Rumble	
Road Attributes				
	0'	0 - 6'	6 - 30'	Undetermined
Is there a guard rail or jersey wall above the structure?		No	Yes, structure only	
Notes:				
Outlet Side: Fencing/Walls				
Photo Number (route_mp_date_photo#)	1:	2:	3:	
Is there fencing associated with the outlet side of the structure?		Yes	No	

Select type of fencing to <i>right</i> when facing structure:				Curb (not including wingwalls)			
Chain Link		Wildlife Fence		Sediment Fence		4-Strand Wire	
If curb or wall, does it have a lip?			Yes		No		
What is the height of fencing/wall?		None	≤ 6"	> 6" - ≤2'	2' - 4'	4 - 6'	6 - 8'
What is the mesh size?		None	6x6"		6x6", graduating smaller to 2x3 at base		
Is it connected to the structure?		Yes		No - small gap (≤0.5')			
Does the fencing reach all the way to ground level without gaps?				Yes		No	
Is the fencing entrenched in the ground to prevent animals from digging under it?				Yes			
Is the ROW fencing the same as the fencing that is immediately adjacent to the structure?				Yes			
If no, what is the ROW fencing type:		Curb (not including wingwalls)					
Chain Link		Wildlife Fence		Sediment Fence		4-Strand Wire	
Minimum distance fence extends from structure:							
≤ 10'		10 – 50'	50 – 100'	>100'	~½ mile	1 mile	____ Miles
Select type of fencing to <i>left</i> when facing structure:				Curb (not including wingwalls)			
Chain Link		Wildlife Fence		Sediment Fence		4-Strand Wire	
If curb or wall, does it have a lip?			Yes		No		
What is the height of fencing/wall?		None	≤ 6"	> 6" - ≤2'	2' - 4'	4 - 6'	
What is the mesh size?		None	6x6"		6x6", graduating smaller to 2x3 at base		
Is it connected to the structure?		Yes		No - small gap (≤0.5')			
Does the fencing reach all the way to ground level without gaps?				Yes		No	
Is the fencing entrenched in the ground to prevent animals from digging under it?				Yes			
Is the ROW fencing the same as the fencing that is immediately adjacent to the structure?				Yes			
If no, what is the ROW fencing type:		Curb (not including wingwalls)					
Chain Link		Wildlife Fence		Sediment Fence		4-Strand Wire	
Minimum distance fence extends from structure:							
≤ 10'		10 – 101'	120 – 250'	¼ mile	½ mile	2 mile	____ miles
What is the general condition of the fencing?				Gaps and areas where fence is down			
Vegetation needs to be cleared from fence							
Is there an escape ramp(s) within a ½ mile of the structure in either direction?						No	Yes - 1

Is there a one-way gate(s) within a ½ mile of the structure in either direction?					No	Yes - 2
None	1	2-5	6-10	>10		
Notes:						
<u>General</u>						
Photo Number (route_mp_date_photo#)		1:	2:	3:		
Wildlife Use						
Are there signs of wildlife use in the structure such as tracks?			Tracks	Scat	Live Animal	None
If yes, describe						
Are there signs of wildlife within 30' of the entrances?			Tracks	Scat	Roadkill	
If yes, describe						
Human Use						
Is there apparent human activity in the structure?			Yes - Frequent/Daily		Yes - Occasional	
What type(s) of activity? (check all that apply):			Camping/Occupancy		Vehicle/ATV Use	
			Recreation	Dog	Night Use	
Daily human activity at both entrances			Daily human activity at one entrance			
Recreational use in a wild setting			Wild setting with infrequent human activity			
Notes:						

Species Movement Guild Rankings

A = This animal could make it though as is, or with small modifications
 C = With modest modifications this structure could be functional
 F = Can't be fixed with a retrofit

Comments:	A	C
Comments:	A	C
Comments:	A	C
Comments:	A	C
Comments:	A	C
Comments:	A	C

Appendix G

Priority WVC Sites in ITD Districts 5 and 6

Field Verified and Mitigation Recommendations

The Research team conducted site visits to ITD District 5 in Pocatello and District 6 in Rigby/Idaho Falls and generated recommendations for future actions to reduce WVCs for those sites. Below Table 24 presents an overview of each road segment and potential wildlife mitigation, and below the table are brief descriptions of potential future mitigation for those sites.

Table 24. ITD Districts 5 and 6 WVC Priority Road Segments Field Checked December 2, and 3, 2013, and Mitigation Recommendations

Road	Mileposts	Nearest Town/City or Local Area	District Ranking	Wildlife Issues Associated with That Stretch of Road	Brief Mitigation Recommendations by Dr. Cramer
ITD District 6					
US-20	325 - 328	Rigby - Thornton	Highest	Mule deer, white tailed deer, moose movements east & west, & along Snake River.	<i>Lorenzo Bridge MP 326:</i> Remove existing vegetation alongside, erect fencing to bridge, cattle guards at nearby interchanges. <i>MP 328.7 Bridge:</i> In 2016 project - install wildlife fencing to channel animals to bridge.
US-20	334.5	South Fork Teton River	Low-Medium		<i>MP 334.35 South Fork Teton River Bridge:</i> Extend future bridge to allow terrestrial wildlife passage. Capitalize on ITD land ownership in NE corner.
US-20	363 - 369	Ashton, Big Bend Ridge	Medium		<i>MP 363.63 Bridge:</i> Remove riprap boulders on both side of river. Install wildlife exclusion fencing.
US-20	372 - 374	Federal Hill	Medium		Initially: Variable message boards for motorists 1 month in fall, 1 month in spring, to warn of migration <i>MP 373 - 374</i> . Long Term: Overpass structure.
US-20	376 - 379	Swan Lake	Medium	Moose & other large herbivores use Swan Lake for water & food resources. Lake just to west of road. Wildlife use heaviest May through October.	Flat area makes crossing structures less feasible. Important grizzly bear breeding area to east. Re-work riprap under <i>MP 379.15 Osborne Bridge</i> to allow for some terrestrial passage. <i>Long Term:</i> Raise level of future bridge for terrestrial passage for moose, grizzly, etc.
US-20	381 - 382	Last Chance/ Henry's Fork	Highest	Moose, elk, grizzly bear, year round, different species move through different times.	Driver warning signs in these flat land wet lands. Plot WVC data to observe best times of year, & if the problem resides with moose, elk, or other species. This area needs special attention, as it is a high priority area.
US-20	383 - 384	Box Canyon	Medium		Problem will need to be addressed in nearby areas.
US-20	386 - 390	Ponds Lodge	Medium-Low		<i>MP 387.04 Buffalo River Bridge:</i> Retrofit by removing riprap.
US-20	391 - 394	Mack's Inn	Not Known		<i>MP 392.76 Henry's Fork Bridge:</i> In future, raise level of bridge to accommodate terrestrial passage.

Table 24 (cont.) ITD Districts 5 and 6 WVC Priority Road Segments Field Checked December 2, and 3, 2013, and Mitigation Recommendations

Road	Mileposts	Nearest Town/City or Local Area	District Ranking	Wildlife Issues Associated with That Stretch of Road	Brief Mitigation Recommendations by Dr. Cramer
US-20	398 - 401	TNC Flat Ranch/ Henrys Lake Outlet	Not ranked	Grizzly bear collar data may identify this area in future as a high priority.	Through future needs assessment, evaluate grizzly solutions. <i>MP 398.76 Henrys Fork Bridge:</i> Retrofit with removal of gates placed on bridge, remove riprap. In future, new bridge to be raised higher & made wider to accommodate grizzly and moose.
US-20 & SH-87	US-20 MP 402 - 404 SH-87 MP 1 - 2	US-20 & SH-87 Junction Island Park	Highest	Mule deer, elk, moose, pronghorn, & grizzly bear migrate out of Yellowstone National Park in colder months, to winter in Madison Valley to the west, & to occupy Madison range.	Driver warning system for this junction, on both roads, seasonal. District 6 is about to install a driver warning-wildlife detection system. <i>Future:</i> In 2019 transportation project, include overpass for multiple wildlife species either between <i>MP 402.8 - 403.3</i> , or near <i>MT-ID Stateline (MP 403.9 - 406.3)</i> for a collaborative wildlife mitigation project. Also, at junction of <i>US-20 and SH-87 (MP 402.27)</i> , on north side, under US-20, install underpass or the overpass at Howard Creek.
SH-87	1 - 6	Henry's Lake	Highest	Elk, pronghorn, mule deer use this area for winter habitat.	Land ownership is critical to keeping wildlife on east side of highway. Work with others to secure conservation easements for winter & spring habitat for elk, pronghorn, wolves, and other wildlife. <i>MP 1.1 Bridge:</i> Possible to retrofit for some species.
SH-31	13 - 16	Victor/Targhee National Forest	Medium	Mule deer migrate out of mountains into valley for winter. Mule deer move across road in warmer months. Grizzly bear use area to move in ecosystem.	May not be immediate (5 year) solutions. <i>Future:</i> When road is upgraded, look for underpass opportunities.

