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A Framework for Optimizing Moose-Vehicle Collision Mitigation Measures in Teton County

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Submitted: September 2013

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Background and Rationale

Introduction

Collisions between vehicles and large wild mammals pose a serious threat both to human safety and to wildlife populations. Wildlife-vehicle collisions involving large ungulates, such as deer (*Odocoileus* spp.), moose (*Alces alces*), or elk (*Cervus elaphus*), are usually fatal to the animal and often result in significant damage to the vehicle and injury to its occupants. An estimated 1-2 million wildlife-vehicle collisions (WVCs) occur annually in the United States—incurring direct costs estimated at $3.39 billion—and these numbers continue to climb as road networks expand and traffic volumes increase (Huisjer et al., 2008a). In Wyoming, where wild ungulates are abundant, WVCs are relatively common; in 2012, 2,487 WVCs were reported in the state, accounting for 18% of all reported collisions.

Collisions between vehicles and moose are of particular concern because they are much more likely to result in human fatalities than collisions with smaller ungulates such as deer. For example, in a study in Maine, moose accounted for only 15.1% of all WVCs but made up 82% of the WVCs that were fatal to humans (Huisjer et al., 2009). The large body size and tall stature of moose makes it highly likely that a moose-vehicle collision will result in serious or fatal injury to the driver and passengers (Pynn and Pynn, 2004). The average moose-vehicle collision is estimated to cost $30,760, largely because of injury and fatality costs (Huisjer et al., 2009). In addition to these road safety concerns, moose-vehicle collisions are often a great concern to the public because of the relative scarcity of moose (e.g. compared to deer), the fact that their populations are declining in some areas (e.g. most of Wyoming's Shiras moose populations), and because this species is charismatic and iconic to many people.

Based on our prior work, we have identified that the two biggest centers of moose-vehicle collision in Wyoming are located in Teton County (Figures 1-2). These collision "hotspots" are situated on HWY 390 between Wilson and Teton Village and on HWY 22 on the west side of Teton Pass. Between 1990 and 2012, there have been 353 reported moose-vehicle collisions in Teton County (excluding Grand Teton National Park)—averaging 16.5 per year. Moose collisions peak in December, January and February, when they average about 2 per month (Figure 3). These collisions receive a great deal of local attention and concern. Various mitigation efforts have been made, including reduced night-time speed limits, temporary warning signs with customized messages, and roadside brush clearing. Although there are some indications that these efforts have reduced the rate of moose-vehicle collisions, the evidence is not yet conclusive.

Currently, the Wyoming Department of Transportation (WYDOT) is considering a suite of possible modifications to both HWY 390 and HWY 22 to accommodate the swelling volumes of traffic using these roads. Measures under consideration include: increasing the number of

