US 89 Wildlife & Transportation Assessment

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YELLOWSTONE SAFE PASSAGES

Disclaimer

Cover Photo: Bill Campbell; taken during an Ecoflight over Paradise Valley piloted by Bruce Gordon, June 2023.

Acknowledgements

Funders: AMB West Conservation Fund, Greater Yellowstone Coalition, Weeden Foundation.

Organizations: Ecoflight, Federal Highway Administration, Greater Yellowstone Coalition, Interagency Grizzly Bear Study Team, Montana Department of Transportation, Montana Fish, Wildlife and Parks, Montana Freshwater Partners, National Parks Conservation Association, Park County Environmental Council, The Common Ground Project, U.S. Fish and Wildlife Service, U.S. Forest Service, Yellowstone National Park.

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Please note: the parties above have provided support, assistance, or input that have helped shape this report, and the authors are grateful for their assistance. Their inclusion is not intended to suggest endorsement of this report or its recommendations.

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1. Introduction

1.1 Overview

The US Highway 89 (US 89) Assessment is intended to improve community understanding of interactions between the highway, drivers, and wildlife in the Upper Yellowstone Watershed in southwest Montana. The landscape—known as Paradise Valley north of Yankee Jim Canyon and the Gardiner Basin to the south of the canyon—is surrounded by Yellowstone National Park to the south, the Absaroka-Beartooth and Gallatin mountain ranges to the east and west respectively, and the town of Livingston to the north. From the high mountain peaks to the Yellowstone River meandering through the valley floor, this landscape is home to a diversity of people and wildlife. It boasts world-class outdoor recreation activities, maintains a “wild and working” character through its agricultural heritage, and holds a remarkable and complex relationship with Indigenous Peoples.

Constructed in 1961, the portion of US 89 from Livingston to Gardiner located in Park County, weaves between public and private lands, serves as the main commuting option for the communities of Gardiner and Emigrant, and is a primary entrance to Yellowstone National Park.

Enhancing habitat and protecting migration routes for animal species along US 89 is vital for the economy of Park County. Out-of-state travelers alone spend more than $236 million annually in the county, and when asked why they chose to visit Montana’s Yellowstone Country, 39% of visitors report that “wildlife watching” is a priority (RRC Associates and the Institute for Tourism and Recreation Research 2022).

This report is the culmination of years of collaboration between the Yellowstone Safe Passages Partnership and citizens of the Upper Yellowstone Watershed. The assessment, initiated by the Yellowstone Safe Passages Partnership [section 1.2.1] and conducted by the Center for Large Landscape Conservation (CLLC), Montana State University’s Western Transportation Institute (WTI), Montana Freshwater Partners, and Dr. Shane Doyle, provides an overview of the state of wildlife-transportation interactions along the highway corridor and proposed opportunities for improving driver safety and ecological connectivity for all species sharing the landscape.

The mitigation measures proposed in this report are intended to provide a starting point for agencies, elected officials, and community members to collaboratively determine what the highway corridor could look like and how it could function in the future. The suggestions throughout this report are intended to inform, rather than prescribe, future action. Implementing any of the suggested mitigation measures will depend on factors such as public support, design and engineering feasibility, funding availability, and agency discretion. Montana Department of Transportation will be key in implementing any proposed measures. Montana’s 5-year Statewide Transportation Improvement Program (STIP) and the Montana Wildlife and Transportation Partnership’s Project Program will be the key avenues for advancing projects on US 89. Any efforts to mitigate safety issues on the highway will occur over a multi-year period as a result of the collective will of the stakeholders in the Upper Yellowstone Watershed.

1.2 Existing Partnerships: Yellowstone Safe Passages Partnership

Yellowstone Safe Passages (YSP) began with the recognition that a community-led partnership would be best equipped to address and resolve wildlife-vehicle conflicts (WVCs) in the watershed. YSP is a Partnership of organizations and individuals who live, work, and recreate in the Upper Yellowstone Watershed. The partnership consists of state and federal agency representatives, private foundations, community groups, conservation groups, business owners, and local landowners and citizens who aim to enhance the safety of people and wildlife traveling US 89. YSP envisions the Upper Yellowstone Watershed to be a place where visitors and locals can travel the highway without wildlife-related accidents and where the highway doesn't act as a barrier to the movement of Yellowstone's wildlife populations.

YSP is recognized as a leading model for community-based, collaborative partnerships addressing WVCs in Montana. The partnership was founded on the principles of being diverse in skills, well-informed, and well-resourced. The core leadership team demonstrates these character traits through their collaborative culture. In 2022, Yellowstone Safe Passages partnered with the Center for Large Landscape Conservation and the Western Transportation Institute to develop a fine-scale Wildlife and Transportation Assessment ("Assessment") of US 89 from Livingston to Gardiner.

1.2.1 Yellowstone Safe Passages Activities to Date

Over the past three years, YSP ignited a sense of urgency for community members, business owners, nongovernmental organizations, conservation groups, agencies, foundations, and landowners to address and resolve the complex issue of WVCs on US 89. Their work, to date, has focused primarily on "listening and learning," elevating awareness about the negative impacts of WVCs, implementing citizen science and highway monitoring programs, building relationships with the state transportation and wildlife agencies, and engaging local community members. They have convened numerous public conversations in Livingston, Gardiner, and Emigrant to gain local perspectives on wildlife, roadway safety, and road corridor development. Activities ranged from discussions to active data gathering and mapping exercises.

1.3 Objectives

The goal of this report is to inform Paradise Valley and Gardiner Basin residents and agency staff of the potential avenues for roadway safety improvement, from wildlife accommodation options to funding opportunities for implementation [Section 11]. Available funding for wildlife passage measures is at an all-time high, making the content of this report timely for the Upper Yellowstone Watershed.

The assessment uses agency wildlife-vehicle collision, wildlife carcass data, wildlife movement (collar), and habitat suitability data to determine priority sites through spatial analysis [Section 4]. An interdisciplinary Technical Advisory Committee of state and federal agency representatives, biologists, engineers, and transportation ecology experts visited each priority site to discuss the feasibility of accommodation measures in each location. Yellowstone Safe Passages also conducted extensive community outreach to gather local expertise about wildlife movement in the area before the site visits. YSP additionally conducted a weekly systematic survey of roadkill along the highway corridor and facilitated a citizen science program of opportunistic roadkill data collection.

Based on the results of YSP analysis and public engagement, they identified locations for a range of potential wildlife accommodations—such as upsized bridges and culverts, underpasses and overpasses, animal detection systems, and exclusionary fencing—that consider both terrestrial and aquatic species needs. However, the implementation of specific measures is contingent upon site-specific factors such as topography, land ownership, species presence, engineering feasibility, and cost-benefit considerations. Crossing structures, like underpasses, overpasses, and fencing require significant initial investment; however, extensive research has shown they are cost-effective over their lifetime due to their efficacy in reducing wildlife-vehicle collisions, and minimal maintenance costs when compared to options such as animal detection systems (Brennan, Chow, and Lamb 2022; Huijser et al. 2009, Huijser and Duffield 2022).

Additionally, upscaled bridges and culverts can offer co-benefits of both accommodating wildlife movement and ensuring greater infrastructure resiliency in the face of increasingly frequent, extreme weather events. In the Spring of 2022, Paradise Valley and the Gardiner Basin experienced an extreme flood that caused significant damage to infrastructure in the area. Replacing and upsizing bridges and culverts along the US 89 corridor presents a unique opportunity to enhance the resilience of highway infrastructure and improve safe crossing opportunities for wildlife species.

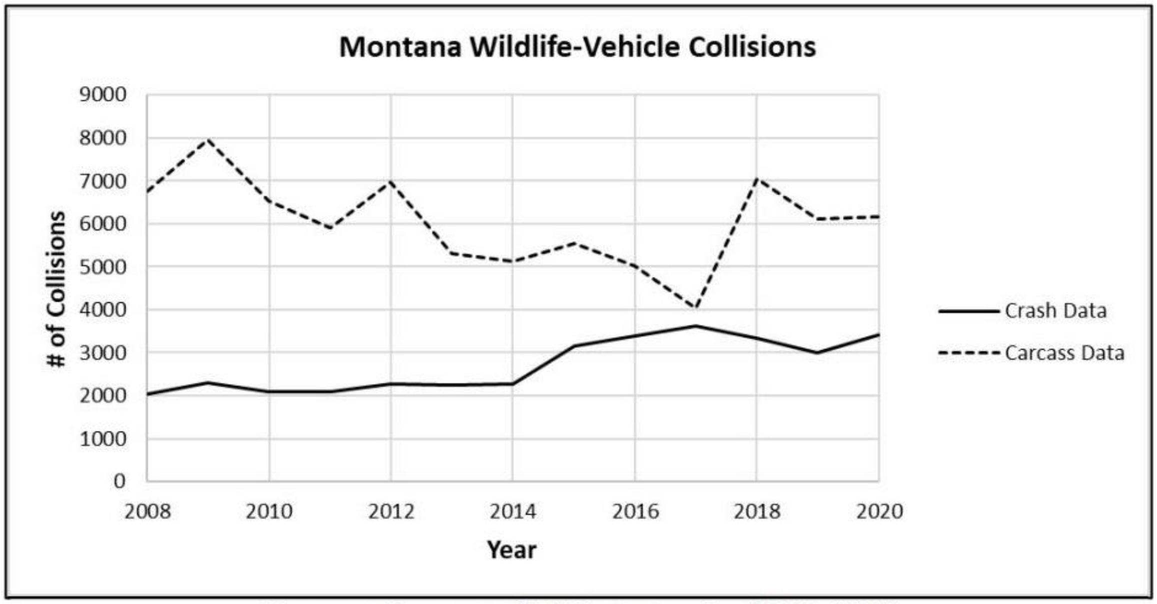
1.4 Impacts of Roads

Linear infrastructure, such as roads, railways, and transmission lines, is among the most direct threats to ecological connectivity. Roads can create barriers to wildlife movement, limiting the ability of wildlife to find water, food, and mates, and can sever routes used by wildlife to migrate seasonally between winter and summer ranges.