Table 24 (cont.) ITD Districts 5 and 6 WVC Priority Road Segments Field Checked December 2, and 3, 2013, and Mitigation Recommendations

Road	Mileposts	Nearest Town/City or Local Area	District Ranking	Wildlife Issues Associated with That Stretch of Road	Brief Mitigation Recommendations by Dr. Cramer
SH-31	10 - 13	Victor/Swan Valley	Highest	Mule Deer	<i>MP 12.8:</i> curve in road at creek could be the location of a future underpass. <i>Future:</i> straighten and widen road, place underpass. <i>MP 10.2 North Pine Creek Bridge</i> project in 2014 at West Pine Creek: new bridge being placed in 2014 should be elevated to allow approximately 10 feet height above creek, lengthened to include more of floodplain, all to allow terrestrial passage of large herbivores & grizzly bear. Add 1 mile of wildlife exclusion fencing in each direction.
SH-31	8 - 10	Victor	Medium	Mule Deer	<i>Future:</i> road upgrades, look for potential mitigation solutions.
District 5					
I-15	57.5 - 64	Inkom/Pocatello	Highest	Mule deer migrate down into the I-15 Corridor area which runs through Black Rock Canyon, mule deer winter range. Mule deer reside in area during winter.	<i>MP 63 Mink Creek Exit Ramps:</i> Monitor to evaluate how mule deer enter here, install double cattle guards; improve fence to close gap between fence & road. <i>MP 61.7 Black Rock Road Split Box Culvert:</i> Monitor to evaluate if mule deer are using this culvert, retrofit if necessary, low volume road, high potential for use. <i>MP 57.8 West Inkom Exit Bridge:</i> Move wildlife exclusion fencing to bridge abutments rather than near road; install double cattle guards rather than single guards on north & south bound ramps; replace eastern fencing with rail fencing; use this interchange as a major wildlife passage. <i>MP 57.1 Rapid Creek Bridge:</i> Behind City Hall, work with landowners about possibility of funneling mule deer through this natural stream area. <i>MP 56.5 East Inkom Exit 57:</i> re-route fencing to allow mule deer to move under bridge along side of highway on slope but not on pavement; <i>MP 55.6 Portneuf River Bridge:</i> Re-route wildlife fencing to channel mule deer under highway at this interchange. Needs a more in-depth field visit. <i>Future:</i> After several years of fencing, re-evaluate WVC hotspots to see if there is potential for a new structure made exclusively for wildlife. Structure made exclusively for wildlife.

District 6

Road, MP's Site Name: US-20 MP 325 - 328 Rigby to Thornton

WVC Challenges: Mule deer, white-tailed deer, and moose move east and west across US-20, especially along Snake River.

WVC Potential Solutions: Lorenzo Bridge MP 326 and Interchange MP 328.7

Approximate Bridge Dimensions: Height ~ 16 ft, Width/Span ~ 400 ft, Length ~ 100 ft.

Remove existing vegetation along both sides of river, north and south, to allow for terrestrial passage for wildlife and anglers.

Erect wildlife exclusion fencing to bridge, both sides of road, both directions.

Install Cattle Guards at nearby Menan-Lorenzo Interchanges on entrance and exit ramps to US 20, but leave main road 4200 East clear so wildlife can use road area to pass beneath US-20 bridge at this interchange. MP 328.7

Lorenzo Bridge: In the 2016 project add the installation of wildlife fencing to channel animals to bridge. See Figures 47 - 50.

Potential Costs: These cost estimates are just ball park estimates for the end of 2013.

Vegetation Removal: Less than \$10,000 to remove vegetation and promote terrestrial movement on both sides of river.

Wildlife Exclusion Fencing: Approximately \$300,000 per mile, which includes both sides of road (price based on Utah experience, along I-80, in 2009). Place ¼ mile to north, ¾ mile to the south, both sides of road.

Double Cattle Guards at US 20 Entrance and Exit Ramps: \$60,000 each, upwards of \$240,000. (Price estimates from discussions with MDT and UDOT environmental specialists, 2013).

Total Ball Park Cost for all Retrofits: \$350,000. Based on Dr. Cramer's experiences in Utah and Montana.



Figure 47. Lorenzo Bridge US-20 MP 326, from South Looking North



Figure 48. Lorenzo Bridge US-20 MP 326 Vegetation that Could Be Removed



Figure 49. Lorenzo Bridge As Seen from East Side of Rail Tracks



Figure 50. Menan Interchange at US-20 and 4200 East, MP 325.6 from the East

Road, MP's Site Name: US-20 MP 334.35 South Fork Teton River

WVC Challenges: White-Tailed Deer, Moose

WVC Potential Solutions: ITD owns land on Northeast corner of river-highway interchange. Could be extend future bridge to allow terrestrial wildlife passage. Capitalize on ITD land ownership in NE corner.

Potential Costs: When bridge is replaced, raising height several feet, extend bridge, ball park estimate, \$50,000 to \$500,000 additional costs, based on P. Cramer's experiences, in 2013.

Road, MP's Site Name: US-20 MP 363 - 369 Ashton and Big Bend Ridge

Approximate Bridge dimensions: Height > 20 ft, Width/Span ~ 200 ft, Length < 100 ft.

WVC Challenges: Wildlife move from east to west in fall, and back in spring. The ridgeline demarcates where mule deer and elk spend their seasonal time. Elk, mule deer, and moose are involved in WVC at this site.

WVC Potential Solutions: Mule deer, elk, moose migration area, east to west and southwest

MP 363.36 Bridge: Remove riprap boulders on flattest portion of riprap field, to allow for a pathway, as little as 3 feet wide, on both side of river. This would have to be approved by the engineer who stamped the plans.

Install wildlife exclusion fencing, minimum ½ mile in each direction, with more fencing to north where wildlife come off ridge. Also county park and ITD lands to east of bridge that could be capitalized on to create mitigation lands, conservation easement lands to protect connectivity under bridge.

Dump Ground Road-Sheep Falls Road ITD Project: May 2014 - October 2014 will occur in this stretch, with 3 miles of road stripped, soils stabilized, and drainage added. This is a missed opportunity to include a wildlife crossing in a road project that will have road torn up and made to drain better. ITD and IDFG should continue to look for future projects where additional wildlife crossings can be placed in this area. This should include the creation of a wildlife overpass structure between MP 367-368. See Figure 51.

Potential Costs:

Remove riprap in a 3 feet wide path, if approved by engineers < \$10,000.

Fencing: Approximately \$300,000 for 1 mile both sides of road, with more feet of fence to north. Based on P. Cramer experiences in Utah, along I-80, in 2009. Costs could be different with type of fence and year installed.

Cattle Guards on Road on North Side of River: 2 x ~ \$25,000 = ~ \$50,000. Guard estimates based on work in Utah with UDOT and double cattle guards and wildlife guards.

Overpass: \$1.8 – \$3 million. Overpass costs based on US 93 Overpasses built in Montana and Nevada in 2010-2013.



Figure 51. Ashton Bridge over Henry's Fork, View from East, US-20 MP 363.36
Riprap Should Be Removed Up-Slope to Allow Terrestrial Wildlife Passage and Angler Movement Below Bridge.

Road, MP's Site Name: US-20 MP 372 - 374 Federal Hill

WVC Challenges: Mule deer and elk migrate east to west in fall and back in spring, from summering grounds in Yellowstone National Park area to wintering areas on the Targhee National Forest to the west.

WVC Potential Solutions:

Initially: Variable message boards for motorists 1 month in fall, 1 month in spring, to warn of migration MP 373 - 374.

Long Term: Consider wildlife overpass.

Potential Costs:

Variable Message Board: Negligible

Overpass: \$1.8 – \$3 million (see overpass cost estimates basis above).

Road, MP's Site Name: US-20 MP 376 - 379 Swan Lake and Osborne Bridge

Approximate Bridge Dimensions: Height 3 - 12 ft, Width/Span ~ 180 ft, Length < 65 ft.

WVC Challenges: Moose and other large herbivores use Swan Lake for water and food resources. Lake is on the west side of the road. Wildlife use heaviest May through October.

WVC Potential Solutions: Flat area makes crossing structures less feasible. There is important grizzly bear breeding area to east.

Short-Term: Install variable message boards in seasons with most WVC;
Re-work riprap under MP 379.17 Osborne Bridge to allow for some terrestrial passage.

Long-Term: Raise level of future bridge for terrestrial passage for moose, grizzly, etc.
See Figures 52 and 53.

Potential Costs:

Variable Message Board: Negligible

Riprap removal along a 3 feet wide pathway on most flat area along width of bridge, if the engineers approve: < \$10,000, based on P. Cramer estimates.

Raise Level of Future Bridge, Lengthen Span of New Bridge: \$50,000 - \$500,000 additional.



Figure 52. Osborne Bridge, US-20 MP 379.15



Figure 53. Osborne Bridge, US-20 MP 379

Road, MP's Site Name: US-20 MP 381 - 382 Last Chance Henry's Fork

This is the highest WVC area and received the highest ranking in the prioritization process for this entire stretch of US- 20.

WVC Challenges: Moose, elk, grizzly bear, and year-round, different species move through different times.

WVC Potential Solutions:

Short-Term: Driver warning signs in these flat land wet ands. In order to best place message boards, signs, plot WVC data to observe best times of year, and if the problem resides with moose, elk, or other species. This area needs special attention, as it is a high priority area.

Long-Term: Evaluate use of driver warning system in conjunction with wildlife detection systems.

Potential Costs:

Variable Message Boards: Negligible.

Driver Warning System: ~ \$775,000, Based on P. Cramer's experience, known cost for AZDOT warning system.

Road, MP's Site Name: US-20 MP 383 - 384 Box Canyon

WVC Challenges: Mule deer, elk, and moose

WVC Potential Solutions: This area is known as an important crossing area for resident moose. Would have to include a crossing structure and fencing in the future. Problem will need to be addressed in nearby areas.

Road, MP's Site Name: US-20 MP 386 - 390, Ponds Lodge Bridge/Buffalo River Bridge MP 387.04

Bridge approximate dimensions: Height 10 ft, Width/span 50 ft, length thru ~30 ft.

WVC Challenges: Grizzly bear, moose, and elk.

WVC Potential Solutions:

Short-Term: Remove riprap and illegal gates and fences at bridge.

Long-Term: Bridge replacement should be higher, longer span to allow terrestrial passage for wildlife and anglers. See Figure 54.

Potential Costs:

Remove Riprap in a 3 ft Wide Path, If Approved by Engineers: < \$10,000 based on P. Cramer 2013 estimates.