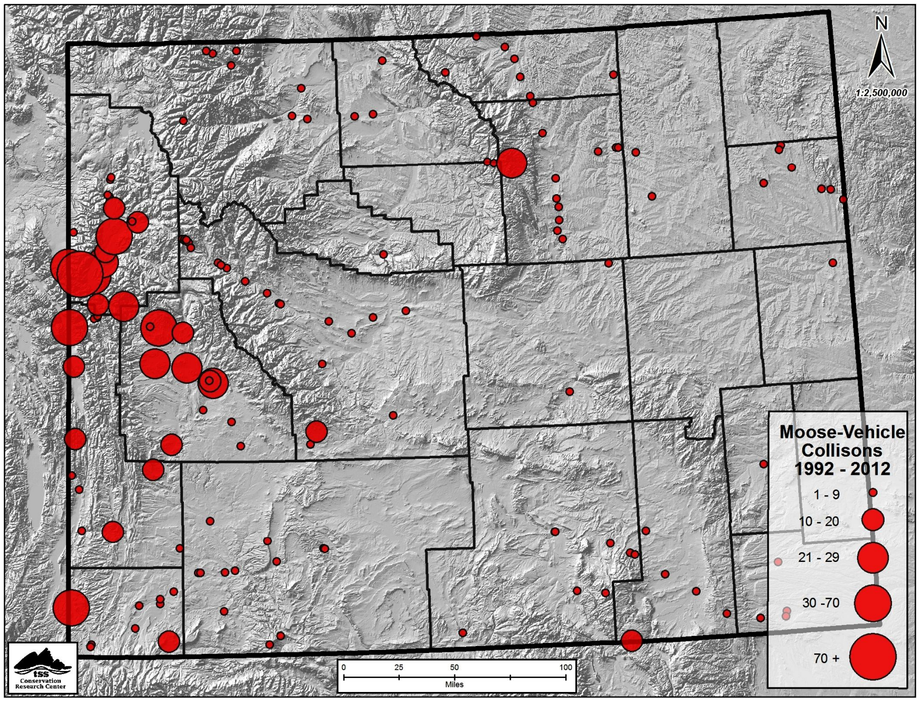

Figure 1: Total number of moose-vehicle collisions by mile of highway for the state of Wyoming between 1992 and 2012. Data were obtained from WYDOT's WVC and Carcass databases. We removed duplicate records, referenced all collisions to the nearest mile marker, and converted data to a geo-database to facilitate geo-spatial analysis and data visualization.

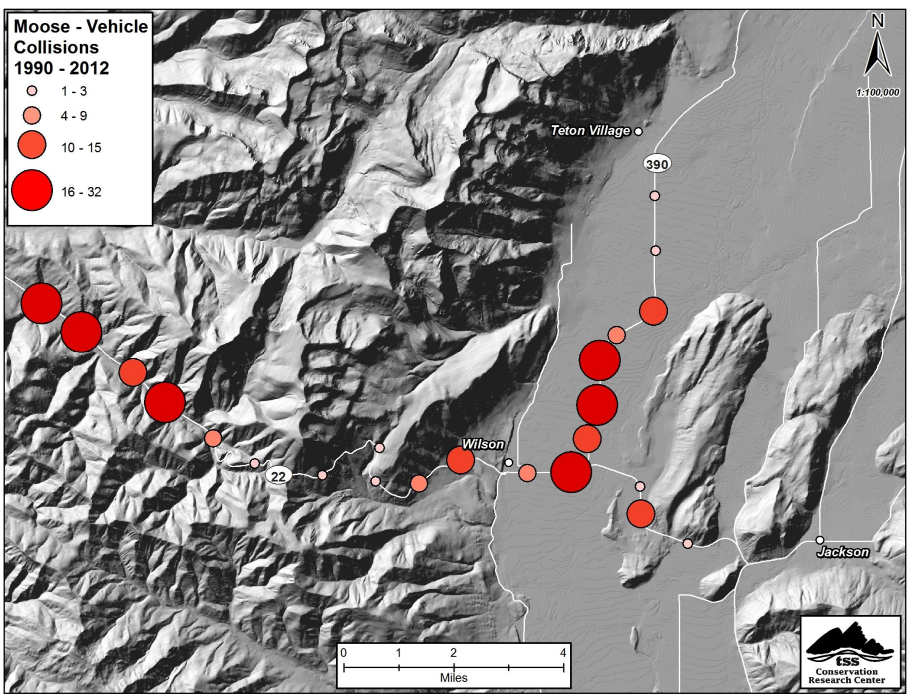

Figure 2: Total number of moose-vehicle collisions by mile of highway for the Teton County between 1990 and 2012. Data were obtained from WYDOT's WVC and Carcass databases as well as the Jackson Hole Wildlife Foundation's NatureMapping citizen science observations. Data were processed as for Figure 1.

lanes on both roads; re-configuring certain intersections to facilitate more rapid flow of traffic through them; creating frontage roads and/or one-way turning lanes on HWY 390; and creating a divided highway on HWY 390 via an elevated or depressed divider (22/390 Corridor Study; http://www.22-390corridorstudy.com/).

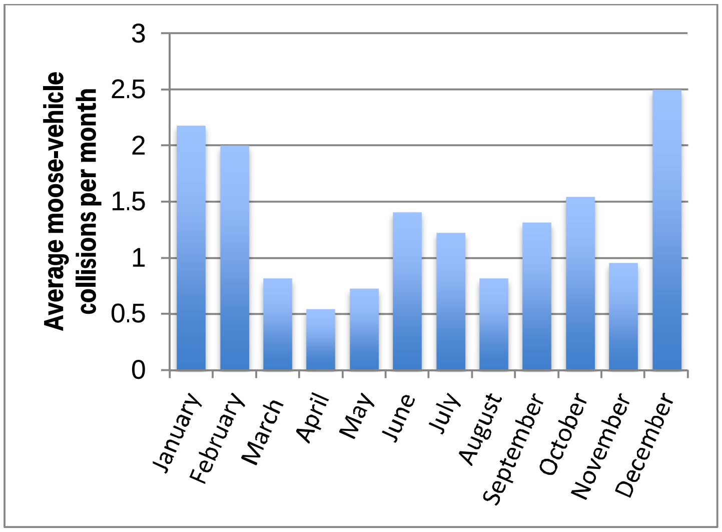

Figure 3: Monthly average moose-vehicle collisions recorded in Teton County between 1990 and 2012. Data were obtained and processed as for Figure 2. Data do not include Grand Teton National Park.