One of the most pressing dangers for people and wildlife on roadways is wildlife-vehicle collisions. These accidents almost always result in wildlife mortality, fragment habitat, and, in some cases, impact populations of threatened and endangered species. These impacts are particularly relevant for the Upper Yellowstone, which has diverse and robust wildlife populations that are rare in the rest of North America. The species of wildlife most associated with WCVs in the Upper Yellowstone watershed are white-tailed deer, followed by mule deer, elk, moose, bison, bighorn sheep, pronghorn, black bear, grizzly bear, mountain lion, coyote, fox, raccoon, skunk, and many smaller creatures. Large birds of prey are also occasionally struck along the highway, often as they feed on carcasses of other road-killed animals.

Not only does linear infrastructure directly threaten wildlife populations, but it also poses a serious and sometimes lethal threat to motorists. Each year in the U.S., WVCs cause more than 200 human fatalities, and tens of thousands of human injuries. These collisions result in over $8 billion of direct costs to the American public each year (Conover et al. 1995; Huijser et al. 2009).

State Farm Insurance ranks Montana second among states where drivers run the highest risk of hitting wildlife, and ten percent of all reported crashes in the state are with wildlife (WTI-MSU, unpublished data, 2023).



Montana: Percent of WVCs by Species (2008-2020)

White-tailed Deer	Mule Deer	Elk	Pronghorn	Moose	Grizzly Bear	Wolf	Other
67.78	26.46	2.80	1.24	0.42	0.03	0.02	1.24

Figure 1. Reported Crashes and Carcasses Collected in Montana, 2008-2020 and Average Percent of Wildlife-Vehicle Collisions by Species. Compiled by Matthew Bell, WTI-MSU.

However, in the Upper Yellowstone Watershed, roughly 50% of all highway accidents are attributed to wildlife conflicts (MDT 2014). This compares to just 5% of all accidents nationwide and 10% of accidents in Montana (WTI-MSU, unpublished data, 2023). Since the Spring of 2020, the team at Yellowstone Safe Passages has been monitoring US 89 with ArcGIS software and via game-trail cameras near the highway. YSP conservatively estimates there are well over 160 WVCs per year on US 89 between Livingston and Gardiner. These WVCs can be very expensive and pose a direct economic threat to local livelihoods. Between 2012 and 2023 CLLC/WTI estimated the direct cost [Section 9] of WVCs in the Upper Yellowstone Watershed to be nearly $32 million.

1.5 Supporting Research

A 2014 US 89 corridor study by the Montana Department of Transportation (MDT) concluded that "wildlife-vehicle conflicts commonly occur throughout the study area and present a danger to human safety and wildlife survival. Grade separation, fencing, advance animal detection, signing, or speed-reduction strategies may have merit in corridor areas. Due to the complexities and numerous variables to consider when evaluating the feasibility of wildlife mitigation strategies, these should be explored in sufficient detail during project-level design as part of the project development process" (MDT 2014). The study also noted that the public expressed concern over the number of wildlife-vehicle collisions in the corridor, and the study partners agreed that wildlife-vehicle conflicts warrant further investigation through a conservation assessment. They continue: "Such an assessment could be undertaken by other parties, such as non-governmental conservation groups, citizen groups, or natural resource agencies. MDT and Park County are not in a position to contribute financially to a valley-wide wildlife conservation assessment but may be able to provide 'in-kind' services in terms of mapping, review, and/or data contributions, and would consider any available data or information that arises from such a study in the analysis and recommendations for wildlife mitigation strategies as projects are developed along the US 89 corridor." This report is a direct effort to fulfill that identified need.

In February of 2018, then secretary of the U.S. Department of the Interior Ryan Zinke signed into law Secretarial Order 3362 (SO 3362) with the purpose of improving habitat quality in western big-game winter range and migration corridors specifically for pronghorn, elk, and mule deer across the western U.S. In the Montana State Action Plan for SO 3362, Montana Fish, Wildlife, & Parks (FWP) identified "Yellowstone National Park to Paradise Valley," the study area for this Assessment, as one of four priority areas across the state due to the fact that "…this corridor hosts multiple species that include elk, antelope, and mule deer. Further, this corridor hosts multiple iconic wildlife species and connects the world-renowned Yellowstone National Park with the adjacent Paradise Valley" (FWP, 2020). However, in 2022 FWP updated its action plan and replaced this priority area with another due to a perceived lack of projects ready to be implemented. This report hopes to help identify implementable projects to improve movement and migration for these species and potentially elevate this area back into priority status.

1.6 Wildlife Overview

The study area along the US 89 corridor has a variety of notable species, including white-tail and mule deer, elk, moose, pronghorn, bighorn sheep, black bear, mountain lion, gray wolf, and coyotes. A herd of bighorn sheep use the area around Corwin Springs and are frequently seen near the roadway, particularly in the winter (MDT, 2014). Many other common mammals can be found in the study area, including rabbit, porcupine, raccoon, striped skunk, badger, bobcat, red fox, beaver, muskrat, Richardson's ground squirrel, deer mouse, vole species, and a variety of bat species, and other small mammals (MDT, 2014). A diverse assemblage of birds (migratory and non-migratory) as well as other nongame species (including amphibians and reptiles) use the area surrounding US 89. Grizzly bears are present in the study area, with five recorded mortalities due to wildlife-vehicle collisions in the past 10 years (Section X), and other threatened and endangered species such as Canada lynx and wolverine may also traverse the corridor.

The study area is particularly valuable for some large-ranging species such as elk, mule deer, grizzly bears, and wolves, and is an important landscape for ecological connectivity within the Greater Yellowstone Ecosystem. Migratory ungulates such as elk, mule deer, and pronghorn rely on parts of the study area as migratory corridors, stop over locations, and winter range. For example, an elk migration by the Northern Yellowstone Elk herd occurs through the southern portion of the study area from winter range centered around the Dome Mountain area to summer range high in Yellowstone National Park (FWP, 2020). The wintering area includes the Dome Mountain Wildlife Management Area and the surrounding private ranchlands, highlighting the importance of these areas to the future of this herd (FWP, 2020).

In addition to resident deer, mule deer have been observed migrating through the study area from their summer range in Yellowstone National Park, north through Paradise Valley, to winter in the lower elevations of the Bridger Mountains (FWP, 2020). Pronghorn that winter near Gardiner are partially migratory, with some animals moving into Yellowstone National Park, using a well-defined migration route near Mount Everts, and some animals remaining on winter range near Gardiner year-round (FWP, 2020). In the Paradise Valley, pronghorn are mainly found on the west side of the river and highway, though suitable habitat and historic range exists on the east side as well. Efforts by groups such as FWP and National Parks Conservation Association have focused wildlife-friendly fencing projects to allow pronghorn to move more freely throughout their range.

1.7 Conceptual connectivity for the Gardiner Basin and Paradise Valley

Human development has substantially changed wildlife habitat in the Gardiner Basin and Paradise Valley over the past few hundred years. Agriculture, villages, towns, dispersed houses, and other buildings, roads, and wildlife management practices have all affected where different wildlife species are present and how they move through the area. Investments in mitigation measures, also called wildlife accommodation measures, along US 89 would address some of these impacts and help reduce them, making it more likely that wildlife can endure in this area alongside humans. Such mitigation measures are typically reactive to immediate problems, e.g., "there are too many collisions with large wild mammals on road section A" or "pronghorn have too much trouble crossing the highway at road section B." Mitigation measures along infrastructure can restore lost connectivity due to changes in land use or create connectivity in new areas, given opportunities or constraints in current land use patterns, independent of historical evidence of wildlife migration in the past.

In other words, road sections selected for implementing mitigation measures can be based on:

1. solving current challenges related to human safety, wildlife mortality, and/or barrier effects for wildlife,
2. restoring historical wildlife connectivity previously impaired or lost, or
3. creating new connectivity along certain road sections and adjacent lands, even if there were not concentrated wildlife movements in the area in the past.

There is no need to aim for only one of these three ambitions in a project. It is possible, perhaps even desirable, to include a combination of them.

There are six distinct sections of US 89, each with unique needs. Going from south to north in the Gardiner Basin and Paradise Valley, they are:

1. Gardiner Basin: Despite a town (Gardiner), a village (Corwin Springs), dispersed houses, agriculture, and multiple roads, there is extensive wildlife habitat and movement in the valley, including bison, elk, deer, pronghorn, sensitive species like bighorn sheep, and threatened species such as grizzly bear. Investment in both human safety and biological conservation is needed in this area. Improving connectivity across US 89 and the surrounding bottomlands in the valley would address current problems and needs for the full range of species. Wildlife habitat and connectivity still exist, at least to a certain degree, both in the mountains and hills around the valley and in the valley itself.

2. Yankee Jim Canyon: The topography is steep, the Yellowstone River is confined with multiple rapids, and US 89 is situated immediately adjacent to the river in most of the canyon. This makes wildlife movement across the highway and adjacent river difficult, even without considering the impact of development. Measures would be primarily aimed at improving access for resident animals between water and escape terrain (e.g., bighorn sheep, mule deer), and less about connecting habitat between the foothill habitat on the west and east sides of the canyon.

3. Southern Paradise Valley (Dome Mountain area through Emigrant): Alongside dispersed houses, agriculture, and multiple roads in the valley, wildlife use the valley in this section intensively. Species include elk, deer, pronghorn, and sensitive and threatened species such as grizzly bears. Wildlife habitat and connectivity still exist, at least to a certain degree, both in the mountains and hills around this southern part of the Paradise Valley and in the valley itself. Connectivity across US 89 and the surrounding bottomlands in the valley would address current problems and needs for the full suite of species. Investing in both human safety and biological conservation is needed based on the current situation. There is also the potential to "restore" habitat and connectivity for specific species (e.g., bison, pronghorn) that have historically migrated between the Gardiner Valley and Paradise Valley (east and north of Dome Mountain).

4. Northern Paradise Valley (Emigrant until south of Livingston): This area is characterized by agriculture, dispersed houses and other buildings, and increasing housing developments. Connectivity across US 89 and the surrounding bottomlands in the valley would address current problems and needs for common ungulates such as deer and elk, which are the greatest concern from a human safety perspective. Roadway mortality of grizzly bear has not been recorded here, and investments in connectivity for sensitive species along the highway are likely to be negated by further housing developments.

5. Wineglass/Allenspur Canyon: This area is characterized by some agriculture and dispersed houses and other buildings, but also by remaining tracts of natural habitat. The hills west of the highway come close to the highway, and the Yellowstone River and its floodplain is immediately east of the highway, giving rise to the foothills of the Absaroka Range nearby. Connectivity across US 89 and the valley bottom, connecting the hills and mountains west and east of the valley, could potentially "create" connectivity, including for sensitive species, regardless of whether this area ever had a concentration of wildlife movements.