Future Bridge Replacement: \$50,000 - \$500,000. Based on P. Cramer's estimates, very ball park estimate.



Figure 54. US-20 MP 387.04 Ponds Lodge/Henry's Fork Bridge

Road, MP's Site Name: US-20 MP 392 - 398 Mack's Inn, Henry's Fork Snake River Bridge MP 392.76

WVC Challenges: Grizzly bear, moose, and other wildlife. Nearby The Nature Conservancy's Flat Ranch is protected for conservation and is home to grizzly bear, future needs assessment may find this area as a priority for grizzly bear.

WVC Potential Solutions: MP 392.76 Henry's Fork Bridge: in future, raise level of bridge to accommodate terrestrial passage.

Potential Costs:

Remove riprap in a 3 feet wide path, if engineers approve, < \$10,000, ballpark estimate from P. Cramer.

New Bridge that is higher and greater span: \$50,000- \$500,000 additional, ballpark estimate from P. Cramer.

Road, MP's Site Name: US-20 398 - 401 The Nature Conservancy Flat Ranch/Henry's Lake Outlet, Bridge MP 398.76

Bridge dimensions: Approximately Height < 6 ft, width/span 30 ft, length 24 ft.

WVC Challenges: Grizzly bear collar data may identify this area in future as a high priority.

WVC Potential Solutions: Through future needs assessment, evaluate grizzly solutions.

MP 398.76 Henry's Fork Bridge: Retrofit with removal of any gates placed on bridge, remove rip rap. In future, new bridge should be raised higher and made wider to accommodate grizzly and moose. See Figure 55 and 56.

Potential Costs:

Riprap Removal If Approved by Engineers, or Gates: < \$10,000 based on P. Cramer estimates.

New Bridge that is higher and greater span: \$50,000 - \$500,000 additional, ballpark estimate from P. Cramer



Figure 55. US-20 MP 398.67 Henrys Lake Outlet Bridge



Figure 56. US-20 MP 398.67 Henrys Lake Outlet Bridge

Road, MP's Site Name: US-20/US-87 Junction, US-20 MP 402 - 404, US-87 MP 1 - 2 Island Park

WVC Challenges: Mule deer, elk, moose, pronghorn, and grizzly bear migrate/move out of Yellowstone National Park in colder months, to winter in Madison Valley to the west, and to occupy Madison range.

WVC Potential Solutions:

Short-Term: Driver warning system for this junction, on both roads, seasonal. District 6 will install a driver warning-wildlife detection system.

Long-Term: In Future: there is a 2019 transportation project. Include overpass for multiple wildlife species either between MP 402.8 - 403.3, or near MT-ID Stateline from 403.9 - 406.3 for a collaborative Idaho-Montana wildlife mitigation project. Also, at junction of US-20 and SH-87, on north side, under US-20, install underpass or the overpass at Howard Creek.

Immediate: Future Camera - driver warning systems should be evaluated for efficacy in reducing WVC, and used to make future recommendations. Important wildlife monitoring with camera traps by Tim Cramer of ITD District 6 found multiple species of large herbivores using the right way to access the road in this area, including elk, moose, mule deer, and pronghorn antelope (see Figures 57 - 61.)

Potential Costs:

Driver Warning System: \$20,000 - 775,000, based on P. Cramer estimate, based on AZDOT system, in 2013.

Wildlife Overpass: \$2 - 3 million, based on P. Cramer estimates, based on US-93 overpasses built in MT, and NV in 2010-2013.

Wildlife Underpass: \$775,000 - 1.5 million, P. Cramer ball park estimate, based on national costs in 2013.



Figure 57. Elk Cow Leads Newborn Calf to Edge of US-20, Near Island Park, Idaho
Photo Courtesy of Tim Cramer, ITD



Figure 58. Pronghorn Antelope Enter Right-of-Way, Headed Toward Road Surface on US-20, Near Island Park, Idaho
Photo Courtesy of Tim Cramer, ITD



Figure 59. Mule Deer Buck Enters Right-of-Way and Heads Toward Road Surface on US-20, Island Park, Idaho
Photo Courtesy of Tim Cramer, ITD

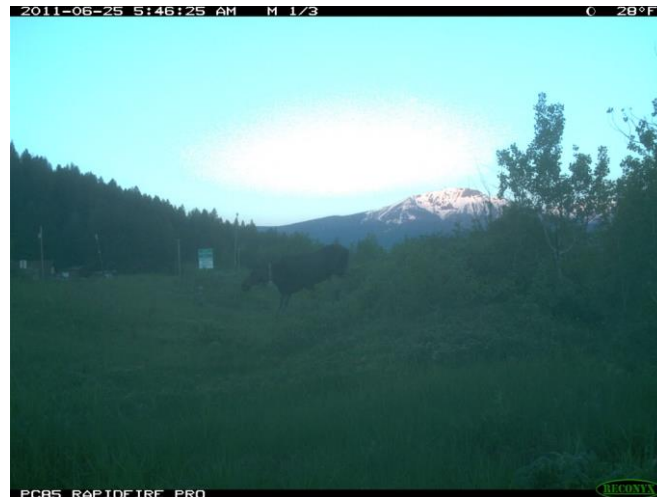


Figure 60. Collared Moose Enters US-20 Right-of-Way, Toward Road Surface near Island Park, Idaho
Photo Courtesy of Tim Cramer, ITD



Figure 61. Wolf Departs US-20 Road Surface and Enters Right-of-Way near Island Park, Idaho
Photo Courtesy of Tim Cramer, ITD

Road, MP's Site Name: SH-87 MP 1 - 6 Henry's Lake

WVC Challenges: Elk, pronghorn, mule deer use this area for winter habitat. Wolves follow the prey species and are present in colder months.

WVC Potential Solutions: Land ownership is critical to keeping wildlife on east side of highway. ITD and IDFG need to work with others to secure conservation easements for winter and spring habitat for elk, pronghorn, wolves, and other wildlife. MP 1.1 Bridge: possible to retrofit for some species. See Figure 62.

Potential Costs: Partners would bear the heavier costs with conservation easements and land purchases.

New Bridge: When replaced, MP 1.1 bridge may cost \$50,000-\$750,000 more than straight replacement, ballpark estimates by P. Cramer.



Figure 62. SH-87 Approximately MP 1 through MP 2, East Side of Highway
Madison Mountain Range in Background

Road, MP's Site Name: SH-31 MP 8 - 16 Victor and Targhee National Forest, West Pine Creek Culvert and Future Bridge MP 10.2

WVC Challenges: Mule deer migrate out of mountains into valley for winter. Mule deer move across road in warmer months. Grizzly bear use area to move in ecosystem.

WVC Potential Solutions:

Short-Term: There may not be immediate (5 year) solutions.

Long-Term Future: When road is upgraded, look for underpass opportunities. MP 12.8 curve in road at creek could be the location of a future underpass.

Future: Straighten and widen road, place underpass at MP 10.2 North Pine Creek Bridge. West Pine Creek culvert will be placed in a project in 2014: this new bridge should be elevated to allow approximately 10 feet (3 meters) height above creek, lengthened in span to include more of floodplain, all to allow terrestrial passage of large herbivores and grizzly bear. Add 1 mile (1.6 km) of wildlife exclusion fencing in each direction. In future road upgrades, look for potential mitigation solutions. See Figure 63.



Figure 63. SH-31 MP 10.2 North Pine Creek Culvert, 2013

District 5

Road, MP's Site Name: I-15 MP 57.5 - 64, Inkom

WVC Challenges:

Mule deer migrate down into the I-15 Corridor area which runs through Black Rock Canyon, mule deer winter range. Mule deer reside in area during winter.

WVC Potential Solutions:

MP 55.6 Portneuf River Bridge: Re-route wildlife fencing to channel mule deer under highway at this interchange. Land use in the area that allows the area to remain more natural than developed would encourage mule deer use. There is livestock present near bridge and few homes or development.

MP 56.5 East Inkom Exit 57 and Ramps Have Bridges Below I-15: Re-route fencing to allow mule deer to move under bridge along side of highway; fencing could encourage mule deer use up and down slope to east without animals on road. See Figure 64.

MP 57.1 Rapid Creek Bridge: Behind City Hall, work with landowners to possibly funnel mule deer through this natural stream area. See Figure 65.

MP 57.3: Chain link fence on west of I-15 is not high enough to deter mule deer access, replace or add additional fencing to top. See Figure 66.

MP 57.8 West Inkom Exit Bridge: Move wildlife exclusion fencing to bridge abutments rather than near road; install double cattle guards rather than single guards on north and south bound ramps; replace eastern fencing with rail fencing; use this interchange as a major

wildlife passage. Existing trees and bushes are important cover to encourage mule deer and other prey species use. See Figures 66 - 70.

MP 61.7: Black Rock Road Split Box Culvert: Monitor to evaluate if mule deer are using this culvert, retrofit if necessary, low volume road, high potential for use, Figure 71.

MP 60 – 62: Add more escape ramps.

MP 63: Add cattle guard to single cattle guards to create double cattle guards at west entrances and exits to I-15, Figure 72.

MP 64: Box culvert near Pocatello's Century High School could be a potential mule deer passage. Needs a more in depth field visit, see Figure 73.

Overall Future: After several years of fencing, re-evaluate WVC hotspots to see if there is potential for a new structure made exclusively for wildlife.

Potential Costs - All Estimates by P. Cramer, 2013, Based on Known Costs of Similar Actions in Utah and Montana:

Fence Removal: Less than \$5,000.

Additional Escape Ramps: ~ \$10,000.

Additional Fencing at MP 56.6: ~ \$2,000-\$5,000.

Double Cattle Guards at MP 63: ~\$30,000 to add guards to existing guards.

Monitoring MP 57.8 Re-Route of Fence Under Bridge, MP 64 Culvert: \$ 2,500-7,000.