The Role of Scale in Road Crossing Behavior and WVC Mitigation

As WYDOT considers future changes to these roadways and WVC mitigation efforts, a thorough understanding of the effects of these changes on wildlife is necessary. Road engineering should, ideally, minimize wildlife-vehicle collisions while maintaining traffic flow and habitat connectivity for wildlife. Achieving this goal requires a complete understanding of how wildlife use the landscape in relation to roadways, where and when they are most likely to cross roads, where and when collisions with vehicles are most likely to occur, and the costs and benefits of different mitigation options (Huisjer et al., 2008b; Huisjer et al., 2009).

Where wild ungulates choose to cross roads may depend on a variety of factors acting at a hierarchy of different spatial scales. At the coarsest scale, ungulates might cross roads that bisect their migration routes, home ranges, or key habitats (Danks and Porter, 2010; Becker et al, 2011; Gunson et al., 2011; Sawyer et al., 2012; Beyer et al., 2013). At an intermediate scale, ungulates might choose crossing locations based on “neighborhood” factors like the density of roadways, buildings, fences, or other forms of development in the area, the forage available to them in that area, topography, or the diversity of habitats in the area (Nielsen et al., 2003; Dussault et al., 2007; Friar et al., 2008; Ng et al., 2008; Gunson et al., 2011; Laurian et al., 2012; Eldegard et al., 2012; Beyer et al., 2013). At the fine scale, ungulates might make decisions about where to cross roads depending upon factors like the presence or absence of a fence gap or guard rail, the steepness of roadside embankments, or the presence of a resource patch (e.g. forage or salt) along the roadway (Rea, 2003; Dussault et al., 2007; Laurian et al., 2008; Rea et al. 2010; Gunson et al., 2011; Laurian et al., 2012). Similarly, the likelihood of a vehicle hitting an animal will depend on both coarse-scale variables (e.g. traffic density, speed limit, type of road) and fine scale variables (e.g. visibility, road curvature) (Gunson et al., 2011). Further, these spatial dynamics may vary depending on the time of day or night (Eldegard et al., 2012; Neumann et al., 2013) or depending on season, weather and snow depth (Eldegard et al., 2012).

Understanding and predicting the locations of ungulate road crossings, the locations of collisions, and the effectiveness of mitigation measures requires simultaneous consideration of all three of these spatial scales and their interactions with temporal variables. Failure to do so may result in ineffective mitigation measures. For example, measures to improve roadside visibility (fine-scale mitigation) may not be necessary in areas where the "neighborhood" landscape architecture (intermediate scale) is such that animals do not frequently cross the road in that area. Conversely, the locations of targeted fine-scale mitigations (e.g. signage, reduced speed limits, or speed bumps) could be optimized with knowledge of the intermediate- and coarse-scale contexts in which ungulates are most likely to cross roads. In other cases, mitigation measures may best be aimed at modifying the intermediate scale (e.g. fencing off an area with high WVC risk).

Most studies on WVCs have focused on identifying coarse-scale variables associated with patterns of ungulate road crossings and vehicle collisions (see Gunson et al., 2011 for review). For moose in particular, almost all studies have focused on coarse-scale patterns of habitat. These studies typically use WVC and carcass data or GPS collar data and relate spatial patterns of collisions or road crossings with habitat data. For example, Danks and Porter (2010) showed that moose-vehicle collision locations in Maine were related positively to recent timber harvesting and road traffic volume. Similarly, Seiler (2005) found that moose-vehicle collisions in southern Sweden were more likely in forested areas that had been clear-cut or were in the early stages of recovery, in areas with higher traffic volumes, and in unfenced areas. Using GPS tracking data, Becker (2008; 2011) showed that moose in the Buffalo Fork area of northwest Wyoming crossed the highway more frequently in areas where riparian habitat occurred on both sides of the highway.