6. Livingston South: this area has a high concentration of commercial properties and houses. Despite this development, mule deer and white-tailed deer come from the hills and mountains to the west and often cross US 89 to access food and water from yards and the Yellowstone River and its floodplain. This environment has been permanently altered, and recent road reconstruction included no wildlife mitigation. If mitigation measures were developed in this area in the future, they should probably be founded in the reality of a "novel ecosystem" that has no reference in the past (i.e., acknowledge human and wildlife coexistence in a heavily developed landscape with few remaining natural characteristics).

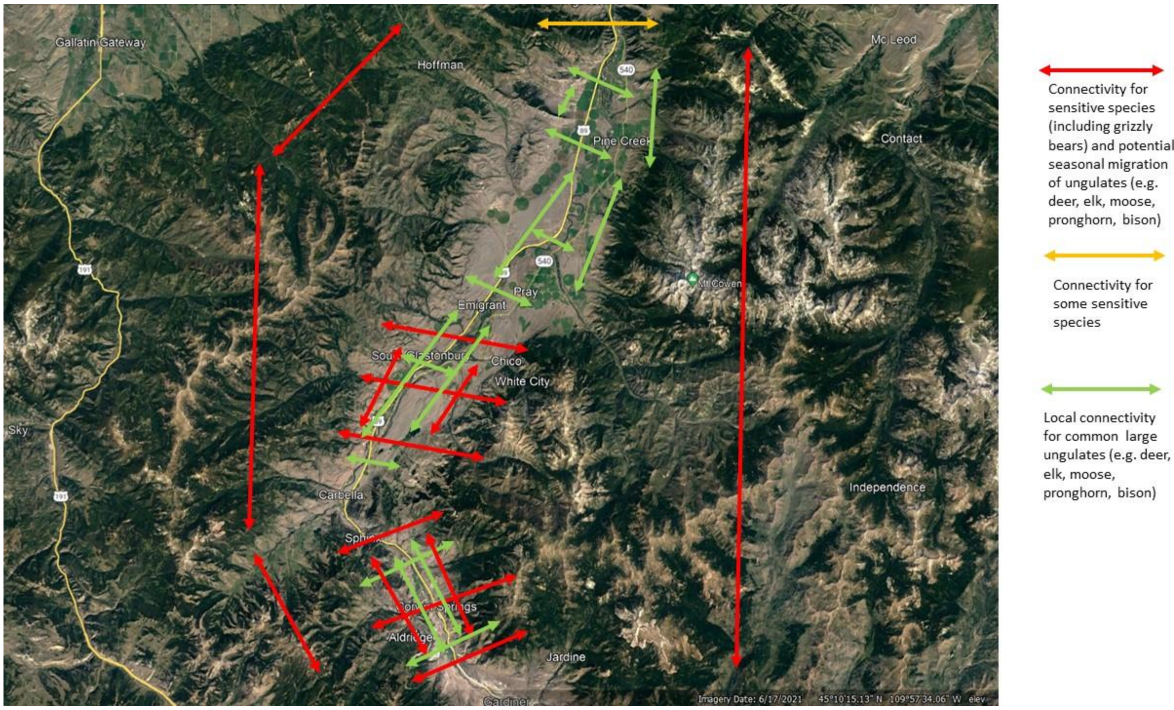


Figure 2. Conceptual Connectivity in Paradise Valley and the Gardiner Basin

1.8 Integrating Local and Traditional Ecological Knowledge

Understanding the interactions between humans and wildlife in the Gardiner Basin and Paradise Valley today demands an examination of both local ecological knowledge and traditional ecological knowledge.

Recognizing the current and long-term human occupation, use, and movement through this ecosystem is crucial to this assessment. Ecological restoration—in this case, in the form of mitigation measures to increase the safety of humans and restore wildlife movement across the highway corridor—can also restore a healthier relationship between people and the ecosystem where they live, work, and recreate (Gann et al., 2019).

Some fundamental principles that guide ecological restoration are effectively engaging a wide range of stakeholders and fully utilizing available scientific, traditional, and local knowledge (Gann et al., 2019). This assessment sought to include the insights of the people of Paradise Valley and the Gardiner Basin from history to today in the ways explained below.

Local Ecological Knowledge

Local Ecological Knowledge (LEK) is defined in part as local, place-based knowledge of the land and wildlife (Gann et al., 2019). In 2022, YSP held a series of local mapping workshops to incorporate LEK from landowners and those who live and work in Paradise Valley. Locals plotted location points and descriptions on the maps provided to indicate wildlife they encountered either in WVCs or moving across or near the highway. As part of this effort, YSP held a meeting in Gardiner, Montana, with local outdoor guides and Yellowstone National Park (YNP) biologists to incorporate LEK from those who make a living in the recreation economy or by studying and managing wildlife in the study area.

A series of public meetings in the study area communities also allowed local residents to share their stories about their use of the land, their observations of wildlife over time, and how the highway affects their livelihoods. Some stories included cattle ranchers' operations being fragmented by the highway and the increasing traffic during their seasonal cattle drives to pastures across the highway. There were also stories from property owners who have personally euthanized badly injured or orphaned wildlife after a WVC. Valuable insight was gained into the movements and presence of certain herds and species of wildlife and how some have changed over time.

Traditional Ecological Knowledge

It is also vital to consider the traditional ecological knowledge of the peoples who lived in the regions for thousands of years. Traditional Ecological Knowledge (TEK) is defined as knowledge and practice passed on from generation to generation and informed by strong cultural memories, sensitivity to change, and values that include reciprocity (Gann et al., 2019). Honoring YSP's mission to support collaborative and effective solutions incorporates these perspectives with intention.

Indigenous Peoples' observations of the study area have been passed down over millennia. Because TEK observations are long-term, they can be particularly valuable in guiding ecological restoration (Gann et al., 2019). Research demonstrates that the long-term perspectives gained from traditional knowledge offer critical, complementary information that can supplement scientific study and data gathering, improving the odds of successful wildlife management strategies (Polfus et al., 2014)

It is also crucial to consider TEK when implementing wildlife management strategies to prevent a continuation of historical injustices (Souther et al., 2023). Strategies must consider these perspectives because the study area continues to play a vital role in the traditional cultural practices of many tribes.

The TEK of those who lived in and migrated through the region offers essential insight into contemporary efforts to protect species and human safety. Below, Native American Cultural Consultant Dr. Shane Doyle examines the Indigenous background of the study area.

2. An Indigenous Cultural Background of the Paradise Valley

A singular combination of geologic, geographic, climatic, biological and cultural characteristics makes the Paradise Valley one of the most significant Indigenous pathways in the Western Hemisphere.

Human History in the Paradise Valley

2.1 Clovis Era – 19th Century

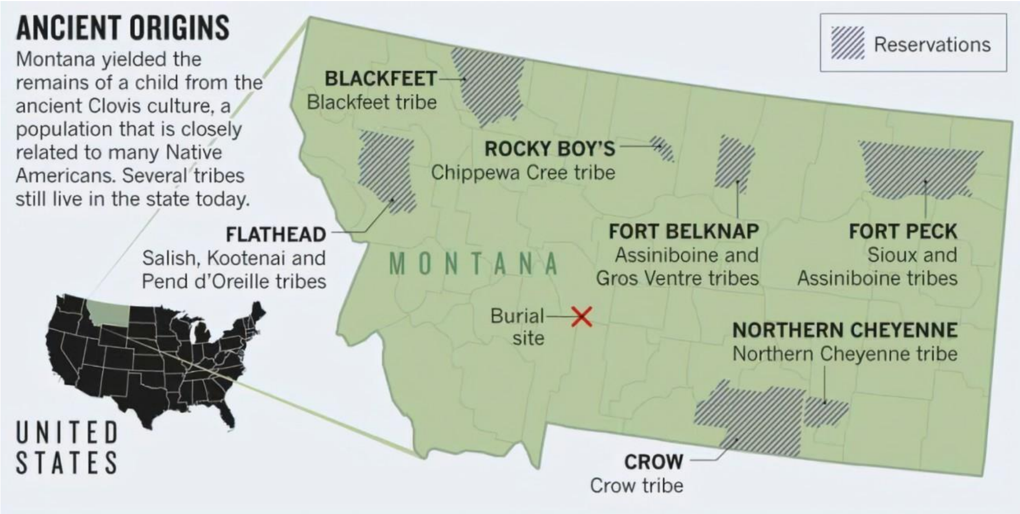


Figure 3. Map of where Clovis remains were found north of Paradise Valley. Source: Montana Office of Public Instruction.

The oldest evidence of Indigenous people traversing through the Paradise Valley are remnants of 11,000-year-old Clovis culture spear points recovered along the Yellowstone River, north of Gardiner. Additionally, the 12,600-year-old Anzick Clovis site is located about 30 miles north of the Paradise Valley and is recognized as the oldest known burial in the Western Hemisphere. The Anzick site is near the town of Wilsall in the Shields Valley and is directly connected to the Paradise Valley through ancient bison migration patterns. Predominant winds, protein rich grasses, and fresh river water brought vast herds of bison southward through the Judith Gap in Central Montana and then towards the Shields River Valley and continuing through the Paradise Valley. As peoples who relied primarily on bison for their food, shelter, and all-purpose tools, Tribal people of the region didn't "chase buffalo"; instead, they placed themselves in strategic positions to harvest this vital natural resource as they followed the wind and the smell of grass and water. All of these environmental factors combined to create predictable animal behaviors, and the Native people understood that the Paradise Valley was an important area where all of those key elements combined to create an ecosystem ideal for hunting bison, but also for elk, deer, and pronghorn.

Over 300 pounds of 2,000-year-old Yellowstone obsidian has been recovered from Hopewell culture mounds located over 1,600 miles to the east in present day Ohio. This discovery is the strongest proof yet that the Paradise Valley was one of the continent's most significant conduits for precious resource access, trade, and dispersal. Ancient obsidian miners had to simply follow the Yellowstone River upstream through the Paradise Valley, then take the path along the Gardner River to reach the Obsidian Cliffs. Their return to the east would've been made easier with boats floating downstream to the confluence of the Missouri and then Mississippi Rivers. Yet, this hypothetical journey 2,000 years ago may not have been necessary if trade networks of the day were able to suffice. Regardless of the mining and transportation processes, Yellowstone obsidian's closest, easiest, and most utilized trade route passed through the Paradise Valley.