Figure 64. I-15 MP 56.5, Exit 57 Bridge Interchange
Mule Deer Winter on Hills to East in the Background



Figure 65. I-15 MP 57.1 Rapid Creek Bridge
Natural Vegetation Would Encourage Wildlife Use



Figure 66. I-15 MP 57.3 West Side of 6 Feet High Chain Link Fence That May Allow Mule Deer Access to I-15



Figure 67. I-15 MP 57.8 West Inkom Exit Bridge.
Fencing comes down slope and should be moved up to bridge abutments to allow wildlife movement along slopes, under I-15



Figure 68. I-15 MP 57.8 West Inkom Exit, West Side
Fencing That Should Be Moved Up Slope



Figure 69. I-15 MP 57.8 West Inkom Exit, East Side of Bridge, ITD and IDFG Meet To Discuss Action Options



Figure 70. I-15 MP 57.8 West Inkom Exit, East Side



Figure 71. I-15 MP 61.7 Black Rock Road Split Box Culvert



Figure 72. I-15 MP 63 Mink Creek Interchange At Ramp, Single Cattle Guard



Figure 73. I-75 MP 64 Box Culvert on Local Road Just North of Century High School, Pocatello

Appendix H

Existing Wildlife Crossing Structures and Other Treatments in Idaho

Wildlife Crossings in Idaho as of November 2013

Primary investigator on the research project, Dr. Cramer, and Project Manager Caleb Lakey queried ITD and IDFG personnel for information on wildlife crossings and other mitigation for wildlife across Idaho to create the first comprehensive database of Idaho's efforts to mitigate transportation corridors for wildlife (Table 25). Mitigation is organized by IDFG regions and ITD districts. UTM coordinates may not all be accurate.

Table 25. Wildlife Crossings and Wildlife Mitigation in Idaho as of November, 2013

Crossing Name	Road	MP	UTM/GPS	UTM/GPS	Type	Height	Width/Span	Length	Target Species	Year Installed
IDFG Region 1 Panhandle / ITD District 1 Coeur d'Alene										
US-95 - Silverwood Bridge	US-95		47d52'51.11"	116d43'45.59"	Bridge	4 m	7 m	54 m	Deer, Elk, Moose	2013
US-95 Silverwood Fencing Length								14,354 ft	Deer, Elk, Moose	2013
US-95 Copeland Concrete Box Culvert	US-95		48d53'15.44"	116d20'48.61"	Culvert	4 m	7 m	40 m	Deer, Elk, Moose	2005
US-95 Copeland Concrete Box Culvert	US-95		48d53'37.39"	116d21'08.76"	Culvert	4 m	7 m	42 m	Deer, Elk, Moose	2005
US-95 Copeland Concrete Box Culvert	US-95		48d54'14.43"	116d20'55.32"	Culvert	4 m	7 m	54 m	Deer, Elk, Moose	2005
US-95 Copeland Fencing Length								~8,000 ft		2005
IDFG Region 2 Clearwater Lewiston / ITD District 2 Lewiston										
North of Moscow Wildlife Warning System	US-95	350 - 351			Break the Beam Warning System	n/a	n/a	n/a	Deer	2009 - 2010

Table 25 (cont.) Wildlife Crossings and Wildlife Mitigation in Idaho as of November, 2013

Potlatch River Tributary near Lewiston - Aquatic Culvert, Corrugated Metal Pipe with Weirs	SH-3				Culvert		15 ft	160 ft	Anadromous Fish, Steelhead, Salmon	2001
US-12, Wendover Creek - Warm Springs to Montana State Line - Aquatic Culverts Corrugated Metal Pipes 5 to 6 ft Baffled	US-12				Culvert	~6 ft	~6 ft	100 ft	Anadromous Fish, Steelhead, Salmon	2002
Riggins, Idaho County Trail Creek Aquatic Culvert Bottomless Metal Arch	US-95				Culvert	6 ft	6 ft	60 - 70 ft	Steelhead	2002
IDFG Region 3 Southwest Nampa / ITD District 3 Boise										
SH-21 Wildlife Bridge	SH-21	18.2	43,36.117	115,59.162	Bridge	4.88 m	21.03 m (9.144 m Width for 16 ft High Passage)	10.36 m	Mule Deer, Elk	Nov, 2010
SH-21 Fencing length								9,300 (as of 2013)		2010 /2011
SH 21 Aquatic Organism Passage	SH 21	82.7	44,06.267	115,27.226	Bridge	7.92 m	37.19 m	10.97 m	Fish	2011 & 2012
IDFG Region 4 Magic Valley Jerome / ITD District 4 Shoshone										
Ketchum - Driver Warning System Not an ITD Project, but Local County	SH-75				Driver Warning System				Mule Deer, Elk	2010?
North of Hailey - Reduced Speed Zones for Wildlife, <i>See Article in Appendix C</i>	SH-75								Mule Deer, Elk	2013
SH-75 near Hailey, East Fork of Wood River, near Greenhorn Gulch – Bridge Extension	SH-75	122.2	43,35'50.87"	114,20'47.86"	Ledge Under Bridge of Rock / Gravel	1.5 - 2m	1m path, each side of river	18m	Potential Riparian migration corridor for Canada lynx	2002

Table 25 (cont.) Wildlife Crossings and Wildlife Mitigation in Idaho as of November, 2013

Crossing Name	Road	MP	UTM/GPS	UTM/GPS	Type	Height	Width/Span	Length	Target Species	Year Installed
I-84 Sublet Mule Deer Herd - Deer Fence Keeping Off Highway	I-84								Mule Deer, Elk	1968 Removed 2012
IDFG Region 5 Pocatello / ITD District 5 Pocatello										
Fish Creek Bridge 1	US-30		44,44.05575	-112.72703	Bridge	3.61m, 4.26m	22.65m	16.6m	Mule Deer	1978
Fish Creek Bridge 2	US-30		45,43.06450	-113.22235	Bridge	3.33m, 4.09m	22.65m	16.6m	Mule Deer	1978
Fish Creek Bridge 3	US-30		46,43.13473	-113.32444	Bridge	5.99m, 3.11m	22.57m	20.55m	Mule Deer	1978
Fish Creek Fencing Length										1978
Portneuf River Bridge 1, previously a culvert, see Appendix for diagrams	US-30	364.2	44,44.05575	-112.72703						2010/ 2011
Portneuf River Bridge 2, previously a culvert	US-30	364.6	45,43.06450	-113.22235						2010/ 2011
Topaz, was a bridge already & animals didn't use it then & still don't because of RR & canal & steep rock slopes	US-30	365.3	46,43.13473	-113.32444						2010/ 2011
IDFG Region 6 Upper Snake Idaho Falls / ITD District 6 Rigby										
Targhee Creek Bridge	SH-87				Bridge				Yellowstone Cutthroat Trout	2005
Howard Creek Bridge	SH-87				Bridge				Yellowstone Cutthroat Trout	2005
Garden Creek Culvert	US-26				Culvert				Yellowstone Cutthroat Trout	2005

The wildlife mitigation actions and crossing structures in Table 25, above that had correct UTM coordinates (GPS) were plotted in Figure 74 below. On SH-75 near Ketchum, there have been driver warning systems and wildlife slower speed zones, but no actual structures. Note, future research and dialogue must be maintained between ITD District and IDFG Regional personnel regarding crossings. This may help elucidate why wildlife crossing structures are sometimes in WVC priority road segments, meaning there are still WVC problems. This may be due to the fact that the crossings are near a WVC problem area, but are not in the center of that area. Often fencing to wildlife crossing structures ends and there is a WVC end of fence problem. It should be noted that a single bridge in an area where mule deer, elk, and moose move over the road in a sheet flow pattern may not be adequate mitigation for the wildlife movement phenomenon happening on the ground.

Idaho Highway Prioritization and Current Crossings

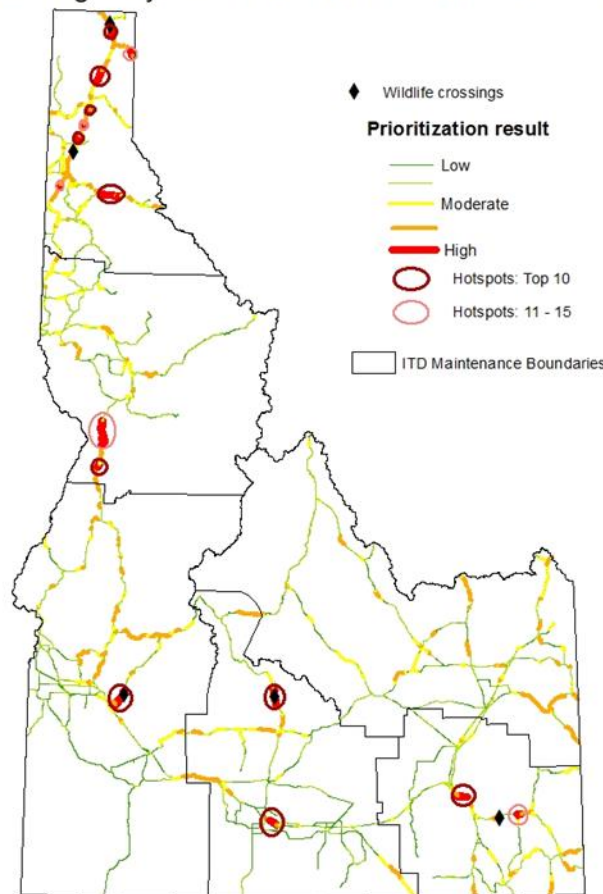


Figure 74. Wildlife Crossing Structures in Idaho as of December 2013
Figure Depicts Only Those Structures for Which UTM Coordinates Were Obtained as of November 2013