Studies such as these can provide useful information about coarse-scale patterns of collisions and crossings but are limited in what they can tell us about finer scale patterns. This is because most carcass and WVC data (particularly older data, before GPS units were regularly issued to State Troopers and other highway safety officers) are rounded to the nearest landmark or mile/kilometer marker, introducing a great deal of error when these data are related to specific landscape features (Gunson et al., 2009). Similarly, GPS collar data are typically collected at 1-2 hour time intervals, introducing error in estimates of where animals actually crossed roads. Such data can be related to coarse-scale landscape and road features but have limitations for determining fine-scale crossing locations, actual WVC locations, or intermediate- to fine-scale variables associated with these locations.

Thus, coarse-scale information is an important first step in mitigating WVCs but has limited value for siting specific mitigations on specific stretches of road (Gunson et al, 2011). Coarse-scale patterns (at a scale of 1 km/mile or more) may be sufficient for siting crossing structures (underpasses and overpasses) that will be combined with long stretches of roadside fencing to facilitate migratory animals' crossings. However, an understanding of intermediate- and fine-scale road crossing and WVC patterns may be necessary in places where animals are resident or semi-resident and cross the road frequently, or where crossing structures are not a feasible mitigation option.

Road Crossing Behavior in the Urban, Ex-Urban, and Rural Contexts

Intermediate- to fine-scale information is also critical for understanding crossing and WVC location patterns in more developed urban and ex-urban areas. Almost all studies of moose-road relations have focused on rural areas with relatively few roads and large tracts of undeveloped land (Seiler, 2005; Dussault et al., 2007; Laurian et al., 2008; Danks and Porter, 2010; Becker, 2011; Eldegard et al., 2012; Laurian et al., 2012; Beyer et al., 2013; Neumann et al., 2013). A handful of studies on deer have examined WVC patterns in relation to "neighborhood" road networks and urban development in urban and ex-urban areas (Neilson et al., 2003; Ng et al., 2008). Only one such study focused on moose in an urban area (Rea, 2012) but was limited to expert opinion in the absence of any spatially explicit moose crossing or vehicle collision data.

Thus, our understanding of the specific features associated with where moose are most likely to cross roads and be hit by vehicles is extremely limited, particularly in urban and ex-urban areas. We propose to develop and test a framework for identifying fine-scale moose crossing and vehicle collision patterns—and the intermediate- and fine-scale variables driving these patterns—along two defined stretches of road (HWY 390 between the junction with HWY 22 and the Lake Creek Bridge, and HWY 22 on the west side of Teton Pass). For both of these roads, some coarse-scale patterns of moose-vehicle collisions can already be inferred using existing WVC and carcass data (Figures 1-2), allowing us to focus on developing and testing methods to examine the critically important finer-scale patterns of crossings and collisions. By comparing HWY 390 and HWY 22, we will not only further the scope of our study but will also test our framework and methods under two different sets of conditions. Whereas HWY 390 is an ex-urban area adjacent to many private residences that is mostly used by commuter traffic, HWY 22 west of Teton Pass is situated in undeveloped US Forest Service land and is used by a mixture of commuter and large truck traffic. Thus this study will be novel in two ways: first, by focusing on intermediate- and fine-scale dynamics of moose-road relations, and second, by examining these dynamics in both an undeveloped and ex-urban setting.

The results of this study will provide valuable information about the specific locations of moose road crossings and patterns of vehicle collision likelihood along these stretches of road as well as the scale and specific location of mitigations most likely to be effective at preventing further collisions.

Study Benefits

Our research will provide tools, methodologies, and data that can be used to improve human safety and environmental stewardship on Wyoming roadways. Our work will take a novel and integrated approach to the problem of WVCs—providing a framework with which to examine this problem across all of the relevant spatial and temporal scales. At present, established methodologies exist to identify coarse-scale patterns of WVC risk. Here, we propose to develop a new approach that will yield a more detailed and refined understanding of fine-scale ungulate use of roadways and WVC likelihood within coarse-scale areas that currently experience high rates of WVCs. This information will provide the foundation for a spatially explicit cost-benefit analysis of mitigation alternatives. The approach that we develop and test here could later be applied to other WVC hotspots across the state and beyond.

This work is an important next step towards understanding and mitigating the problem of moose-vehicle collisions in Teton County and WVCs more generally. Options for mitigating WVCs range widely in scope, price, and public support or compliance (Huisjer et al., 2008b)—from relatively cheap but sometimes unpopular measures like reduced speed limits or roadside vegetation management to multi-million dollar wildlife crossing structures coupled with extensive roadside fencing. Before considering any of these options in Teton County, it is necessary for both WYDOT and the public to understand how likely these options are to be effective, what their benefits are relative to their costs, and where they would best be sited for maximum cost-effectiveness.