2.2 Apsáalooke

Known to the Apsáalooke people as Púchéetá'annaáu, or "well-traveled road," the Paradise Valley holds a rich and ancient history and continues to remain a very important place to the Apsáalooke community. Over the past 500 years, the Apsáalooke nation was the Tribe most closely associated with the Paradise Valley, and the high mountains along the eastern edge of the Paradise Valley were named Absaroka, in their honor. According to most Apsáalooke oral histories, the Tribe walked to the Big Horn Mountains and Paradise Valley over 500 years ago. The people were coming from the east, around the Great Lakes, following a visionary leader named No Vitals, who dreamed of sacred tobacco plants growing on a high mountain (known today as Cloud Peak). The Tribe lived as hunter-gatherers-traders throughout the Big Horn and Yellowstone region and traveled the many trails connecting valleys and animal migration routes. Paradise Valley was the "well-traveled road" to the north that connected travelers to a wealth of natural resources in the Land of Steam and a nexus of divergent pathways that lead to the east, south and west. Every year on a seasonal basis, family and community groups moved through Púchéetá'annaáu, but the Paradise Valley was not just a pass-through zone—it was also a destination place for bison hunters. In his book *From the Heart of Crow Country*, Dr. Joseph Medicine Crow cites the Apsáalooke historian Charles Ten Bear, who relayed that Tribal groups camped near Emigrant every year in the Fall, and used the Emigrant buffalo jump, known as Awáassheele Hátchke Koón Bishéelapee or "Long Ridge Where the Buffalo Were Driven Over" to harvest the migrating herds of bison. Findley Creek, a tributary of the Yellowstone River, was the key source of local water used in processing the bison. The 1851 Fort Laramie Treaty designated the Yellowstone River and all the lands east of the river within the Paradise Valley as part of the original Crow Indian Reservation, so this bison jump stayed a part of the Crow Reservation until 1868, when a new treaty moved the Reservation's western boundary about 60 miles to the east.

Twenty-first century Apsáalooke people recognize the Paradise Valley as their homeland and continue to visit there frequently for many reasons, including swimming at the Chico Hot Springs, and gathering igneous rocks like basalt and pumice along the Yellowstone River and on private property like the Nelson Story Ranch near Emigrant. These igneous rocks are vitally important to the Apsáalooke sweat-lodge ceremony, as they are superheated over a fire and then placed inside the lodge and used to create sacred steam when water is poured onto them. This ceremony continues to be the most ubiquitous traditional practice on the Crow Reservation.

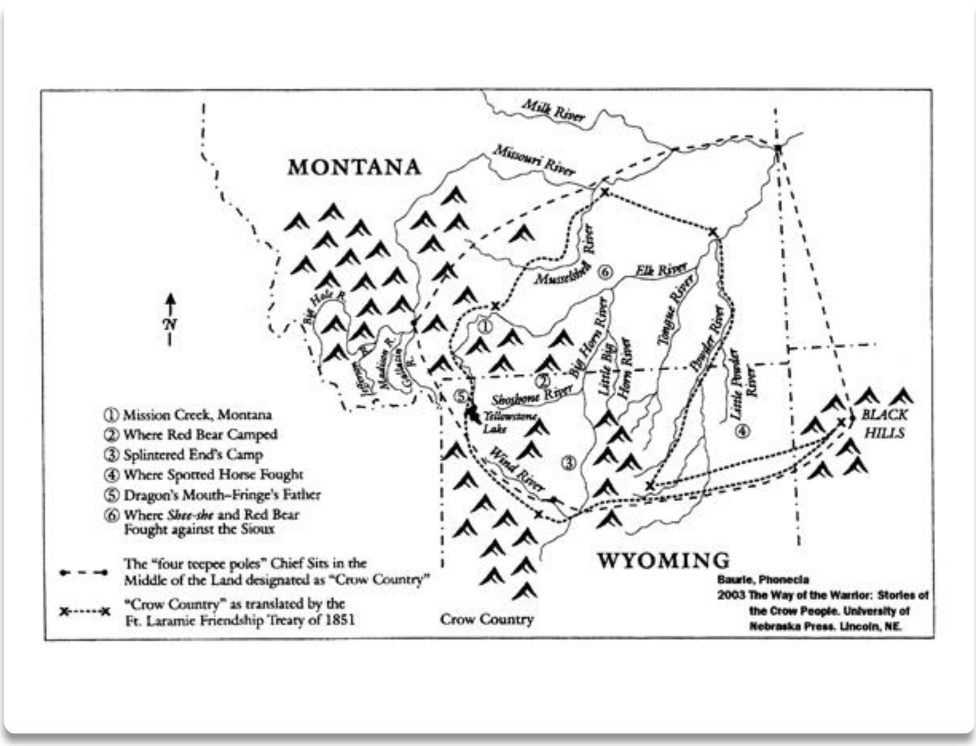


Figure 4. The Way of the Warrior. Source: Dr. Phenocia Bauerle

2.3 Blackfeet

The Paradise Valley has been a key part of the Blackfeet Nation's homeland for thousands of years and their hunting and traveling activity there over the past 500 years has been similar to that of the Apsáalooke, but less frequent. Most of the Blackfeet Nation wintered north of the Missouri River and along the Rocky Mountain Front and typically only ventured into the Paradise Valley during the summer months. Although the Blackfeet bands spent most of their year hundreds of miles north of Paradise Valley, their knowledge of the Missouri River watershed, as well as the Continental Divide and Columbia River watershed, was extensive and detailed. A Blackfeet chief named Feathers displayed this knowledge of the Missouri River and its major tributaries in 1801, when he drew a map on the ground for a French-Canadian trapper named Peter Fidler. Fidler copied the map, which included ethnographic information of the Tribal names, populations, days travel, and the Continental Divide, into his journal, and is shown in the photo below. The map describes roughly 150,000 square miles of watersheds, lands, and people, and identifies the Yellowstone River and Paradise Valley as well as prominent areas within the center of the watershed. Blackfeet oral traditions also identify the Elk (Yellowstone) River and the Paradise Valley as the southernmost areas of their homeland.

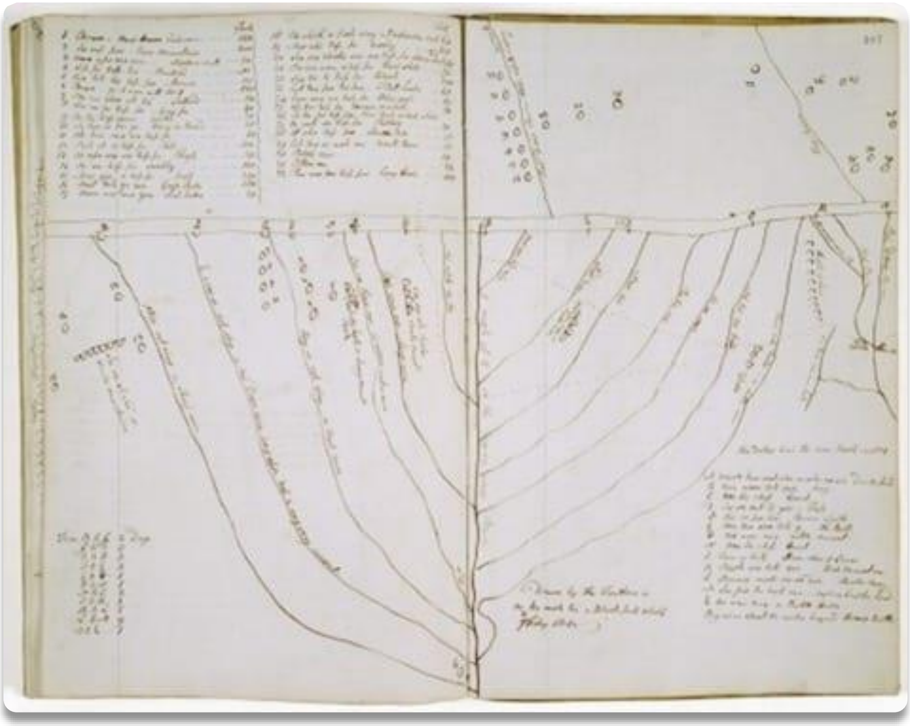


Figure 5. Peter Fidler and Ack-Mo-Mick-mi 1801 Map.

2.4 Shoshone & Bannock

Shoshone-speaking people have lived in the Yellowstone region since time immemorial and were likely some of the first arrivals in the area. The Eastern, or Bison Eater Shoshone, Sheep Eater Shoshone, and the Lemhi, or Salmon Eater Shoshone are the only Tribal groups that are known to have lived within the high mountain plateau country throughout the year, although the Sheep Eater Band was pushed out of Yellowstone National Park after 1872 and their members disbanded and absorbed into the Eastern and Salmon Eater bands. The Salmon Eater Band united with their longtime neighbors, the Bannock, and settled on the Ft Hall Indian Reservation in southeastern Idaho. The ancient and historic trail used by the Shoshone and Bannock to travel east to hunt buffalo goes through Yellowstone and the Paradise Valley, and can be viewed on this link: The Great Bannock Trail (arcgis.com).

2.5 Wildlife

Bison Migrations and Hunting Sites

Prior to the 18th century, it is estimated that 30 – 60 million bison lived on the grasslands of North America, and the upper Yellowstone region was in the heart of this mammal's territory for many important reasons. Buffalo are well known for walking towards oncoming wind, and before they were nearly exterminated in the mid-to-late-19th century, strong winds blowing northward through the Paradise Valley guided migrating herds of bison there. Like salmon swimming upstream, millions of bison passed through the wind-strewn valley since the end of the Pleistocene Era, following their noses and their sensibilities towards the green, watered meadows and pastures of the Paradise Valley.

The Paradise Valley's large-scale topographic manipulation by Tribal bison hunters is nearly unprecedented in world history from a hunter-gatherer-trader perspective. Only one other site in Syria, where hunters used rock lines to funnel migrating gazelles for harvest some 5,000 years ago, can compare. Local archaeologist Tom Jerde and others have identified over 60 miles of rock lines and walls created by Native hunters to assist in harvesting bison. A lack of organic material connected to their construction makes drivelines and other rock formations difficult to accurately age. However, local archaeologist Scott Carpenter estimates that the elaborate, labor-intensive line construction, hunting strategy techniques, and presumed high level of social organization all point to most of the drive lines being constructed and used in the late-prehistoric/pre-contact period (ca. 1500-1800 ce). Drivelines or drive-lanes, as they are also known, were used to direct herds of galloping bison towards a cliff or natural cul-de-sac where strategically positioned hunters would kill them with bows and arrows and other implements. The drivelines were effective for directing herds because bison are typically reluctant to go over a visual barrier out of caution for a possible misstep. Modern cattle guards mimic this same principle by relying on the bovine sensibility for staying on level ground. The stone circles and rock cairns closely associated with these drivelines and kill sites and lithic deposit areas are likely ceremonial in nature and provided a sacred space for the harvesting of these most important animals.

