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A SUMMARY OF THE WILDLIFE LINKAGE AND HIGHWAY SAFETY ASSESSMENT: A PRIORITIZATION AND PLANNING TOOL FOR WESTERN MONTANA

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Abstract

Protecting habitat connectivity for wildlife is a management imperative facing agencies and wildlife organizations across the United States. To maintain connectivity and improve highway safety across transportation routes in western Montana, American Wildlands conducted a rapid wildlife linkage and highway safety assessment. This analysis had two primary objectives: 1) to provide a planning tool to direct American Wildlands' conservation efforts for protection of habitat connectivity across transportation routes; and 2) to provide data and information useful to agencies and other conservation partners. This assessment used four criteria to identify priority areas: i) road kill concentration areas, ii) important wildlife linkage areas, iii) planned transportation projects, and iv) land ownership as an indicator of the likelihood of conservation success. To complete the analysis, kernel density estimation and percent volume contours were used to identify high concentration areas where there is a dual concern for wildlife and human safety based on elevated numbers of road kill. Additional GIS data sets were used to further prioritize the potential priority areas. This process resulted in improved understanding of the road kill concentration areas in western Montana as well as a planning document which can be used by both public and private sector entities to improve local and regional planning and coordination. Critical to the success of this project was an engaged advisory group and a focus on delivery of the analysis results and products to the agencies and other partners. To ensure that advisory group members, representing their respective organizations, endorse and utilize the analysis results in their planning processes we actively encouraged and incorporated member input into the analysis process and data products. Delivery mechanisms (hard copy reports, GIS data, and web access) were agreed upon by the advisory group and are available with the final report. Continued collaborative efforts between public and private entities will be essential to ensure the appropriate level of conservation dollars and effort to meet protection needs in the identified priority areas. Since the western Montana study can be considered a pilot for a possible statewide initiative, the lessons learned may be used to create an improved product at the statewide level. Additionally, we propose this model be considered for application to other western states in need of a wildlife linkage and highway safety planning tool.

Introduction

Protecting habitat connectivity for wildlife is a management imperative facing agencies and wildlife organizations across the United States. An important component to ensuring habitat connections is maintaining successful wildlife movement across transportation routes (Forman et al. 2003). Research has shown wildlife-vehicle collisions are on the rise in the United States (Huisjer et al. 2007), and efforts are needed to reduce the number of these accidents.

The goal of this assessment was to use a systematic, transparent process to improve wildlife movement and human safety through the prioritization of wildlife movement areas suitable for mitigation along transportation routes in western Montana. Due to the high quality wildlife habitat present in the study area, there are numerous areas where wildlife mitigation is both needed and warranted along roadways. Personnel in wildlife and transportation agencies are aware of important locations through their work experience but have no coordinated mechanism by which to set and apply priorities. This rapid assessment was initially designed as a planning tool to prioritize American Wildlands' (AWL) wildlife and highway conservation work and to identify the intersection between human safety concerns due to wildlife-vehicle collisions and important wildlife linkages in western Montana. It was designed to incorporate best available data and utilize a collaborative process to find common ground and prioritize where wildlife linkage and wildlife vehicle collision issues should be addressed in the next five to ten years. Based on the high level of agency interest in the process and results, we expanded the project in June 2008 to act as a pilot to develop a multi-agency endorsed wildlife and highway planning document.

To guide the assessment process, American Wildlands relied heavily on a multi-agency and organization advisory group as a guiding force for goal setting and methodology. Through this 14 member advisory group, AWL developed a

prioritization framework to rank wildlife movement areas along transportation routes that are in need of mitigation. The advisory group's role was to: 1) guide the assessment methodology and report, 2) help American Wildlands understand the obstacles and opportunities for collaborative wildlife conservation efforts along transportation routes, 3) find areas where improvement in collaboration strategy is needed, and 4) devise actions to improve the ability to collaborate.

This project and the resulting report function both as an analysis document and a planning tool. Our work is relevant to any individual, agency or organization who wishes to better understand methods for identifying important wildlife-transportation project areas, as well as those wishing to plan and prioritize wildlife and highway mitigation efforts in western Montana. Potential users of this report therefore include state wildlife and transportation agencies, federal, state and county planners, wildlife conservation organizations, and rural development organizations.

This paper summarizes the draft report provided to the working group (Williamson et al. 2009). The full report provides detailed methods, results, recommendations of the assessment as well as an extensive appendix. For those interested in applying this type of process to your work, the final report will be available in September 2009 and can be found at <http://wildlands.org/programs/safepassages/assessment/>.