A 2011 report by the Western Transportation Institute (Huisjer et al., 2011) presents an analysis of road crossing hotspots and mitigation options for several highways in Teton County, including HWY 390 and HWY 22 east of Wilson. This analysis has several limitations upon which we will improve. First, Huisjer et al.'s analysis of where animals cross these highways is based on expert opinions regarding large ungulate migration routes. We will use direct observations of ungulate road crossings and include non-migration crossings as well as migration crossings in our analyses. Our recent work in Teton County (WYDOT-funded project we are currently completing: RS03210: Understanding mule deer movement and habitat use patterns in relation to roadways in NW Wyoming) shows that more than 95% of mule deer crossings are not part of migrations, and in fact that animals crisscross the roads very frequently as part of their daily winter habitat use. This conclusion likely applies to moose as well as mule deer. Whereas Huisjer et al.'s analysis focuses on crossing structures as mitigation options, these structures may not be effective for non-migratory animals and/or may not be feasible on many roads. We will consider a wider suite of mitigation options including reduced speed limits, targeted warning signs, and fine-scale roadside modifications to improve visibility and detectability of crossing moose. Finally, our study will include HWY 22 west of Wilson up to the Idaho border – an area with high moose-vehicle collision rates that has not been considered in previous studies.

It is important to note that the kind of fine-scale analysis of ungulate road crossing behavior we are proposing has never been done before. Most prior studies have used intermediate to coarse spatial scale observations derived from GPS-collared animals. Ideally we would couple our fine-scale analysis of road crossing behavior with GPS collar data, using fine-scale data to refine and validate information derived from GPS collar data. Unfortunately, collaring moose is not possible right now for logistical reasons. After consulting with wildlife biologists at the Jackson Office of the Wyoming Game and Fish Department, it became evident that the terrain and high amounts of private land in the study area would preclude capturing moose using a helicopter and net-gun. Most recent moose captures in Wyoming have used a helicopter and net-gun and have not required immobilizing moose with any drugs. However, in our study area, we would need to capture moose by baiting and free-darting. At present, the drug necessary to immobilize moose (carfentanil) is under national review after a number of captures resulted in terminated pregnancies. Further, there is no veterinarian in Wyoming currently certified to administer this drug. Thus, there are a number of obstacles at present that need to be resolved before capturing and collaring moose in this area becomes possible.

While it would be advantageous to collar moose in the future, we propose, in the interim, to focus on developing new methodologies for obtaining fine-scale data on moose behavior using non-invasive techniques. Doing so offers two important benefits. First, we will still generate useful, scientifically-sound information on moose-road interactions and develop methods that could be up-scaled later to encompass a broader study area. Second, our work will provide opportunities for the public in Teton County to engage directly with the issue of moose-road interactions and learn more about the biology underlying various mitigation options. Given the high degrees of public concern over moose mortalities and public interest in possible changes to HWYs 390 and 22, our research and non-partisan, education-oriented outreach work will be extremely timely.

Study Objectives

Our specific objectives are to:

1. Identify fine-scale patterns of moose road crossings in space and time along specific stretches of HWY 390 and HWY 22 that experience high WVC rates.
2. Identify fine- and intermediate-scale spatial variables, as well as relevant temporal variables, that explain crossing patterns. Important variables might include:
    a. Intermediate spatial scale: habitat and cover, including footprint and spatial arrangement of ex-urban development; extent and type of roadside fences; and density of roads.
    b. Fine spatial scale: roadside vegetation; intersections with other roads; fence gaps; guard rails and embankments.
    c. Temporal variables: day/night; season; weather conditions and snow depth.
3. Identify important fine-scale road and roadside variables associated with moose vehicle collision locations.
4. Conduct a cost-benefit analysis of various mitigation options and provide decision support information for type and siting of mitigation measures.

These study objectives support WYDOT's Overall Strategic Plan and Balanced Scorecard goals of (1) keeping people safe on the state transportation system, and (2) exercising good stewardship of our resources. More specifically, our results will provide much-needed information about where and why moose cross these roads as well as the scale, type, and location of mitigations most likely to reduce rates of moose-vehicle collision in Teton County and in other, similar areas. This information will be vital for weighing the environmental and monetary costs and benefits of various modifications to US 390 and US 22 that are being considered.