District 1



Figure 75. US-95 Copeland North Wildlife Crossing Culvert

Photo courtesy of P. Cramer



Figure 76. US-95 Copeland South Wildlife Crossing Culvert

Photo courtesy of P. Cramer



Figure 77. US-95 Copeland South Wildlife Crossing Culvert West Entrance
Photo courtesy of P. Cramer



Figure 78. Cow Elk Photographed in US-95 Copeland Culvert
Photo courtesy of W. Wakkinen, IDFG

District 3



**Figure 79. SH-21 MP 18.2 Wildlife Crossing Bridge near Boise, Idaho
Also Known As the Lucky Peak Wildlife Underpass**

Photo courtesy of S. Rudel, ITD

Note: the 34 ft length measurement under the bridge is the length in the above table



Figure 80. Elk Approaching and Then Using the SH-21 Wildlife Crossing Bridge

Photo courtesy of S. Rudel, ITD



Figure 81. SH-21 Five Mile Creek (Near Lowman, ID) Prior to Aquatic Organism Passage Project: Barrier to Fish and Wildlife
Photo Courtesy of S. Rudel, ITD



Figure 82. SH-21 Five Mile Creek (Near Lowman) After Aquatic Organism Passage Project: The New Structure Allows for the Passage of Both Fish and Wildlife
Photo Courtesy of S. Rudel, ITD

District 4



Figure 83. SH-75 Bridge with Wider Bank Width than Previous Bridge, to Accommodate Terrestrial Wildlife Passage, such as Lynx

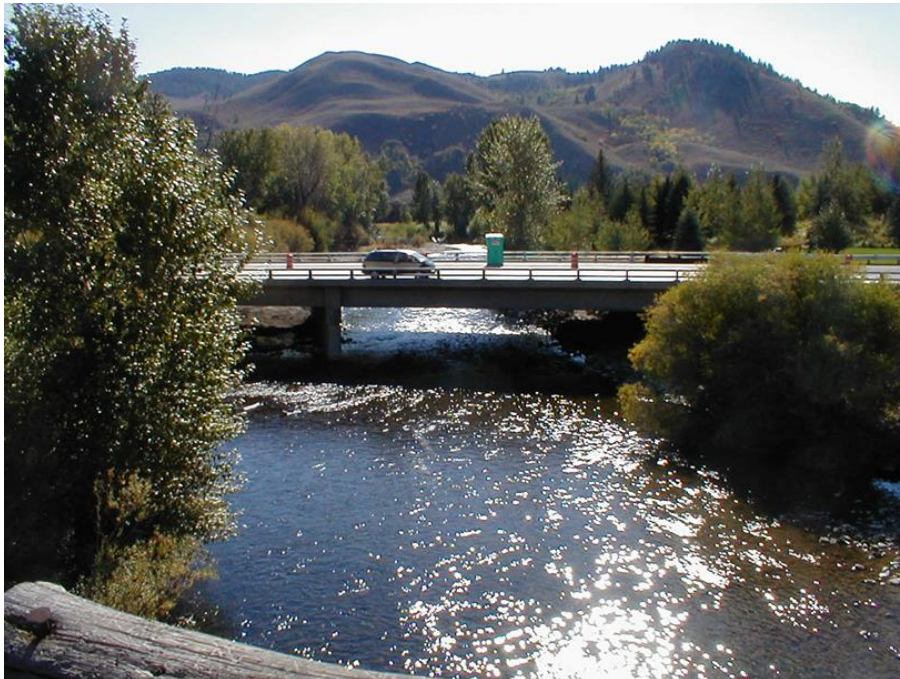


Figure 84. SH-75 Bridge from Above

District 5



Figure 85. US-30 Fish Creek Lower Wildlife Crossing Bridge, East of Lava Hot Springs, ID
Photo Courtesy of C. Class, IDFG



Figure 86. US-30 Fish Creek Middle Wildlife Crossing Bridge, East of Lava Hot Springs, ID
Photo Courtesy of C. Class, IDFG

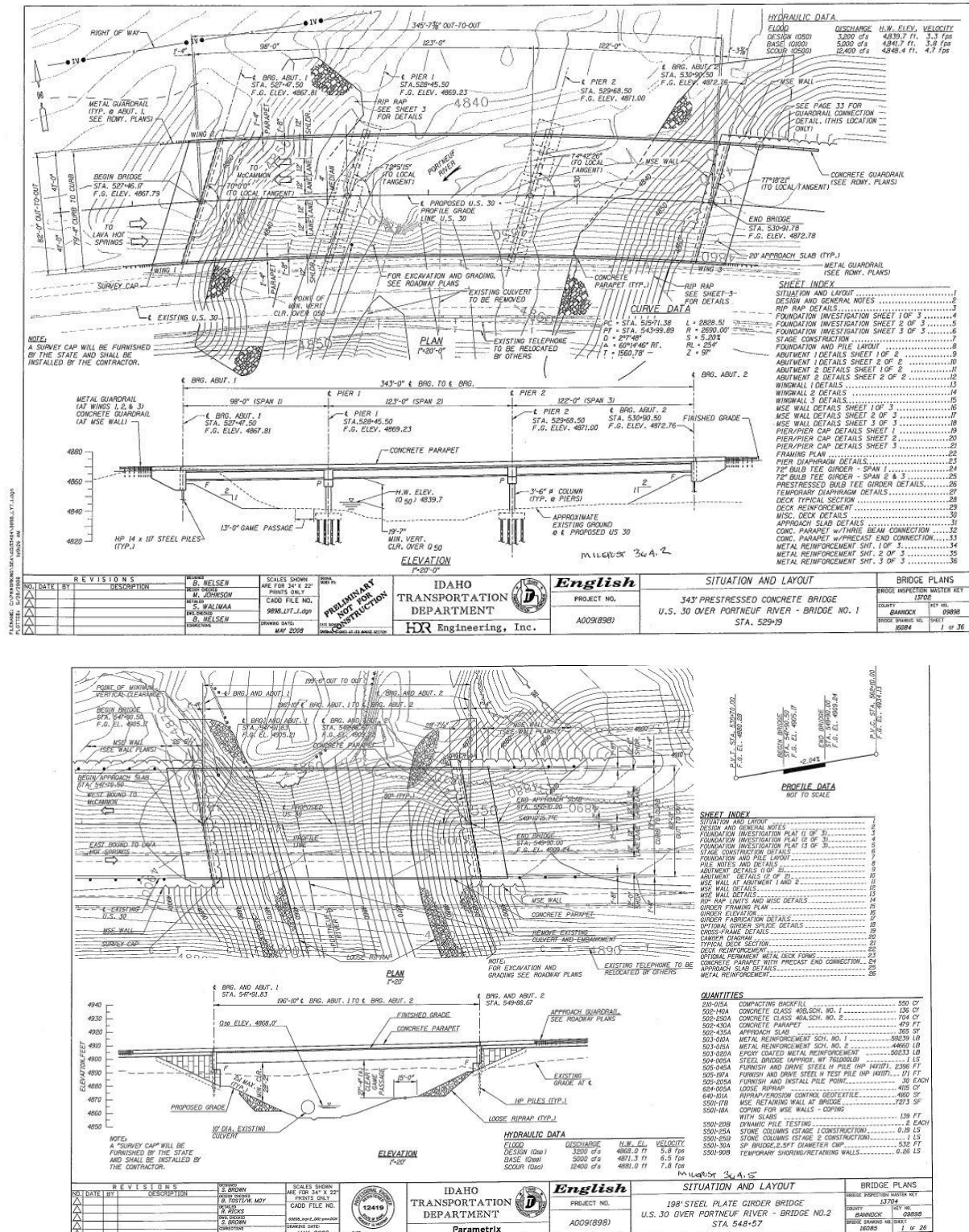


Figure 87. US-30 Fish Creek Upper Wildlife Crossing Bridge East of Lava Hot Springs, ID
Photo Courtesy of C. Class, IDFG