Artifacts at some of the sites and the level of some single lines may be earlier and once stood alone on the landscape before a later florescence of the late-prehistoric major landscape utilization areas. Also, any earlier lines are easily confused and sometime obscured by the major construction of numerous late period line complexes. This is where OSL dating strategy will help, someday. Researcher Shane Doyle is also looking into the use of Artificial Intelligence (AI) strategies to sort out the "forest from the trees" of so many rock alignments. AI can help to define potential spatial patterns that the human eye cannot readily discern.

The accompanying topographic map below provides the location of the lines identified so far, although on-going work continues to identify lines and other stone sites. The map also indicated where the sites of rock cairns, stone circles, lithic material zones, and bison kill sites were discovered.

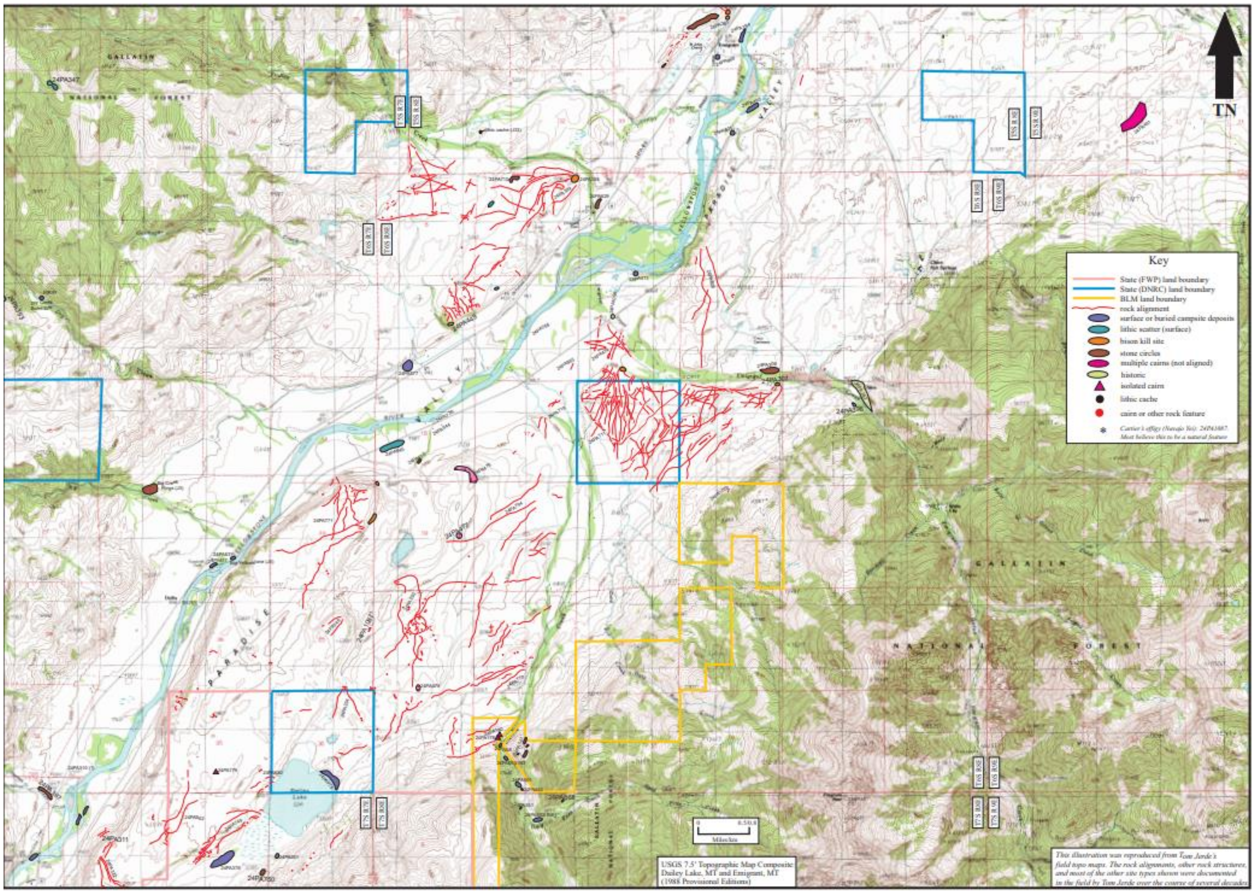


Figure 6. Identified bison drivelines. Source: Tom Jerdy, Patrick Rennie, and colleagues.

2.6 Elk River

Along with migrating herds of bison, expansive herds of elk also traveled through the Paradise Valley and followed the Yellowstone River to its source at Yellowstone Lake. The Apsáalooke people so closely identified elk with the area that their name for the river was Elk River, and the lake was known by the names Elk Lake, Where the Elk Flirt, and Where Elk River Starts. All the Tribes of the region referred to the river as Elk River, except for the Bitterroot Salish, who knew it as Hide Scraper River. The Hide Scraper is a cliff along the river, about 13 miles east of Livingston, known today as Sheep Mountain.

The elk of the Paradise Valley were an extremely important resource for Native people, as they were a rich source of high protein meat, and their hides were ideal for shirts, leggings, and hand drums. Elk ivory teeth have always been highly valued by the Apsáalooke people, who are known for their iconic wool dresses covered with hundreds of elk ivories.

As elk only have two ivory teeth, dresses displaying hundreds of teeth demonstrated the outstanding hunting skills and abilities of the family. Elk tooth dresses continue to be an essential part of Apsáalooke fashion and identity, although nearly all the dresses are adorned with plastic, lookalike elk teeth.

2.7 Bighorn Sheep, Deer, and Pronghorn

Bighorn sheep, deer, and pronghorn were all plentiful in the Paradise Valley, although most evidence of bighorn sheep hunting has been documented just south of the Yankee Jim Canyon. Bighorn sheep were synonymous with the region because of their year-round habitation there, unlike bison and elk, who migrated out of the high country during the winter months. Caches of Yellowstone obsidian uncovered in ceremonial burials found in Hopewell Mounds also included bighorn sheep horns from the Yellowstone area, so they were clearly an important part of the Hopewell culture's ceremonial tradition. As the only communities who lived in the Land of Steam year-round, the Sheep Eater Shoshone came to rely heavily on the animals for their source of food and bone tools.

2.8 Conclusion

Until the disappearance of the bison and the onset of the reservation era in the 1880s, the tribal cultures of the Northern Plains maintained a seasonal, circular way of life, and the path through the Paradise Valley was pivotal in that lifestyle. From an anthropological perspective, Montana stands out as the only state in the Union where archaeologists find no year-round habitation sites, and for good reason. The always unpredictable and usually freezing climate rebuffed Native peoples' attempts over the centuries to create a sustainable farming economy, so Native peoples turned to the abundance of the land.

Seasonal wild plants and animal migrations provided enough food and resources to thrive, but only if they moved their homes to the proper places at the correct times of the year. Hunkering down for up to 6 months in a campsite that provided water, fuel for fire, shelter from the wind, proximity to a grass pasture, and a nearby hill for scouting was a key to surviving on the Northern Plains. The Paradise Valley had several ideal wintering sites, and it was traversed throughout the year, particularly during the 130-year horse era, from 1750 – 1880. During the winter months, Apsaalooke communities would bring their herds to graze the northern pastures that the Paradise Valley's powerful south winds blew free from snow.

When days grew longer, and springtime flooding inundated the lowlands with mosquitoes and other unwelcome summer traffic, winter campsites were left behind for higher ground and adventurous travel and trade. Every tribal community had their own geographic circle that they traveled during the year, but far from nomadic, their movements were intentional and well-informed. The circles of their travel and influence were dramatically enlarged with the acquisition of horses, but the cycle remained much the same.

The tie that bound the tribes of the Paradise Valley region was a common sign language. Plains Sign Language was known and used by 44 identified tribes, covering the entire Great Plains. The sign language was especially important to the tribes of the Upper Yellowstone, as the Blackfeet, Apsaalooke, and Shoshone languages are all mutually unintelligible, coming from distinctly different language families. Yet, despite their language barriers, the tribes share many of the same star stories and share a common form of song, dance, dress, housing, ceremony, and social values.

This remarkable sharing of culture was made possible through Plains Sign Language because it was not taught within tribal communities to communicate with just the hearing impaired; rather it was designed as a lingua franca, so that communities could interact on a seasonal basis and maintain peaceful relations. Before English, Plains Sign Language was the lingua franca of the Paradise Valley for thousands of years, empowering tribal communities to strengthen their circles of life and friendship.

Tribal friendships and alliances were transformed dramatically when horses and rifles, European diseases, and the disappearance of the buffalo became part of the permanent cultural landscape in the 19th century. Tribal communities suffered cataclysmic losses of life and resources, striking at the core of their identity and their very survival. Despite the loss of their traditional ways of life and a loss of 80% of their population, the Blackfeet, Crow, Shoshone, and others have persevered into the 21st century, maintaining a sense of their ancient traditions from within their reservation homelands and throughout the region.

Over 150 years since the creation of Yellowstone National Park, Tribal communities have maintained their ancient relationship to the Paradise Valley and the sacred Land of the Burning Ground. Traditional stories connect the people to the sacred places along the Paradise Valley, such as the Emigrant Buffalo Jump and the hot springs known today as Chico. Further to the south of Paradise Valley, Native people visit sites that their ancient stories forever connect them to, like Red Woman's Digging Stick, known today as The Liberty Cap; the Wonderful Rocks, now called The Sheep-eater Cliffs; and Fringe's Father, known today as Mammoth Hot Springs. The ancient sources of spiritual and physical healing still inspire and connect tribal people today and those places will remain at the heart of their cultural identity.