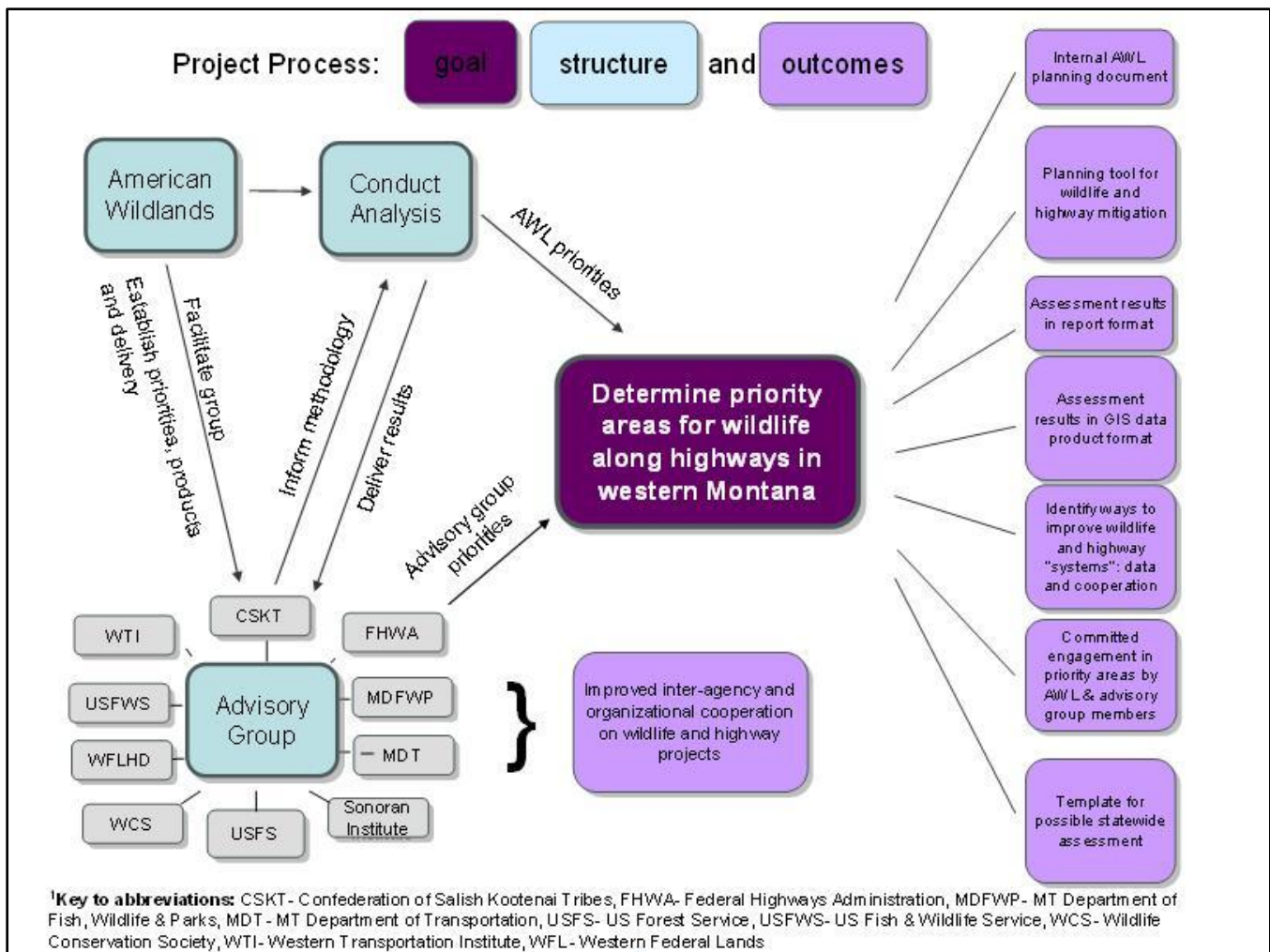


Figure 1. Diagram illustrating the goals, structure and potential outcomes of the project, as well as the roles of American Wildlands and the project advisory group.

Methods

Study Area

The boundaries of the study area are the Canadian border (north), Idaho border (west and southwest), Wyoming border and Yellowstone National Park (southeast) and Rocky Mountain Front and eastern slope of the Crazy, Castle, Beartooth and Little Belt mountain ranges (east).

The landscape of western Montana is characterized by rugged mountain ranges divided by river valleys. Elevations range from 555 meters (1820 ft) at the Kootenai River to over 3810 meters (12,500 ft) in the Beartooth range. Lower elevation habitats, below 1829 meters (6000 ft), vary greatly in composition and include mountain foothills, short-grass/sagebrush prairie, intensively cultivated areas, natural wetlands/lakes, riparian plant communities, man-made reservoirs, small communities, large towns, and cities. Mountainous habitats are dominated by coniferous forest and rocky sub-alpine/alpine communities.

We considered road kill events which occurred in this study area on 7947 kilometers (4914 mi) of Montana Department of Transportation managed roads. This route network is comprised of 282 interstate, state primary, state secondary, state urban, and "state highway" routes.

With guidance from the advisory group, a methodology was developed to identify and prioritize potential areas for wildlife mitigation in western Montana. We incorporated wildlife-vehicle collision highway data, wildlife linkage information, as well as land ownership and state transportation improvement program plans to determine priorities for wildlife mitigation on transportation routes in western Montana using a three step process. The diagram below provides a general illustration of the steps taken and the overall structure of the analysis.