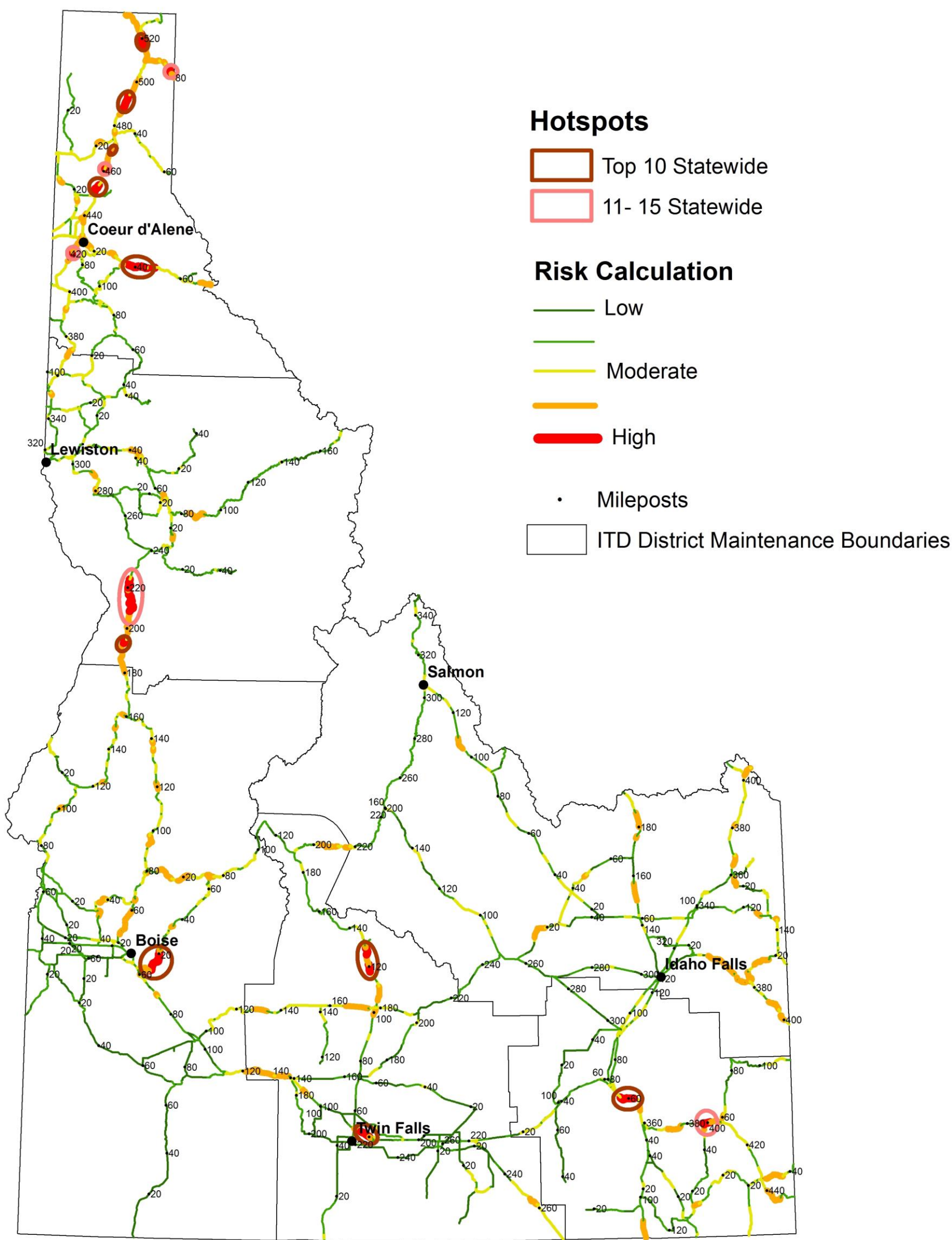


Figure 88. Mule Deer Photographed Using One of the Fish Creek Wildlife Crossing Bridges
Photo Courtesy of C. Class, IDFG

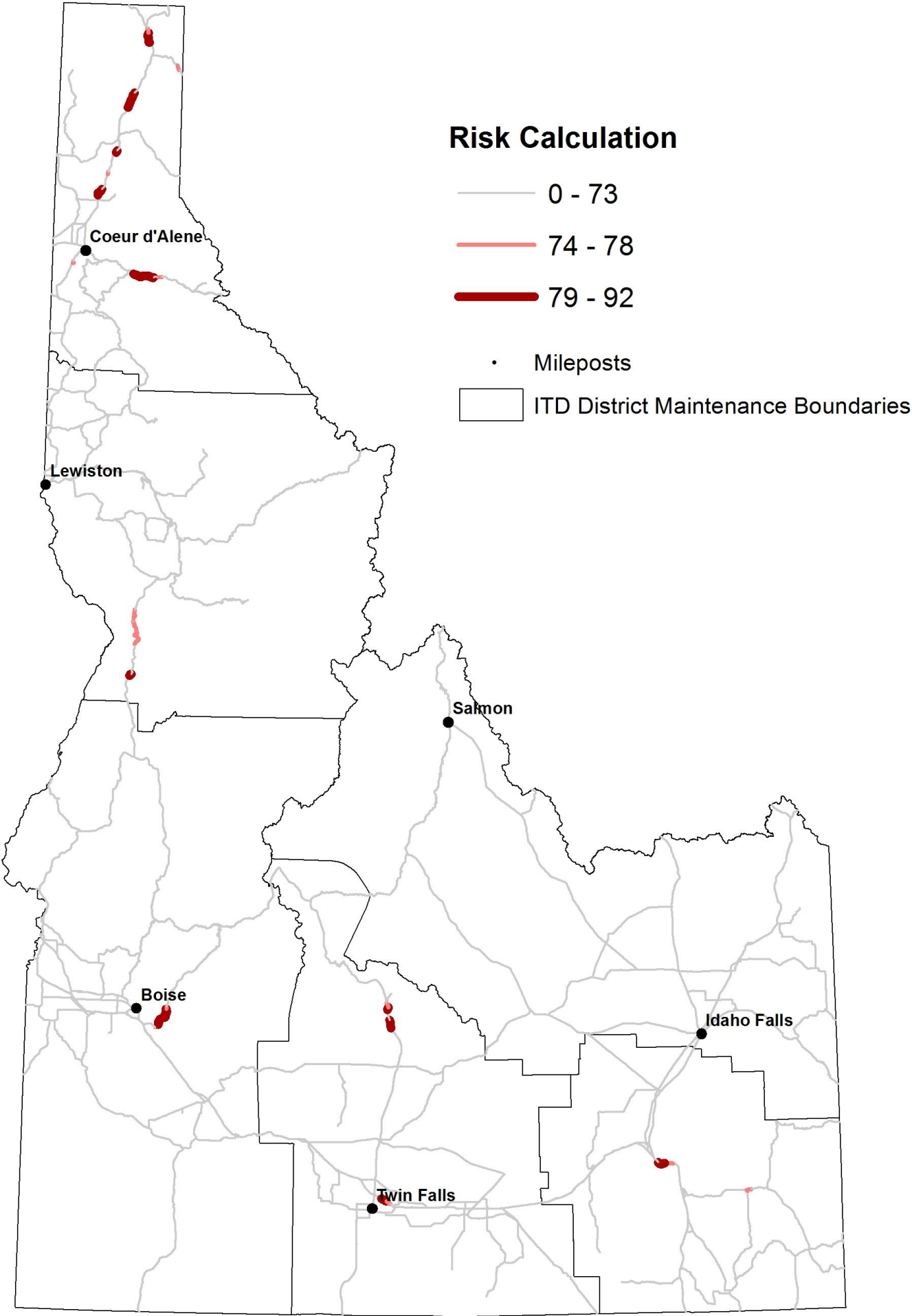
Portneuf Bridge Plans



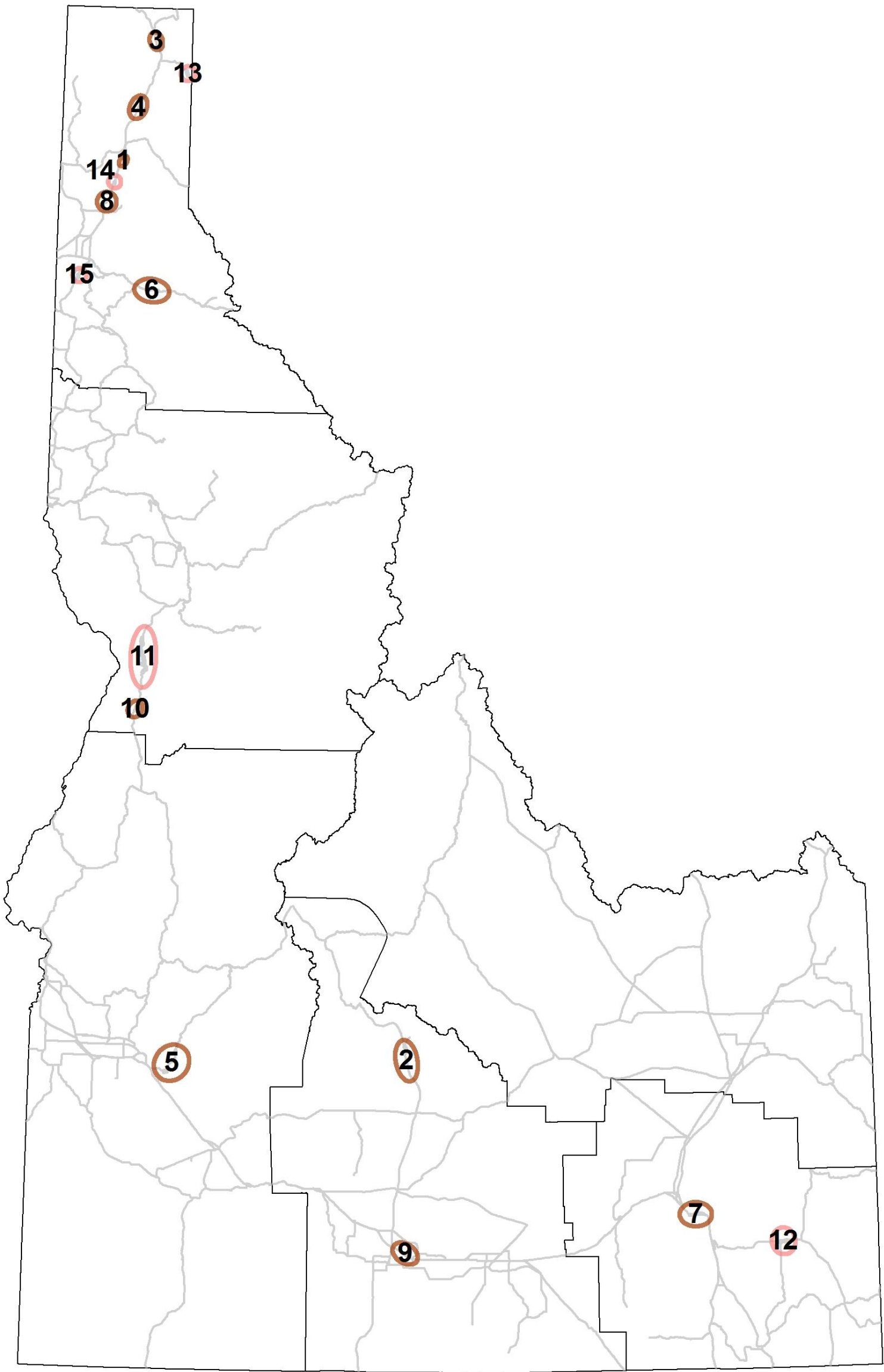
Appendix I
Maps of Wildlife-Vehicle Collision Priority Road
Segments Statewide and By ITD Districts