Methods

We will conduct a two year study, with field work commencing in winter 2013-14 and continuing through summer 2014 and winter 2014-15. Data analysis and synthesis of results will continue until the end of 2015. Although the study will target moose, we will record and analyze any observations of other ungulates (e.g. mule deer and elk) in the same fashion as for moose. For mule deer in particular, we will be able to refine our understanding of fine-scale road crossing patterns, since we have already identified general crossing hotspots using GPS collar data (WYDOT-funded project we are currently completing: RS03210: Understanding mule deer movement and habitat use patterns in relation to roadways in NW Wyoming).

Objective 1*: Identify fine-scale patterns of moose road crossing in space and time along specific stretches of HWY 390 and HWY 22 that experience high WVC rates.*

We will use a combination of snow tracking, video infrared surveillance, and direct observations to identify fine-scale crossing locations.

> Snow tracking: The study area will be opportunistically sampled for moose tracks indicating a road crossing when snow is fresh and tracks can be identified clearly. Roadsides will be searched systematically for fresh tracks and track locations will be recorded using a handheld GPS receiver.
>
> Video surveillance: Systematically positioned automated FLIR (forward-looking infrared) video cameras will be employed to provide spatial and temporal data on moose crossings that occur at night. With FLIR technology it is possible to identify large ungulates even when they are 200-300 m away (in contrast to game cameras, which will only capture animals <30 m away at night). FLIR units will be mounted along road right-of-ways and positioned to "see" the road way and roadside features that will help identify where, exactly, observed animals are crossed. We will systematically rotate video units among a set of fixed locations to sample representative portions of the roadway for nighttime moose crossings. Video footage will be reviewed daily.
>
> Direct observation: During the day, we will use direct observations to document the location and timing of moose crossings. Using both technicians and citizen scientists, we will conduct a combination of transect-based surveys of the roadways while also positioning observers near locations where moose are known to be present.

For all observed crossings (from both direct and video observations), we will record the precise location and time of crossing, moose behavior before and after the crossing, estimated distance to the nearest moving vehicle, and associated weather (temperature and precipitation) and snow-depth data when available. Snow-depth data will also be collected on the same day at five randomly selected locations within the study area to determine whether the crossing location(s) have significantly different snow-depth than unused locations.

Objective 2*: Identify fine- and intermediate-scale spatial variables, as well as relevant temporal variables, that explain crossing patterns.*

Using a combination of GIS and ground surveys, we will map habitat and roadside features directly alongside roadways (fine scale) and in a 1 km buffer around roadways (intermediate scale). Fine-scale mapped features will include: roadside vegetation (including type, height, cut/browse/regrowth status; permanent fence gaps, driveways, or intersecting roads; guard rails, embankments, and any other relevant roadside structures. Intermediate-scale mapped features will include: land cover and vegetation type; houses and commercial developments; density of roads; extent and type of roadside fences.

We will use a generalized linear modeling approach to compare the habitat, landscape, and roadside features associated with areas of high crossing frequency versus areas of low crossing frequency. We will consider the potentially interactive effects of temperature and snow depth with spatial variables and decide whether separate models need to be formulated depending on different temperature and/or snow depth conditions. We will use information theoretic criteria to derive the best models explaining crossing patterns and compare the relative importance of fine- and intermediate-scale variables. We will also use the moose crossing data to identify seasonal or daily temporal patterns for crossings at hotspot locations.

Objective 3*: Identify fine-scale road and roadside variables associated with moose vehicle collisions locations.*

We will identify the subset of Teton County moose-vehicle collision data for which we have a high degree of confidence in the spatial accuracy of the recorded collision location (e.g. WVC locations that were recorded using a GPS unit and not rounded to the nearest mile marker). We will also work with WYDOT to obtain accurate collision location data for any moose-vehicle collisions that occur during the study. For these locations, we will identify road and roadside variables that may be associated with increased likelihood of moose-vehicle collision. These variables might include: ability to see moose on road edges at night or during sunrise/sunset; road curvature; and average vehicle speed at that time (using data WYDOT is already collecting on vehicle speed). We will then compare the road and roadside attributes of real moose-vehicle locations against a set of randomly generated locations. We will use a generalized linear modeling approach to determine which variables best predict a higher likelihood of moose-vehicle collisions occurring. By successfully identifying these variables, we will be able to predict where moose-vehicle collisions are most likely to occur and how these locations relate to moose road crossing patterns. This information will help to inform future mitigation efforts.