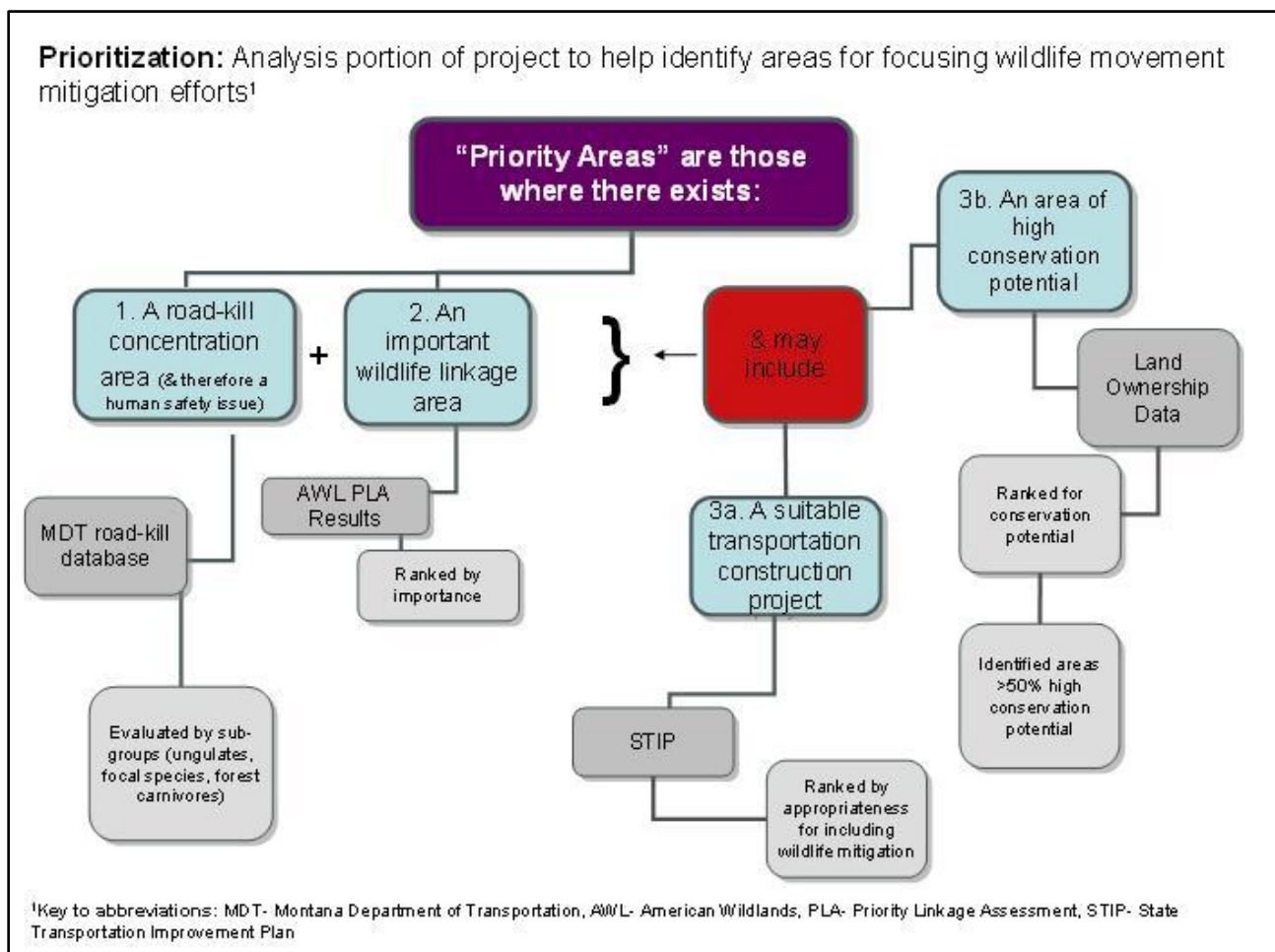


Figure 2. Diagram illustrating steps 1-3 of the analysis.

Step 1. Define high road kill concentration areas (HCA) based on ungulate, focal species and forest carnivore species groups.

A Geographic Information Systems (GIS) analysis point dataset was derived from MDT 2003-2007 tabular animal carcass data. The data was spatially referenced in Environmental Systems Research Institute (ESRI) ArcGIS 9.3 using MDT system mileposts. The dataset was refined to points within the western Montana study area and species of interest for the analysis (elk, fox, bison, bobcat, moose, gray wolf, mule deer, black bear, grizzly bear, bighorn sheep, mountain lion, mountain goat, whitetail deer, pronghorn antelope). Based on species, these data were grouped into three subgroups for separate analyses: ungulate species, focal species and focal carnivores (Williamson et al. 2009). Species groups are not mutually exclusive. Certain road kill events therefore, were included in more than one species group analysis.