2022 was a watershed year for Native People in Yellowstone National Park, with the All Nations Teepee Village becoming a new part of the YNP community. As Native people seek to build on their ongoing presence in YNP, the Paradise Valley will continue to become more important and significant as a welcoming place to arrive and pass through, with a feeling of safety, familiarity, and generosity.

Figure 7. Pretty Shield Foundation Lighted Teepees in Gardiner, 2022. Source: Jade Snell

3. Wildlife Accommodation Measures

Wildlife crossing structures have been in use since the 1950s when the first one was installed in France. In the United States, the first structure was constructed in 1975 on I-15 near Beaver, Utah. New Jersey and other states soon followed with their own dedicated crossings for wildlife. Today, many states have installed wildlife crossing structures, the majority of which allow animals to cross beneath the road surface through specially designed culverts, underpasses, and bridges, rather than more visible wildlife overpasses. While structures usually serve multiple species, they must be located and designed with appropriate characteristics to serve target species and based on data about wildlife crossing locations.

The wildlife accommodation measures considered in this report fall into two overarching categories: a) measures aimed at influencing driver behavior, and b) measures to make roads more permeable to wildlife. While some measures to influence driver behavior may reduce the risk of wildlife-vehicle collisions with varying degrees of success, this category of measures generally fails to address the barrier effect of roads on wildlife movement, a key concern of this study. The latter category, in which wildlife are separated from traffic by fencing and crossing structures designed to enable safe wildlife passage, achieves the dual objectives of reducing wildlife-vehicle collisions and maintaining habitat connectivity.

A 2021 Pooled Fund Study supported by the Departments of Transportation of nine states and the Federal Highway Administration reviewed the literature on known accommodation measures for both large and small (coyote or smaller) animals to determine effectiveness. The information below and summarized in Table 2 is derived from this review by Huijser et al. (2021).

Table 2. Effectiveness of Mitigation Measures. Adapted from Huijser et al. 2021

Mitigation Measure	Effectiveness in Reducing Collisions with Large Mammals	Effectiveness in Reducing the Barrier Effect of Roads and Traffic
Measures aimed at influencing driver behavior		
Seasonal wildlife warning signs	9-50%	None
Animal detection systems	33-97%	None
Seasonal road closure	100% during closure	Reduces barrier effect of traffic, not the road, during closure
Increase visibility for the driver	57-68%	None, may increase barrier effect for some species
Reduced speed limit with traffic calming measures	Unknown-59%	Unknown
Measures to separate wildlife from the road and traffic		
Barriers: fences, boulders, walls	80-100%	None, increases barrier effect
Underpasses and overpasses without fencing	Varies greatly based on structural design and location	Reduces barrier effect
Underpasses and overpasses with fencing	80-100%	Reduces barrier effect

3.1 Measures to Influence Driver Behavior

3.1.1 Permanent or Temporary Warning Signs

While commonly implemented, permanent warning signs have been found to reduce collisions with wildlife for only a short period of time after their installation. They are generally considered to be ineffective, in spite of the fact that they may increase driver awareness or cause temporary speed reduction (Pojar et al. 1975; Coulson 1982; Al-Ghamdi 2004; Sullivan et al. 2004; Meyer 2006; Bullock, Malan, and Pretorius 2011). Researchers believe they may help increase awareness of collision danger yet may also falsely suggest that signs alone are an effective tool.

In contrast, while studies are limited, temporary warning signs may reduce collisions. Effectiveness, however, varies substantially (9–50%) (Sullivan et al. 2004; Colorado Department of Transportation 2014). It appears that seasonal or other types of enhanced warning signs increase in effectiveness when used in increasingly precise locations during specific periods of high risk. However, as enhanced wildlife warning signs are often applied over long road sections, and not limited to periods of high risk, their effectiveness may be limited in practice (Huijser et al. 2015).

Figure 8. Bighorn Sheep approaching US 89. Photo credit: Wes Shifrin

3.1.2 Animal Detection Systems

Like temporary warning signs, animal detection systems can reduce wildlife-vehicle collisions with large mammals. Collisions may be reduced by as much as 33-97% when sensors are able to reliably detect the target species (Mosler-Berger and Romer 2003; Dai, Young, and Vander Giessen 2009; Gagnon et al. 2010; Strein 2010; Minnesota Department of Transportation 2011; Sharafsaleh et al. 2012; Huijser, Gunson, and Abrams 2006). It is important to note that animal detection systems may be most appropriate on low-volume roads (such as less than 5,000 vehicles per day) to limit the likelihood of rear-end collisions when vehicles brake suddenly. Further, vehicle speed may have to be reduced substantially (for example, to 35-40 miles per hour) to reduce the likelihood of a collision (Huijser et al. 2015). Animal detection systems are still considered experimental, especially as a stand-alone measure on open roads over longer distances; technology, operation, and maintenance issues can hamper their effectiveness. Animal detection systems that have had the highest efficacy are those that have been used in combination with other measures and which have a very discreet detection zone, such as at the end of wildlife exclusion fencing or at an animal "crosswalk" or gap in fencing (Gagnon et al. 2010).

3.1.3 Reduced Speed Limit

Speed management is often suggested as a strategy to reduce wildlife-vehicle collisions. However, unless the design speed of the road is also reduced, posting a lower speed limit may lead to more dangerous driving conditions due to a mix of slower and faster drivers who continue to follow a road's "design speed" rather than the speed limit. This phenomenon, called "speed dispersion" (a mix of fast- and slow-moving vehicles), is known to increase crashes (Elvik 2014; Huang et al. 2013). Regardless of speed limit, most drivers operate their vehicles at a rate that is near to or higher than a road's design speed (Fitzpatrick 2003; Ouyang, Jiang, and Jadaan 2016; Donnell, Kersavage, and Tierney 2018).

Further, even with substantial enforcement, lowered speed limits do not change driver behavior sufficiently to reduce collisions with wildlife. For example, despite a 43% increase in citations issued over two years following the reduction of nighttime speed limits (to 55 miles/hr) in marked wildlife crossing zones in Colorado, collisions with wildlife increased in nearly half of the areas studied (Colorado Department of Transportation 2014). Drivers continued to exceed the posted limit by 11 miles/hr (Colorado Department of Transportation 2014). Similarly, in a Wyoming study in which nighttime speed limits were lowered by 15 miles/hour during times of year with the greatest mule deer collision risk, drivers reduced their speed by only 3-5 miles/hr (Riginos et al. 2019).

Finally, because most collisions occur at dawn and dusk, highway speeds would need to be considerably slower than is common for drivers whose headlights have median reach to avoid a collision with a large mammal. An operating speed of only 40 miles/hr is still insufficient to allow one-half of drivers to stop a vehicle in time to avoid a collision (Huijser, Fairbank, and Abra 2017). To allow nearly all drivers to stop in time, the nighttime operating speed of a road needs to be as low as 25-30 miles/hr, far lower than the design speed of most roads (Huijser, Fairbank, and Abra 2017; Huijser et al. 2015).

2.1.4 Highway Lighting

Highway lighting may reduce wildlife-vehicle collisions by 57-68% (McDonald 1991; Riley and Marcoux 2006; Wanvik 2009). It is unclear, however, if collision reductions along lighted highways are because of increased visibility of the animals to drivers or because animals avoid lighted highways.

It is likely that highway lighting contributes to the barrier effect of roads for some species. While a reasonable tool to consider in high-risk areas to reduce wildlife-vehicle collisions, highway lighting is less appropriate where habitat connectivity is an objective. Lights can be expected to increase the barrier effect of roads for species that are light-avoidant, such as nocturnal species. At the same time, other species may be attracted to lights and experience higher risk of road mortality. Since highway lighting can affect animal physiology and behavior, and even predation rates, its use may require additional measures to reduce effects on wildlife (Blackwell, DeVault, and Seamans 2015). Limiting highway lighting to periods when vehicles approach can reduce the negative impacts of lighting on wildlife, such as restricting lighted areas to those that increase drivers' sight distance on the road and roadside.

3.2 Measures to Separate Wildlife from Traffic

3.2.1 Wildlife Crossing Structures

The main objective of wildlife crossing structures is to connect wildlife populations or entire ecosystems and allow ecosystem processes to continue over or under a road. These structures allow for safe daily, seasonal, or dispersal movements between areas on either side of a highway (Dodd et al. 2007; Gagnon et al. 2010; Huijser et al. 2015; Huijser et al. 2016). Wildlife use of crossing structures increases when the structures are connected to fencing (see Wildlife Fencing, below), which also serves to reduce wildlife-vehicle collisions.

3.2.2 Wildlife Underpasses

Wildlife underpasses are designed to allow wildlife to cross safely under the road. When designed for large mammals, they can also successfully allow the passage of smaller species. Designing an underpass and its approaches with appropriate vegetative cover encourages use by target species and makes smaller species feel more secure in its use. Underpasses can also be adapted to accommodate water flow and support use by aquatic and semi-aquatic species, including fish and amphibians.

Often, existing bridges or culverts that span water bodies can be redesigned to be longer and/or wider to make space for riparian habitat alongside a river or stream beneath a bridge or within a culvert, allowing for use by more species. As these structures are often located in riparian areas that are attractive to terrestrial wildlife, appropriately designed culverts and bridges can support the movement of both aquatic and terrestrial species.

Numerous types of underpass structures exist, including open-span bridges, concrete bottomless arches, corrugated steel arches, and box culverts. Because these structures are "bottomless," each allows for the natural substrate of the area to be used within the crossing structure. Dimensions vary greatly depending on the target species, local terrain, and other parameters.

3.2.3 Wildlife Overpasses

Due to their size and visibility to drivers and the public, wildlife overpasses may be the most commonly known type of wildlife accommodation measure and are typically designed to allow movement by a suite of large animals. By including specific design elements, however, they can also attract small- and medium-sized mammals, as well as amphibians, reptiles, semi-aquatic species, ground-dwelling birds, and butterflies. Some species, such as elk, moose, pronghorn, and grizzly bears have demonstrated a preference for overpasses in certain locales. Family groups of species like grizzly bears prefer larger, open structures like overpasses but may also use large-span bridges as a wildlife underpass (Clevenger and Barrueto 2014; Ford, Barrueto, and Clevenger 2017; Sawyer, Rodgers, and Hart 2016).

3.2.4 Wildlife Fencing in Combination with Wildlife Crossing Structures

On average, an 87% reduction in wildlife-vehicle collisions can be expected from fencing when combined with wildlife crossing structures (Huijser 2008). Because fencing itself creates a barrier, it is not a solution to wildlife habitat connectivity, but rather is intended to guide animals to crossing structures.