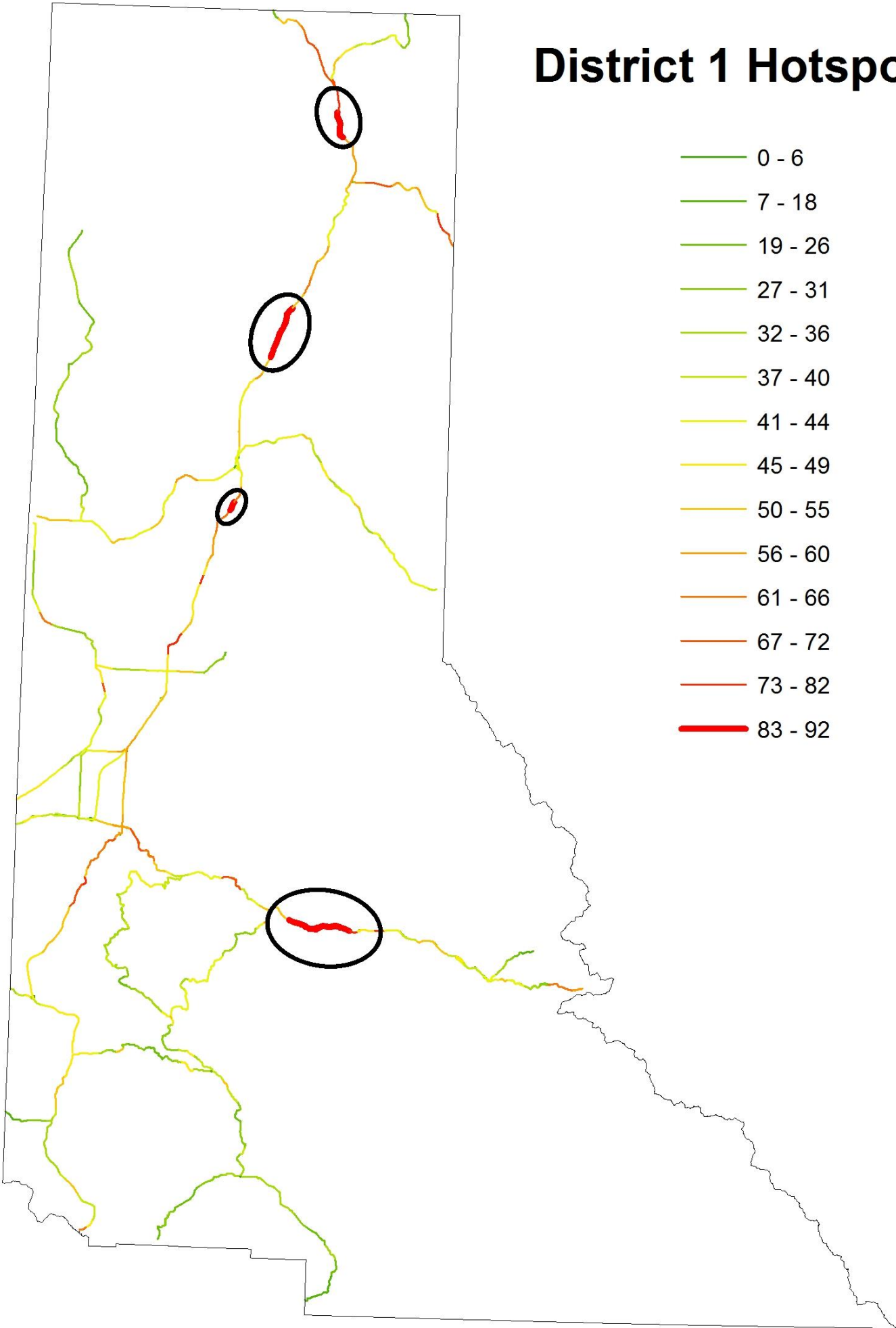
**Idaho WVC Priority Sites for Mitigation
Action with GIS Ranking Scores, Jan. 1, 2014**



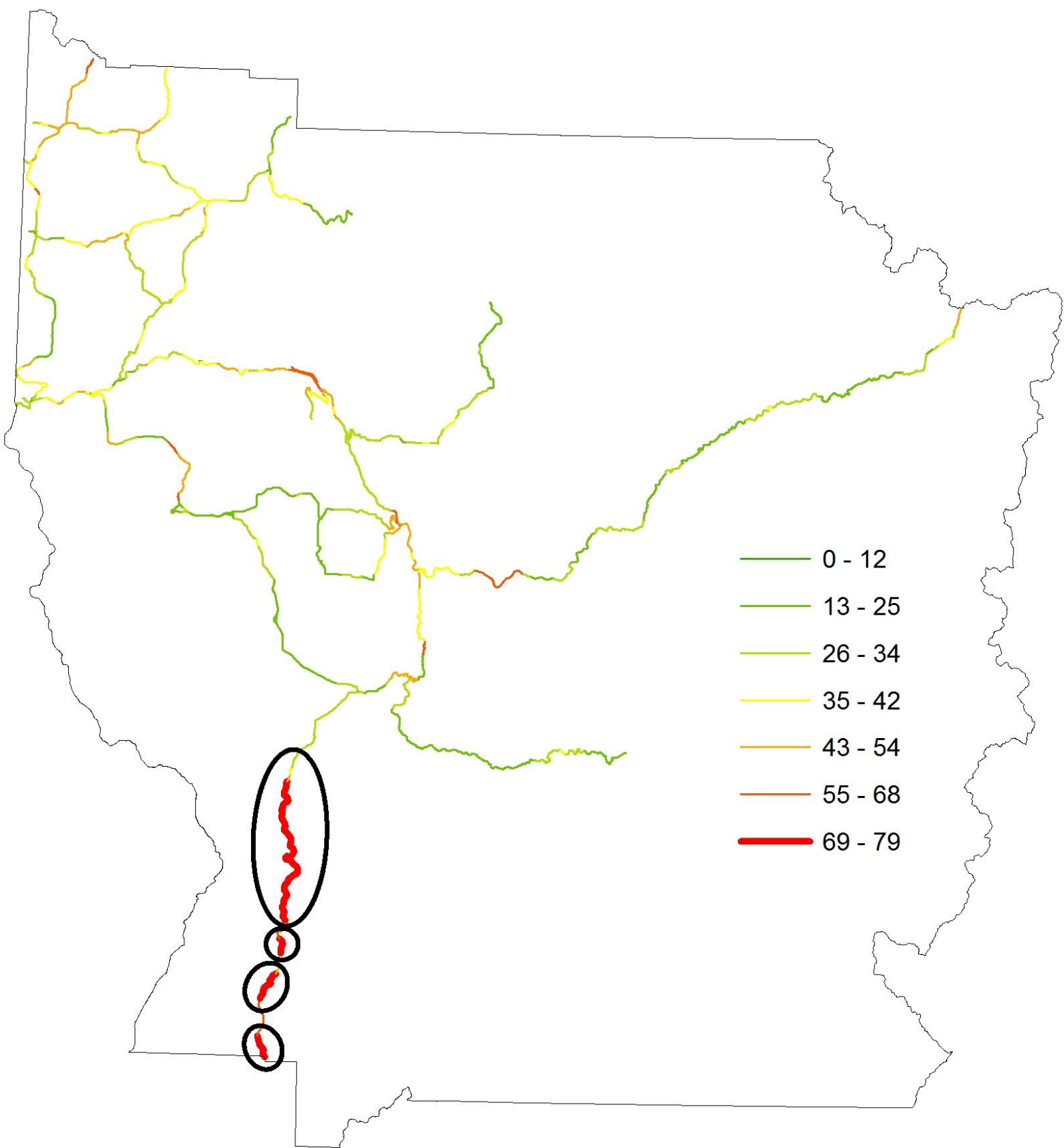
Idaho Top 10 (in Red) and Top 11-15 (in Pink) Wildlife-Vehicle Collision Priority Road Segments Based on GIS Data, January 1, 2014