A density surface was created for the ungulate, focal species and focal carnivore subgroups using standard kernel density estimation (KDE) methods (Clevenger et al. 2006). The analysis was conducted using ESRI's Spatial Analyst® extension. The grid layer generated by the KDE illustrates where road kill point locations are concentrated by calculating a density value for each 800 m² cell.

Percent volume contours (PVC) were calculated to isolate the highest road kill concentration areas for the continuous density surface for the ungulate species, focal species, and focal carnivore subgroups (Beyer 2004). Contour lines were drawn around the areas containing fifteen percent of the volume of the density distribution from the KDE output grid.

Step 2. Overlay of road kill high concentration areas with priority wildlife linkage information to determine and rank potential project areas.

In the next step of the analysis, the road kill high concentration areas were overlaid with wildlife linkage information for western Montana. This linkage data came from the 2007-2008, American Wildlands expert opinion-based model used to prioritize the most important wildlife linkage areas in the U.S. Northern Rockies (American Wildlands 2009).

To determine areas where the road kill high concentration areas intersected the wildlife linkages, three input datasets (ungulate and focal species high road kill concentration areas and wildlife linkage data) were converted to grid layers with a resolution cell size of 800 meters, consistent with the spatial accuracy assumed for road kill point events. The forest carnivore subgroup high concentration area data was removed from the analysis process due to small sample size; only the ungulate and focal species HCA, therefore, are used in the following steps of the analysis. A grid overlay function was used to combine the attributes from the three layers. Ungulate and/or focal species HCA located within or intersecting “very high” or “high” wildlife linkages were identified as potential project areas. These potential project areas were ranked into three categories (Tier I, Tier II, and Tier III) based on the HCA and wildlife linkage rank (Fig. 3).

		Wildlife Linkage Rank	
		Very High	High
High Road kill Concentration Areas	Both Ungulate and Focal Species	Tier I	Tier II
	Ungulate Species or Focal Species	Tier II	Tier III

Figure 3. Schematic illustrating criteria contribution to identification of an initial ranking of potential project areas (in purple).

Step 3. Rank potential project areas based on state transportation improvement program plans and a land ownership conservation potential index.

To provide planners with an increased ability to prioritize important mitigation areas, two decision matrices were used to further rank the potential project areas identified in Step 2. Potential project areas were considered “added opportunity areas” if they were coincident with Statewide Transportation Improvement Program projects (STIP) and/or surrounding land ownership that could facilitate highway mitigations for wildlife. The factors were evaluated independently to isolate the possible contribution of each to mitigation opportunities in the potential project areas.

Potential Project Area Ranking based on Statewide Transportation Improvement Program Projects

For evaluation in the decision matrix, STIP projects were first weighted based on the relative opportunity for including wildlife mitigation efforts in each scope (type) of project (Williamson et al. 2009). The decision matrix was defined with the ranked potential project areas on one axis and weighted STIP projects on the opposing axis. The resulting values were ranked into three categories (Tier I, Tier II and Tier III) that reflected both the opportunity for incorporating wildlife mitigation into highway projects and the need for mitigation based on road kill high concentration areas and highest priority wildlife linkage areas (Fig. 4).

		Ease of incorporating wildlife mitigation into highway project ranking		
		High	Moderate	Low
		8-10	3-7	0-2*
Initial Potential Project Area Rank (based on Step 2)	I	Tier I		Tier II
	II			Tier II
	III			

* A zero indicates that there was no intersection between potential project areas and STIP project.

Figure 4. Ranking of potential project areas based on State Transportation Improvement Program projects.

Potential Project Area Ranking based on Land Ownership Conservation Potential (LOCP)

A simplified decision matrix was also used to evaluate and rank potential project areas based on the land ownership composition of the region within one mile of potential project areas. Rankings of land ownership types were provided by advisory group members (Williamson et al. 2009). This decision matrix was designed to evaluate land ownership influence on potential project areas. The matrix takes into consideration potential project area rank and land ownership conservation potential value to determine the added opportunity tier value presented by favorable land ownership. Tier I project areas have a high need for mitigation based on road kill density and a high potential for mitigation based on land ownership conservation potential. Tier II and Tier III project areas have relatively decreasing need and potential for mitigation based on the same criteria (Fig. 5).

		Land Ownership Conservation Potential Rank				
		Very High	High	Intermediate	Low	Very Low
Initial Potential Project Area Rank (based on Step 2)	I	Tier I		Tier II	Tier III	
	II	Tier I		Tier II	Tier III	
	III	Tier I		Tier II	Tier III	

Figure 5. Ranking of potential project areas based on Land Ownership Conservation Potential.