Wildlife fencing is commonly constructed at a height of 8 ft (2.4 m). Wildlife fencing is typically placed at the edge of a department of transportation's right-of-way, or at least outside of the clear zone of the highway, so it does not interfere with operations such as snow plowing.

Effective fencing may be continuous between safe passage opportunities (Clevenger and Barrueto 2014) or partial (i.e., disjunct fenced segments of highway with numerous fence ends) (Gagnon et al. 2010; Huijser et al. 2016; Huijser, Camel-Means, et al. 2016). Fencing should include escape ramps or "jump-outs," which allow wildlife trapped on the highway side of a fence to jump to safety outside the fenced section. The height of a jump-out should be 4-6 ft (1.2-1.8 m) above the outside surface to deter wildlife from jumping up and entering a roadway. Fencing may also need to include climbing or dig barriers to be effective for species adept at climbing or digging. Fencing usually needs to extend 1.5 miles on either side of a crossing structure, or adjacent to a series of crossing structures, to be most effective. Fence end treatments may be necessary where fencing terminates in an area with wildlife movement potential. Fence end treatments can include cattle guards, electrified mats, boulder fields, or natural landscape features, such as a cliff or other feature that acts as a barrier. Animal detection systems can also be used at fence ends to warn drivers when an animal is approaching or crossing the road.

4. Methodology

4.1 Study Area

The study focused on US 89 between Livingston and Gardiner, an area for which adequate data were available for identifying high-priority sites for potential wildlife accommodations to reduce wildlife-vehicle collisions and maintain or improve habitat connectivity. The study area includes 53 miles of US 89 from mile post RM0 through RM53.

4.2 Data Sources

The Research Team acquired a diversity of data sets to inform its analyses, which can be classified into five categories: (1) law enforcement records of wildlife vehicle collisions (WVC); (2) records of wildlife carcasses observed along roads; (3) observations of live wildlife on or near roads; (4) observations of wildlife crossing roads; and (5) other ecological data such as wildlife telemetry locations, habitat models, and connectivity models. Data sources varied with respect to temporal extent, spatial extent, locational accuracy, and number of observations. Available data emphasize large mammals, which tend to be species of management or conservation concern (e.g., grizzly bears) or greater human safety risks associated with collisions (e.g., deer, elk, moose, deer). Brief descriptions of the data sets in each category follow, with the characteristics of each data set summarized in Table 3.

Wildlife-Vehicle Collision data: Montana Highway Patrol (MHP) records were obtained for wildlife-vehicle collisions occurring during 2012 – 2021 via a data request submitted to Montana Department of Transportation (MDT). These records included the date, time, and location of all WVCs to which MHP responded.

Carcass data: We obtained data on animal carcasses observed along US 89 from five sources: (1) MDT maintenance personnel records from 2012-2021; (2) Montana Fish, Wildlife & Parks (FWP) records of wildlife carcasses from July 2020 – January 2021; (3) Interagency Grizzly Bear Study Team (IGBST) records of grizzly carcasses from 2009 – 2022; (4) records of wildlife carcasses recorded by citizen scientists using the Roadkill Observation and Data System (ROaDS) smartphone application from July 2020 through April 2023; and (5) records of wildlife carcasses recorded systematically using the ROaDS app from February 2021 to May 2023. We reviewed these data for possible duplication of records by date and distance and removed any suspected duplicates.

Wildlife Observation data: We obtained records of observations of live animals on or near roads from eight sources: (1) FWP bighorn sheep telemetry data from 2012 – 2015; (2) FWP Elk herd telemetry data from 2002-2020; (3) FWP pronghorn telemetry data from 2020 – 2022; (4) FWP wolf telemetry data dates unknown; (5) National Park Service elk telemetry data from 2012 – 2021; (6) IGBST repulsion events (where bears approached the road but did not cross) from 2013 – 2019; (7) observations of live wildlife recorded by citizen scientists using the ROaDS smart phone application during 2021 – 2023; and (8) observations of live wildlife recorded systematically using the ROaDS application during 2021 – 2023.

Wildlife Movement data: We received data on wildlife movement from five sources: (1) IGBST road crossing locations of GPS-collared grizzly bears and crossing frequency records during 2008 – 2019; (2) observations of wildlife crossings recorded by citizen scientists using the ROaDS smartphone application during 2021 – 2023; (3) observations of wildlife crossings recorded systematically using the ROaDS application; (4) FWP elk telemetry herd data from 2002 – 2020; (5) FWP pronghorn telemetry data from 2020 – 2022. Elk and pronghorn telemetry data were used to infer locations of road crossings, as detailed below[Section 2.3.1].

Habitat Suitability & Connectivity Models: To capture the habitat and movement needs of a diversity of wildlife species, we obtained habitat suitability and connectivity modeling data for multiple species, ranging from habitat specialists to those with limited dispersal capabilities. The models, which are described below and listed in Table 3, are derived from several sources:

We used geospatial data from *A Wildlife Conservation Assessment of the Madison Valley, Montana* (Brock et al. 2006) on potential habitat suitability for several focal species, including wolverine, bighorn sheep, elk, and boreal toad. These data incorporate relevant human influences and predict the distribution of habitat quality. Potential winter, nesting, and brood habitat for sage grouse and potential habitat for grizzly bears are also included.

We used geospatial data from *Northern Rockies Black Bear Connectivity* (Cushman, Lewis, and Landguth 2013), which was generated by applying cumulative factorial least cost path modeling and resistant kernel analysis to predict a movement corridor network associated with locations of actual bear highway crossings.

We used geospatial data from Peck et al. (2017) on potential grizzly bear road crossings. This dataset includes raster values converted to point features 300 m apart at intersections with major transportation corridors for grizzly bear movement between the Greater Yellowstone Ecosystem and the Northern Continental Divide Ecosystem based on Randomized Shortest Path analysis.

We used geospatial data from Brock et al. (in prep) on range-wide habitat suitability for bison in winter and summer, which is based on Shamon et al. (2022).

We used geospatial data from Krosby et al. (2018) on riparian climate corridors to determine where roads intersect with riparian zones that are likely to facilitate climate-induced species range shifts. This data set includes a resiliency index for each riparian zone based on its ability to facilitate range shifts and serve as a climate micro-refugium (estimated based on the temperature gradient along its length and degree of canopy cover, solar insolation, and human modification).

We used geospatial data from Dickson et al. (2016) on ecological connectivity to determine where roads intersect with major dispersal corridors. This data set is the product of a Circuitscape analysis of species-neutral connectivity among large, protected areas within the western U.S. and contains a connectivity value for each landscape pixel reflecting its estimated contribution to west-wide connectivity. Movement is assumed to be more difficult through areas with more rugged topography and a higher degree of human modification.

Table 1. Description of Data Sets Used in Analyses

Dataset	Description	Sampling Period	Spatial Extent	Sample Size[1]	Precision[2]
MDT Wildlife Crash	Coordinates, date, time	2012-2021	US 89	532	Good
MDT Wildlife Carcass	Coordinates of wildlife carcasses, date, species, sex	2012-2021	US 89	1068	Good
Salvage (FWP)	Coordinates, date, species, where found	7/02/20 - 1/03/23	US 89	125	Good
Grizzly Bear Roadkill (IGBST)	Coordinates, ID, age class, sex, date, location details of loss	2009 - 2022	US 89	5	Good
ROaDS app Systematic wildlife carcasses	Records of wildlife carcasses recorded by systematic monitoring using the ROaDS app	2/26/21 - 5/12/23	US 89	412	Good
ROaDS app Citizen Science wildlife carcasses	Records of wildlife carcasses submitted by local residents using the ROaDS application	07/02/20 - 4/30/23	US 89	172	Good
Bighorn (FWP)	Date, Animal ID, Coordinates	2012-2015	W of 89; S of Tom Miner Creek	13,598	Good
Elk (FWP)	Date, Time, Herd, Animal ID, Coordinates	2002-2020	Yellowstone Lake in WY to southern part of Study Area	2,849,140	Good
Pronghorn (FWP)	Date, Animal ID, Coordinates	2020-2022	Study Area, along US 89	404,594	Good
Wolf (FWP)	Coordinates, Mortality (No, Yes)	Unknown	S MT to NW WY	8,179	Good
Elk (NPS)	Date, Animal ID, Coordinates, Precision	2012-2021	Study Area, southern half	924,605	Good
Grizzly bear repulsion events (IGBST)	Date, Animal ID, Coordinates, Location (e.g. out of den), Sex, Age, Cohort, distance from 89	2013-2019	Study Area, southern half	548	Good
ROaDS app wildlife alive on road (CitSci)	Coordinates, Date, Species, # Individuals	7/2020-5/2023	Study Area	266	Good

ROaDS app wildlife alive on road (Systematic	Coordinates, Date, Species, # Individuals, Confidence, Comments	3/2021-5/2023	Study Area	543	Good
Grizzly Bear Crossings (IGBST)	Date, Line ID, Unique ID	2008-2019	Study Area	212 events	Good
Elk Crossings (FWP)	Generated from elk data listed above (Date, Time, Herd, Animal ID, Coordinates)	2002-2020	US 89	1969 events	Good
Pronghorn Crossings (FWP)	Generated from pronghorn data above (Data, Animal ID, Coordinates)	2020-2022	US 89	149 events	Good
ROaDS App Wildlife Crossings Systematic	Coordinates, Date, Species, # Individuals, Confidence, Comments	3/2021-3/2022	US 89	87 events; 620 individuals	Good
ROaDS App Wildlife Crossings Citizen Science	Coordinates, Date, Species, # Individuals	7/2020-5/2023	US 89	186 events; 2096 individuals	Good
Potential Grizzly Bear Passage Along Major Road Corridors in Northwest Montana	Point features 300 m apart identifying indices of potential passages at intersections with major transportation corridors for grizzly bear movement between GYE and NCDE based on Randomized Shortest Path (Peck et al. 2016).	2018	GYE to NCDE	N/A	Moderate[3]
Grizzly Bear Habitat Suitability (Craighead et al. 2006)	Functional habitat that is of a minimum quality, size, and distance from major core areas	N/A	Study Area	N/A	Moderate[3]
Northern Rockies Black Bear Connectivity (Cushman et al. 2013)	Cumulative factorial least cost path modeling coupled with resistant kernel analysis to predict movement corridor network; associated with locations of actual bear highway crossings.	2013	Montana, Idaho	N/A	Moderate[3]