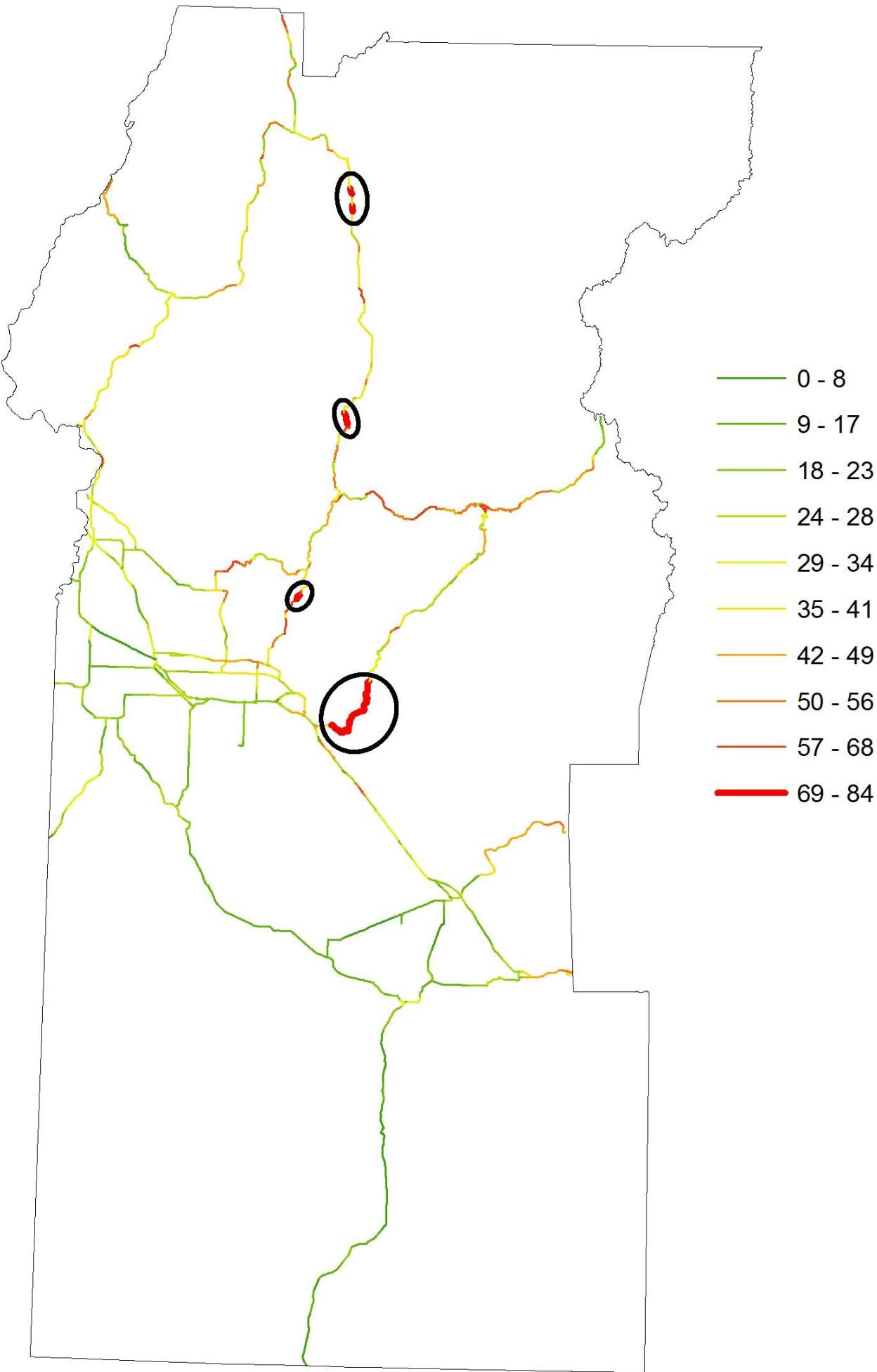
**Top 15 Wildlife-Vehicle Collision Priority Areas in Idaho
with Ranking, Based on GIS Data, January 1, 2014**



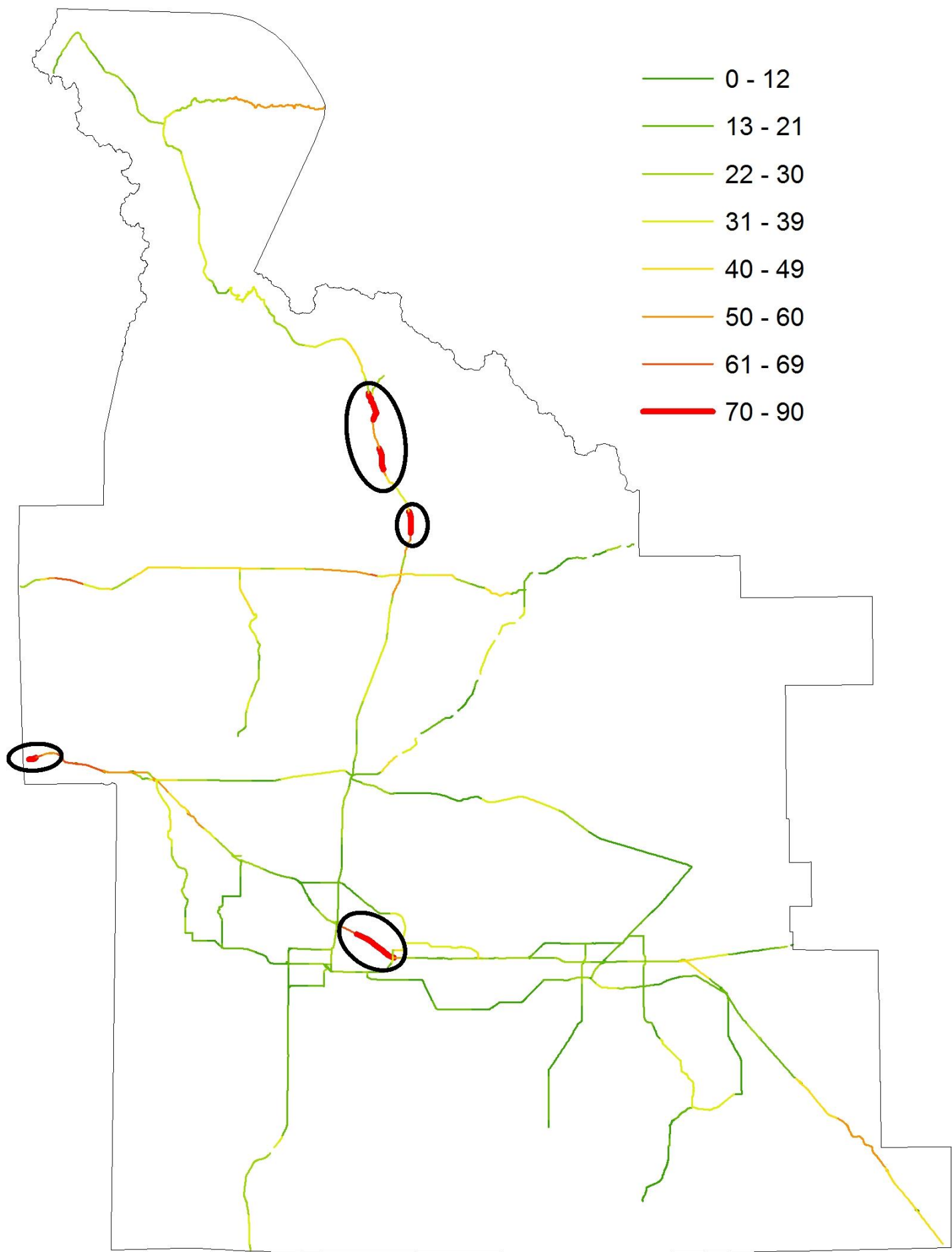
District 2 Hotspots



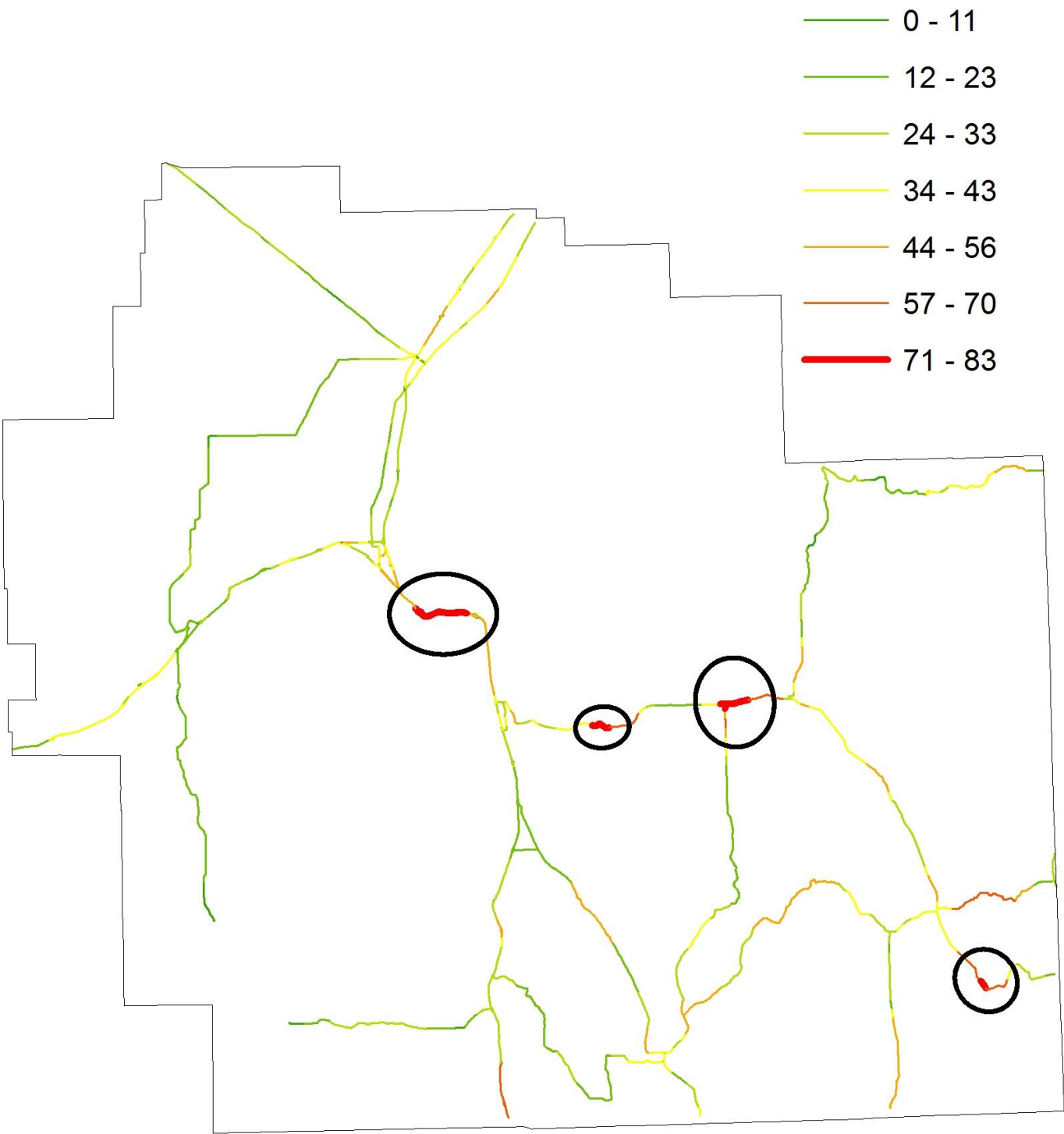
District 3 Hotspots



District 4 Hotspots



District 5 Hotspots



District 6 Hotspots