Results

The major findings of the assessment include:

- One hundred and ten high road kill concentration areas were identified in western Montana based on a Montana Department of Transportation animal carcass database, broken into ungulate, focal species, and focal carnivore subgroups.
- Twenty-nine potential project areas were identified for prioritization; these include ungulate or focal species high concentration areas located in a very high or high wildlife linkage area.
- Nine potential project areas were identified in close proximity to a State Transportation Improvement Program project with high potential for wildlife mitigation.
- Ten potential project areas were identified as having high land ownership conservation potential.
- Three potential project areas had both high value State Transportation and Improvement Program projects and high land ownership conservation potential

As outlined in the methods, the analysis provided three sets of results: 1) an analysis of high road kill concentration areas, 2) the intersection of these areas with priority wildlife linkages, and 3) a ranking of potential project areas based on highway projects and land ownership. The results of each of these steps are detailed below. The results, as they pertain specifically to prioritization needs for western Montana highway mitigation, are provided in detail in the full report.

Step 1: Defining road kill high concentration areas.

There are 27,979 records of species-of-interest road kill that were located in the western Montana study area (Table 1). Roughly 99.4% of the records were included in the ungulate analysis, 4.4% in the focal species analysis, and 0.6% in the focal carnivore analysis.

Ungulates

The total number of ungulate road kill recorded in the study area was 27,813. Of these records, 26,730 were mule or whitetail deer (>96% of the ungulate subset, 93% of all road kill reported in western Montana). There were 66 areas identified as having a high concentration of ungulate road kill events. The number of observed road kill records contained in these areas ranged from 17 to 808. These areas of high concentration cover 303 km of roads, 3.8% of the total length of transportation routes in western Montana.

Focal Species

There were 1249 focal species road kills reported. An annual average of 250 collisions occurred with focal species with a range of 203 to 302 records per year. We identified 25 areas where a high concentration of focal species road kill occurred. Within these areas, records ranged from a minimum of 3 to a maximum of 75. The total length of the road within areas is 95.5 km, 1.2% of the total length of the transportation routes in western Montana.

Focal carnivores

The subset of focal carnivore species had 166 road kill events in five years. The analysis identified 19 areas where a high concentration of road kill involving focal carnivores occurred. These areas ranged from 2 to 5 observed records each. The total length of the road contained in these areas equaled 75 km, representing less than 1% of the road network.

Common Name	# of Records in Database	Species Groups		
		Ungulate	Focal	Focal Carnivore
Bighorn sheep	50	X	X	
Bison	4	X	X	
Black bear	97		X	X
Bobcat	7		X	X
Deer, unknown sp.	114	X		
Elk	738	X	X	
Gray wolf	5		X	X
Grizzly bear	2		X	X
Moose	172	X	X	
Mountain goat	4	X	X	
Mountain lion	22		X	X
Mule deer	6271	X		
Pronghorn antelope	115	X	X	
Red fox	33		X	X
White-tail deer	20,345	X		
Total Records by Group		27,813	1249	166

Table 1. Road kill analysis species subgroups.

Step 2: Potential project areas as defined by high road kill concentration areas with “very high” and “high” wildlife linkage values.

Spatial Relationships

Ungulates: Of 66 ungulate high concentration areas, 48 intersect with a wildlife linkage area. Almost half of these (23 HCA) occurred in a very high or high linkage.

Focal Species: Of 25 focal species high concentration areas, 21 intersect with a wildlife linkage area. A third of these (7 HCA) occurred in a very high or high linkage.

Potential Project Areas

A total of 29 potential project areas were identified and ranked in tiers: 0 Tier I, 13 Tier II and 16 Tier III. The potential project areas are illustrated in Figure 6.

Step 3: Added Opportunity Areas based on STIP and LOCP.

Added Opportunity Areas: Statewide Transportation Improvement Program Projects

Of the 29 potential project areas, nine intersected STIP project areas. A Tier I added opportunity ranking was attributed to six of the 29 potential project areas. All six Tier I added opportunity areas intersected a STIP project with a “high” STIP scope value. Three potential project areas received a Tier II added opportunity ranking. All three Tier I added

opportunity areas intersected a STIP project with a “moderate” STIP scope value. The remaining 20 potential project areas were given a Tier III added opportunity ranking since they did not intersect any STIP projects.

Added Opportunity Areas: Land Ownership Conservation Potential.

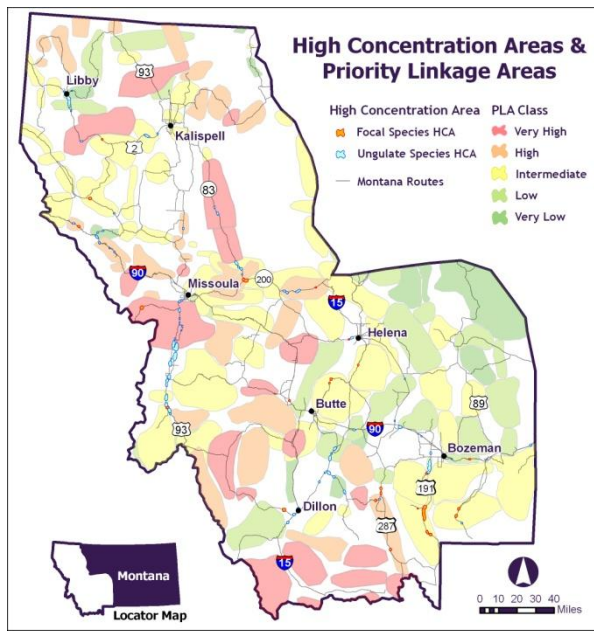
We identified six potential project areas in western Montana that had a Tier I added opportunity ranking based on a “very high” percentage of favorable land ownership within a one mile buffer of the defined area. Four potential project areas were attributed a Tier II added opportunity ranking based on a “high” percentage of favorable surrounding land ownership. The remaining 19 potential project areas received a Tier III added opportunity value based on surrounding land ownership composition with an “intermediate”, “low” or “very low” conservation potential.