Objective 4*: Conduct a cost-benefit analysis of various mitigation options and provide decision support information for type and siting of mitigation measures.*

We will use existing information about the percent effectiveness of different mitigation options, coupled with our observed spatial patterns of moose road crossings and vehicle collisions in the study area, to conduct a spatial cost-benefit analysis that weighs the costs of mitigation against the expected benefits in terms of number of collisions prevented. We will analyze the costs and benefits over a 75 year period using various discount rates (1%, 3%, and7%) to identify spatial locations in the study area where the financial benefits of individual mitigation measures will be maximized (Huijser et al. 2009). The discount rates will be employed to correct for the time value of money – in other words, they will account for the lost interest that could have been accrued if the same amount of money had been invested rather than spent on a mitigation project. Cost benefit analyses on projects that have an up-front cost and benefits that pay off over a much longer time scale have been shown to be particularly sensitive to discount rates, so we propose to calculate a range of values to provide more detailed information to better support future mitigation decisions.

Deliverables

- Maps showing fine-scale likelihood of moose road crossing and vehicle collision
- Maps showing relevant habitat and landscape features
- Analysis of both intermediate- and fine-scale spatial variables, as well as temporal variables, that predict likelihood of moose road crossing and vehicle collision, with assessment of the relative importance of these variables and any interactions among them.
- Based on the above analysis, recommendations about whether mitigations should target intermediate or fine spatial scales
- A spatially explicit cost-benefit analysis of mitigation options, considering cost of mitigations, percent effectiveness, and predicted benefits of moose-vehicle collisions avoided (in map form)

Study Timeline

	2014				2015			
	WIN	**SPR**	**SUM**	**FALL**	**WIN**	**SPR**	**SUM**	**FALL**
Study Design	■	■						
Consult with Partners & Advisory Group	■		■		■		■	■
Hire Field Technicians (2)	■		■		■			
Secure Permits (if required)	■		■		■			
Order Equipment/Supplies	■		■		■			
Field Data Collection	■		■		■			
Data Management/Analysis	■	■	■	■	■	■	■	■
Public Engagement/Education	■		■		■			■
Quarterly/Interim Reports	■	■	■	■	■	■	■	■
Technology Transfer	■		■				■	■

WIN = December - February
SPR = March - May
SUM = June - August
FALL = September - November

Technology Transfer and Public Education

Technology Transfer

Technologies and results from this project will be shared with WYDOT staff in several ways. First, WYDOT staff members will be key partners in developing the specific data collection protocols. An assessment of best protocols for studying ungulate-road interactions will be included in the final report. Second, Conservation Research Center scientists and technicians will work directly with WYDOT highway maintenance crews in District 3 to develop systems for more accurate documentation of carcass locations to facilitate future analysis of the effectiveness of WVC mitigation efforts in the area. We are already working with WYDOT staff to do this in District 5.

WYDOT will receive written or verbal (in-person presentations) quarterly reports over the course of the project. We will also meet with District and Resident Engineers on a regular basis to discuss the project's progress and ensure that our work will best meet their needs and expectations.

At the end of the project, we will provide a comprehensive final report, including research results and map products, conclusions and recommendations, and raw data and metadata. We will be available to assist WYDOT staff with data interpretation and integration of results into transportation planning. We will also be available to assist conservation planning agencies, county government and wildlife managers with interpretation of our results.

Project Advisory Committee

In addition to our WYDOT partners, we will also assemble a Project Advisory Committee comprised of key wildlife professionals and stakeholders who will help (a) provide input to project development and implementation, (b) suggest ways of making project results more useful for, and relevant to, end users in planning wildlife and habitat management, (c) identify potential areas of collaboration with other projects, and (d) disseminate project results. The involvement of the Project Advisory Committee will be vital not only for the success of this project but also for assessing the important next steps towards understanding and reducing WVCs in Teton County and across the state. Advisory Committee members we are already working with include: Tim Fuchs (Jackson Supervisor, Wyoming Game and Fish Department); Doug Brimeyer (Wildlife Biologist, Wyoming Game and Fish Department); Matt Kauffman (Unit Leader, Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming).

Public Education and Engagement

We will leverage our ties to the public and the strong local interest in conservation to initiate a citizen science program wherein citizens can contribute data on ungulate road crossings in the study area. Citizens can submit observational data through a smartphone and web-based application we have developed (http://epicollectserver.appspot.com/project.html?name=tsscitsci) and /or may volunteer to assist with field data collection (Aanensen et al., 2009). We will particularly target residents along HWY 390 who are likely to be interested in the project and can provide invaluable observations from their own backyard. However, we will also encourage other members of the public to volunteer their time or observations for the project. We will seek to collaborate with the NatureMapping initiative of the Jackson Hole Wildlife Foundation in this effort.