Discussion

Analysis considerations

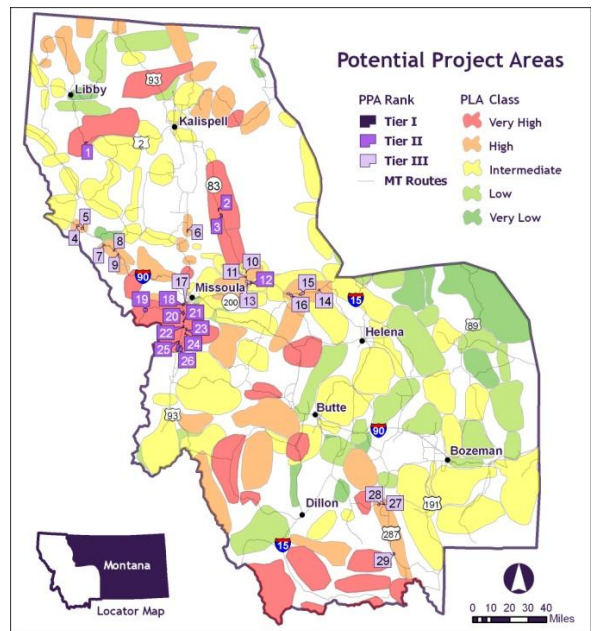
There are several issues that should be recognized when considering the methods used in this project. As with any analysis, it is vitally important to understand the limitations of the datasets being used. The road kill high concentration areas identified in Step 1 were based solely on the existing MT Department of Transportation (MDT) carcass database. The MDT carcass data, while collected over a relatively long period of five years, was not systematically collected. Due to variation in procedures and collection intensity within the study area, the database is opportunistic in design and has inherent limitations. Data gaps were identified in various locations in the study area. Overall, a species collection bias is assumed because MDT personnel are mandated to only remove road kill that pose a threat to the traveling public. Additionally, sensitive species are at times collected by the state wildlife agency, not MDT. Ideally, we would have combined datasets from the multiple agencies that play a role in animal carcass documentation in western Montana. However, due to time constraints and the lack of a central database of carcass information by the other agencies, creating an optimized data set was not possible in the project’s timeframe. To account for these constraints, we relied on the large sample size in the database, over 27,000 records, to help relieve the inconsistencies in data collection. Because of the limitations of the road kill data set, the high concentration areas were also not relied on as a sole indicator of wildlife movement. To strengthen the analysis, we used the priority wildlife linkage data rather than to rely on road kill concentration patterns for this need.

The twenty-nine potential project areas identified in Step 2 are locations where the road kill high concentration area results overlap with either “very high” or “high” ranked wildlife linkage areas. These potential project areas were categorized into three tiers to prioritize where conservation action may be most effective and essential. However, because the underlying data includes high road kill concentration areas and the highest priority wildlife linkages, all of the potential project areas identified should be considered important for potential mitigation measures. Sites with an ungulate species concern are, however, likely to have higher levels of road kill incidence and therefore may be of greater interest to agencies and organizations where human safety is a primary concern. Other data, especially empirical data, may be available for select sensitive species for overlay with the road kill high concentration areas. If future analyses were to be conducted, we suggest that these data be included in the GIS analysis. Embedding or combining disparate data sets, however, is time consuming and may greatly extend the time period needed to provide prioritization products.



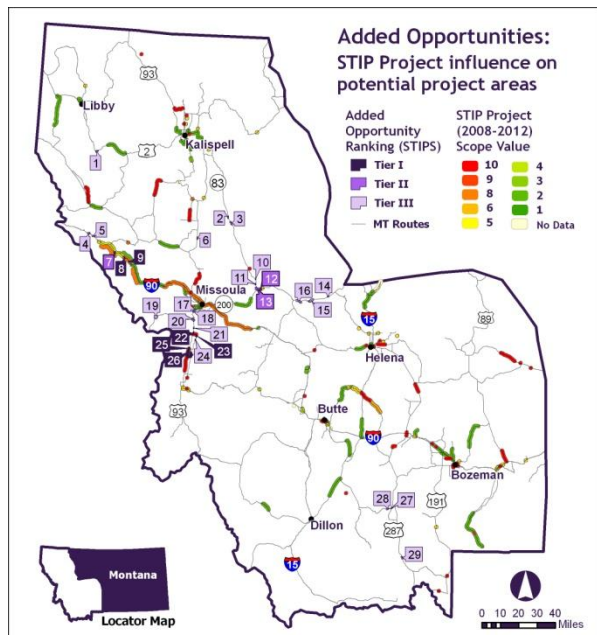
Step 1 Results:
Ungulate Species and Focal Species Road Kill High Concentration Areas.

Note: Linkages are displayed underneath but were not considered in the analysis until Step 2.

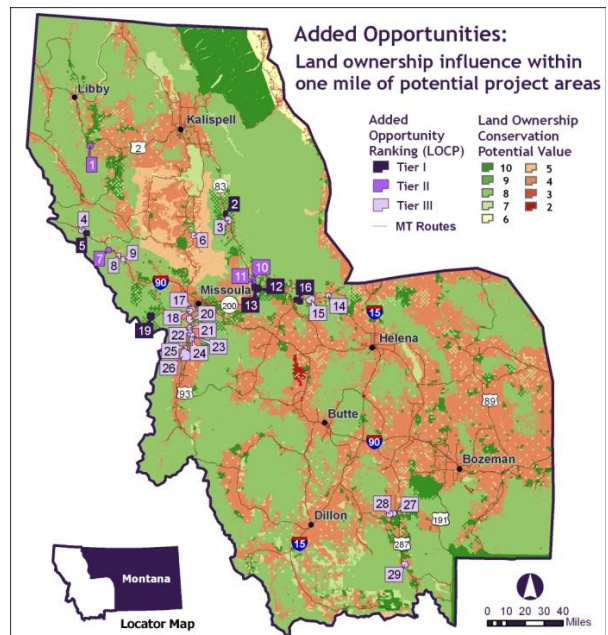


Step 2 Results:
Tier I, II, & III Potential Project Areas based on intersection of Ungulate Species and Focal Species Road Kill High Concentration Areas with highest priority linkage areas.

Note: All wildlife linkages are displayed on map but only “very high” and “high” linkages were considered in determining the potential project areas and consequent tiers.



Step 3a Results:
Potential Project Areas in Tier I, II, & III rankings based on State Transportation Program projects.



Step 3b Results:
Potential Project Areas in Tier I, II, & III rankings based on Land Ownership conservation Potential.

Figure 6. Four map series illustrating prioritization results from analysis steps 1 – 3.

It is important to recognize that the added opportunity areas (Step 3), that are based on the State Transportation and Improvement Program and the Land Ownership Conservation Potential index, are designed to provide additional information for the prioritization process, but not to act as dictating criteria. It should not be inferred that the existence of a STIP project or high value LOCP is required for prioritizing a wildlife mitigation area. The presence of a highly valued STIP project may make highway-based mitigation easier to achieve, but we recognize that other areas without a planned STIP project may be more important for protecting wildlife movement or improving human safety. In these cases, projects can be nominated for mitigation work through the STIP process. The same is true for the Land Ownership Conservation Potential index. While the LOCP was designed to highlight areas where the costs of conservation (in terms of dollars and political capital) may be less, there may be areas with low LOCP values that, due to importance for wildlife, are prioritized.

We found the STIP to be a useful tool for prioritizing areas, especially in the short term, due to the fact that a MDT transportation-related project already exists. Upon discussing the STIP with MDT however, we learned that the projects included in the program are not guaranteed. In MT and most likely in many other states, these projects are provisional and, due to a variety of factors, some projects may not make it to completion.

GIS Techniques

The use of kernel density estimate (KDE) was appropriate in the western MT analysis because it was applied across a large geographic region. KDE spreads density values over a newly created surface, enabling the user to visualize where a high concentration of underlying points occurs, but may not be exactly spatially coincident with the underlying points. For example, where there are many road kill events along a curve in the road, the highest density illustrated will be inside the area defined by the curve. This could result in the appearance of a high concentration of road kill events slightly away from rather than directly on the road. A similar issue arises when road kill events occur near intersecting roads or on roads that are adjacent to one another. Finally, the KDE outputs a relative density value for each cell. Therefore, the user cannot read the density surface such that one color represents an absolute number of underlying road kill events, only that a color represents a density category (“high” to “low”). Of the areas that are displayed as belonging to the same category, it is not possible to determine which has a higher value. For single road networks or across a smaller area (fine scale), we recommend a set of potentially more sophisticated cluster analysis tools, such as those imbedded in CrimeStats (Levine 2007). We used percent volume contour to calculate the desired percent of overall density volume using the center of the grid cells rather than the grid cell as a whole. As a result, the polygon products can be smaller than the input grid cells, suggesting a finer resolution than is attainable given the underlying grid. A 500 meter buffer was added around each area defined by the PVC to address this issue. Buffering the PVC results, to some extent generalizes the resulting high concentration areas. This reduces the potential for product users to misinterpret areas identified in this section as point locations necessitating mitigation. An additional benefit to buffering polygons is that it encourages the user of the results to consider more of the surrounding landscape when investigating the need for mitigation.