At the start of the study, we will convene a series of public meetings to educate residents, natural resource managers, and conservation groups in Jackson, Wilson, Teton Village, and Victor, ID about wildlife-road interactions and present the objectives and planned activities of this study. We will highlight opportunities for their involvement through our citizen science initiatives. We will also present our study to citizen science volunteers who participate in the annual NatureMapping Moose Day.

At the close of the study, we will convene a similar set of meetings to discuss our research findings and how they relate to various mitigation options and to answer questions. In addition, we will offer a "field day" for interested members of the public to visit locations that were identified as common moose crossing areas as well as areas with high wildlife-vehicle collision rates. At these locations, we will discuss ecological, road and roadside factors that were determined to be associated with increased likelihood of moose crossing or wildlife-vehicle collisions.

Budget

	Jan - Dec 2014	Jan - Dec 2015	
	FY 14	**FY 15**	**TOTAL**
STAFF	**$ 84,030**	**$ 59,694**	**$ 143,724**
Principal Investigator	16,225	16,225	32,450
GIS Analyst	7,000	7,000	14,000
Seasonal Technicians (2)	46,800	26,520	73,320
Benefits	14,005	9,949	23,954
EQUIPMENT	**$ 31,926**	**$ 250**	**$ 32,176**
Field computer (4)	2,000	-	2,000
FLIR Thermal video camera (4)	25,196	-	25,196
Deep cycle batteries (4)	400	-	400
Security compartment (4)	4,000	-	4,000
Batteries	250	250	500
Voice recorder (2)	80	-	80
OUTREACH/TECH TRANSFER	**$ 1,000**	**$ 1,000**	**$ 2,000**
TRAVEL	**$ 750**	**$ 750**	**$ 1,500**
Total	**$ 117,706**	**$ 61,694**	**$ 179,400**
Overhead	*$ 11,771*	*$ 6,169*	*$ 17,940*
TOTAL WYDOT REQUEST			**$ 197,340**
TSS/In-kind Contribution	*$ 2,950*	*$ 10,550*	*$ 13,500*

Personnel

Principal Investigator
Dr. Corinna Riginos – Research Ecologist, Conservation Research Center, Teton Science Schools
Corinna has over 13 years of experience conducting original research on large ungulate-habitat interactions in human-dominated landscapes. She is proficient in a diversity of statistical tools and has extensive experience in translating research results into understandable products for managers, planners, and the public. Corinna is a Co-Investigator on two currently funded WYDOT projects relating to ungulate-road relations (RS03210: Understanding mule deer movement and habitat use patterns in relation to roadways in NW Wyoming, and RS05212: Evaluating the effects of deer delineators on wildlife-vehicle collisions in northwest Wyoming).

Co-Investigator
Dr. Doug Wachob – Associate Executive Director, Teton Science Schools
Doug directs the Advancement Team, Conservation Research Center, and Property Management at TSS. He was recently the Director of Conservation for the Alaska Chapter of The Nature Conservancy. His academic background is in wildlife ecology with an emphasis on the ecology of human dominated landscapes.

Co-Investigator

Dr. Kevin Krasnow – Research and Graduate Faculty, Teton Science Schools

Kevin has over 10 years of experience in disturbance ecology and spatial analysis. His research focuses on understanding how and why ecosystems change and identifying opportunities for increasing ecosystem resilience. Kevin is a Co-Investigator on the currently funded WYDOT project RS03210: Understanding mule deer movement and habitat use patterns in relation to roadways in NW Wyoming.

Co-Investigator

Morgan Graham, GIS Manager, Conservation Research Center

Since 2006, Morgan has managed our geographic information systems, overseeing the acquisition, organization, analysis and documentation of geospatial data for conservation services and research projects. Morgan is also skilled in remote sensing image analysis and applications as well as field vegetation and habitat analyses. Morgan is a Co-Investigator on the currently funded WYDOT project RS05212: Evaluating the effects of deer delineators on wildlife-vehicle collisions in northwest Wyoming.

Education/Outreach Coordinator

Kelli Petrick, Research and Stewardship Coordinator, Conservation Research Center

Kelli serves as the primary liaison between the CRC and Teton Science Schools' educational programs, developing research and service opportunities across the organization. She aims to enhance scientific literacy by engaging students and community members in meaningful research through creative, hands-on outreach programs.

Other project staff include: Research Crew Leader and Technician(s) (TBD); Sara Fagan, Grants Administrator.

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