The Assessment as a Planning Tool

A guiding principle of this project was to utilize a rapid and collaborative process to create a planning tool that could be used by American Wildlands and by other organizations and agencies. This type of assessment is a useful prioritizing method for determining areas which warrant activity and protection. As such, this assessment fulfills a variety of planning needs. American Wildlands will use the report for internal planning by using the results, along with other information, to determine the most important and appropriate areas for focusing our program efforts. Through this prioritization process, we strengthened AWL’s internal programmatic planning and improved coordination and communication with our partners. The assessment is also useful as an external planning and coordinating tool for our partners and regional agencies. This effort will help foster better cooperation and coordination between wildlife and highways entities throughout the region.

This assessment was not designed to identify exact areas deserving wildlife mitigation, but rather as an overarching planning tool to target areas warranting increased focus. In those areas, further information regarding specifics of wildlife movement and linkage opportunities is required. This is especially true due to the opportunistic nature of the road kill database, limited road kill data for threatened, endangered and sensitive species, and the regional scale of the wildlife Priority Linkage Assessment data. In areas where enough collective information is already known regarding wildlife movement and the transportation routes, action could be taken quickly. However, due diligence about wildlife and habitat conditions in each of the potential project areas and/or the other high concentration areas is essential. Additionally, the working group discussed alternative ways of viewing the information, especially in terms of MDT’s State Transportation Improvement Program projects. Although locations with added opportunities due to an existing

STIP project were identified, there are many sites in western Montana currently not identified in the STIP which may be well suited for future projects.

While this assessment provided a focused list of potential project areas it also set the stage for capacity and policy improvements within the participating agencies. Through the identification of data gaps and planning hurdles between the agencies the group members were better able to propose new ways to improve interagency coordination. Following the preliminary results of the analysis, the advisory group agreed to work towards a series of process-based next steps. These steps are designed to: 1) improve road kill data collection, and 2) increase cooperation between agencies and organizations on wildlife- transportation issues. They include: setting up an interagency "Montana Wildlife Linkage and Highway Safety Committee;" conducting an advisory group-based prioritization based on individual member organization capacity analysis in conjunction with report findings; and designing an inter-agency centralized road kill database (building off other state database models, such as Idaho's). This level of agreement and the development of next steps highlight the value of this process as a consensus building tool.

Conclusion

This rapid assessment process can be adapted by others to prioritize transportation and wildlife mitigation efforts as well as improve coordination between parties with varied interests and management directives. The ability to complete a draft document in just one year is one of the most valuable aspects of this project. Since this process was centrally driven by dedicated staff at an organization separate from the partner agencies and organizations, the speed of the assessment was greatly increased. This efficiency results in data products that are relevant and timely which, in turn, translate into improvements in policy, data management, and on the ground results. To be successful it is critical that there be sufficient representation from the main parties involved in the issue. Allowing these partners to help direct the analysis process increases the likelihood that the results and products will be internalized into agency policy and actions.

To support improved planning processes, and help ensure that this analysis is fully utilized by the partner agencies, American Wildlands worked closely with working group members to define and then create products that best fit the varied needs of the members. These products include data layers used in the analysis that can be incorporated into internal planning efforts by individual agencies. To effectively convey the results of each analysis step we produced a series of maps that summarize the results. These maps serve as a quick reference for managers and planners as they plan and design projects. We also created short summaries and maps for the 29 potential project areas that were identified for prioritization. We are encouraging broad use of this analysis by packaging the entire process in a comprehensive report and by providing these products in digital form on the internet. Through an inclusive, responsive and data driven process we have created a planning resource and process that is not only useful in western Montana but can serve as a model for others looking to conduct a similar analysis.

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Biographical Sketches

Julie Betsch has 8 years of field experience in wildlife and conservation biology with an emphasis on employing non-invasive methods to study large carnivores. Most recently she was employed as a GIS analyst at American Wildlands, where her efforts focused on wildlife connectivity issues in the northern Rockies. She earned a B.S. in Biology from the University of Cincinnati and is currently an NSF IGERT trainee and PhD student at the University of Montana.

Sarah K.F. Olimb coordinated the geospatial and statistical analyses at American Wildlands from 2006-2009. Since 2003, she has used Geographic Information Systems to guide and strengthen conservation research in the Northern Rocky Mountains, Northern Great Plains, and Southern Appalachia. She has a Masters of Biology from the University of North Dakota (2006) and a B.S. in Population and Conservation Ecology from the University of Georgia (2003).

Dylan W. Taylor works on wildlife habitat connectivity and transportation issues at American Wildlands. He has 10 years experience in conservation policy and wildlife biology in the Rocky Mountains. In addition to his current efforts in Montana, he has worked on transportation and wildlife movement research and advocacy in Banff National Park in Canada, on the Bridger-Teton National Forest in Wyoming, and in the Vail Pass section of Interstate 70 in Colorado. Dylan received a B.A. in Environmental Studies at the University of North Carolina, Wilmington (1994), and a Masters of Forestry at the Yale School of Forestry and Environmental Studies (2002).

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