Wolverine Habitat Effectiveness (Brock et al. 2006)	Potential habitat mapped using logistic regression from wolverine telemetry and GPS locations	N/A	Study Area	N/A	Moderate[3]
Bison Summer Habitat Suitability Index (Shamon et al. 2022)	Preferred summer habitat types and estimates of plant biomass needed to support bison populations, restricted to slopes below 35 percent; further constrained to remove roads and cropland	N/A	Range wide	N/A	Moderate[3]
Bison Winter Habitat Suitability Index (Brock et al. in prep)	Similar to Shamon et al. (2022), modified for preferred winter habitat types, snow depth and other human influences on the landscape.	N/A	Range wide	N/A	Moderate[3]
Bighorn Sheep Potential Habitat Effectiveness (Brock et al. 2006)	Preferred habitat types within a certain distance of escape terrain, adjusted to eliminate areas impacted by domestic sheep grazing allotments and road salting	N/A	Study Area	N/A	Moderate[3]
Boreal Toad Habitat Effectiveness (Brock et al. 2006)	Modeled habitat components wetlands, landcover, edge, and soils within 300 m of lakes, ponds and springs and adjusted to address threats (dewatering, fish stocking, floodplain loss, pollution, roads)	N/A	Study Area	N/A	Moderate[3]
Sage Grouse Potential Nesting Habitat (Brock et al. 2006)*	Modeled stands of sagebrush with 15-31% cover using 30 m GAP Land Cover and late May NDVI	N/A	Study Area	N/A	Moderate[3]
Sage Grouse Potential Brood Habitat (Brock et al. 2006)*	Fall greenness calculated from Landsat imagery, masked to include only areas within potential brood habitat landcover classes (e.g., sagebrush, shrub/steppe, grassland)	N/A	Study Area	N/A	Moderate[3]

Sage Grouse Winter Habitat Suitability (Brock et al. 2006)*	Preferred habitat types refined with slope, aspect and NDVI calculated from spring Landsat Thematic Mapper imagery to detect areas where sagebrush protrudes above snow cover	N/A	Study Area	N/A	Moderate[3]
Ecological Connectivity (Dickson et. al. 2016)	Estimated value for facilitating ecological flows (e.g., wildlife movement) between protected areas in the Western U.S.	NA	Study Area	NA	Moderate[3]
Riparian Climate Corridors (Krosby et al. 2018)	Estimated value of riparian corridors for facilitating climate-induced species range shifts	NA	Study Area	NA	Moderate[3]
[1] Sample size is the total number of observations (e.g., carcasses, crashes, or live animal sightings) along study roads.					
[2] A rough categorical estimate of locational error associated with data set. Good: location recorded at time of observation with GPS coordinates. Moderate: location recorded at time of observation with road reference marker to nearest mile or detailed location description based on local landmarks. Poor: location estimated based on memory of past events.					
[3] Data set consists of connectivity model output rather than locations of specific events; assigned to the moderate precision category based on the spatial resolution of the model.					

* Sage grouse do not currently occupy the study area.

4.3 Initial Screening of Road Segments

To identify an initial set of road segments for potential wildlife accommodation measures, we categorized the data sets described in Section 2.2 and Table 5 into four Prioritization Characteristics, each of which represents a specific mitigation rationale: 1) wildlife-vehicle collision risk, 2) live wildlife observations along roads, 3) evidence of wildlife crossing roads, and 4) modeled wildlife habitat suitability or connectivity value. Each Prioritization Characteristic is informed by a distinct subset of the available data sets, which were weighted according to the sample size, spatial precision, duration, and diversity or conservation importance of wildlife species represented (Table 4), and then applied to each road segment. Finally, based upon a weighted average of the four Prioritization Characteristics (Table 5), we calculated a Composite Importance Index for each road segment.

To identify potential locations for wildlife crossing improvements, we used 0.10-mile road segments as our unit of analysis. To determine these segments, we used the Montana Department of Transportation (MDT) reference markers point shapefile to divide polyline shapefiles for US 89 into 1-mile segments between mile markers using the Split Line at Point tool in ArcGIS. [N.B. The starting mile MDT reference marker was included in each segment]. Each 1-mile segment was then divided into 0.10-mile segments using the Split Command and given a unique ID using the

MDT reference marker as a prefix (e.g., RM 32.0 through RM 32.9). Overall, the study area includes 580 0.10-mile segments.

Table 2. Within-Category Weights for Each Prioritization Characteristic

Dataset	Within-category weight	Weight Justifications
Wildlife Vehicle Collision Risk Prioritization Characteristic		
MDOT Wildlife Crash	0.3	Large, precise dataset
MDOT Wildlife Carcass	0.3	Large, precise dataset
Grizzly Bear Roadkill (IGBST)	0.1	Very small number of observations, but high conservation importance
Salvage (FWP)	0.05	Small dataset
ROaDS app Citizen Science	0.05	Species identification and spatial precision have more uncertainty
ROaDS app Systematic wildlife carcasses	0.2	Small number of observations and short study duration; precise spatial precision.
Wildlife Observation Near Roads Prioritization Characteristic		
Bighorn sheep (FWP)	0.15	Large, precise, single-species dataset
Elk (FWP)	0.15	Large, precise, single-species dataset
Elk (NPS)	0.1	Relatively large number of observations, only partial spatial coverage
Pronghorn (FWP)	0.15	Large, precise, single-species dataset
Wolf (FWP)	0.05	Small number of observations, two individuals
Grizzly bear (IGBST)	0.15	Very small number of observations, but high conservation importance
ROaDS app Systematic wildlife alive on road	0.15	Small number of observations and short study duration; probably poorer spatial precision than other WVC datasets
ROaDS app Citizen Science	0.1	Large, precise, single-species dataset, only partial spatial coverage
Wildlife Road Crossings Prioritization Characteristic		
Grizzly Bear Crossings (IGBST)	0.25	Moderate number of observations and high conservation importance conservation importance
Elk Crossings (FWP)	0.2	Large number of observations but lower conservation importance
Pronghorn Crossings (FWP)	0.25	Moderate number of observations, weighted higher due to species reluctance to cross roads
ROaDS App Systematic	0.15	Relatively large number of observations
ROaDS App Citizen Science	0.15	Large number of observations and probably poorer spatial precision than other movement datasets
Habitat Suitability/Connectivity Prioritization Characteristic		

<table>
<tr><td>Potential grizzly bear passage along major road corridors in northwest Montana</td><td>0.1</td><td rowspan="5">Weights were divided evenly among the 10 different species/characteristics in this category, with weights divided further equally among the multiple models for some of the species (e.g., each of the two grizzly models weight of 0.05, each of the 3 sage grouse models gets 0.033, etc.).</td></tr>
<tr><td>Grizzly Bear Habitat Suitability (Craighead et al. 2006)</td><td>0.1</td></tr>
<tr><td>Northem Rockies Black Bear Connectivity (Cushman et al. 2013)</td><td>0.1</td></tr>
<tr><td>Wolverine Effectiveness</td><td>0.1</td></tr>
<tr><td>Bison Summer Habitat Suitability Index (Brock et al. in prep)</td><td>0.05</td></tr>
</table>

Table 3. Weights for Composite Importance Index

Prioritization Characteristic	Weight
Wildlife Vehicle Collision Risk	0.50
Wildlife Observations Near Roads	0.15
Wildlife Road Crossings	0.25
Habitat Suitability/Connectivity	0.10

4.3.1 Indices of Road Segment Importance for each Prioritization Characteristic

Establishing a segment-level importance index for each Prioritization Characteristic required combining results across data sets. First, we developed segment-level indices for each data set within each characteristic. Indices for the WVC Risk, Wildlife Observation, and Wildlife Road Crossing Prioritization Characteristics are based on counts of events (e.g., crashes, carcasses, pathways intersecting the road) or numbers of individuals (e.g., live animals) within each 0.10-mile road segment. We generated indices for the Habitat Suitability/Connectivity Prioritization Characteristic by extracting the maximum value (e.g., highest suitability, maximum connectivity value) of the pixels intersecting each road segment. The Index values generated for each data set were rescaled to range from 0 and 1 to allow for comparison. A weighted averaging approach that considered the contribution of each data set was used for each Prioritization Characteristic, and the resulting values were rescaled 0 to 1 as a segment-level importance index for that characteristic.

We also generated general summary statistics for each data set and Prioritization Characteristic.

Wildlife-Vehicle Collision Risk Prioritization Characteristic: We calculated the number of recorded collisions with wildlife and the number of carcasses within each 0.10-mile road segment, as described in Table 4, as an index of WVC risk using 6 data sets:

- Wildlife Crash (MDT)
- Wildlife Carcass (MDT)
- Wildlife Salvage (FWP)

- Grizzly Bear Roadkill (IGBST)
- ROaDS Tool: Wildlife Carcass (Citizen Science)
- ROaDS Tool: Wildlife Carcass (Systematic Surveys)

We calculated the rate of collisions or carcasses (x per 0.10-mile) for each segment in each data set. We then normalized the native values from each data set (i.e., rescaled from 0 to 1). Using the within-category weights in Table 4, we developed a Wildlife Vehicle Collision Importance Index calculated from the weighted mean of the normalized values across the data sets. “F

Wildlife Observation Near Roads Prioritization Characteristic: We calculated the number of recorded wildlife observations within 500 meters of each 0.10-mile road segment as an index of animal use intensity using 8 data sets:

- Bighorn sheep collar data (FWP)
- Elk collar data (FWP)
- Pronghorn sheep collar data (FWP)
- Wolf collar data (FWP)
- Elk collar data (NPS)
- Grizzly Bear repulsion events (IGBST)
- ROaDS Tool: Wildlife Alive on Road (Citizen Science)
- ROaDS Tool: Wildlife Alive on Road (Systematic Surveys)

We calculated the number of recorded wildlife observations within 500 m of the road for each segment within each data set. We then normalized the native values from each data set (i.e., rescaled from 0 to 1). Using the within-category weights in Table 4, we developed a Wildlife Observation Importance Index calculated from the weighted mean of the normalized values across the data sets.

Wildlife Road Crossings Prioritization Characteristic: We calculated the number of grizzly bear or elk paths intersecting each 0.10-mile road segment (i.e., number of inferred road crossings by bears or elk) or live observations of road crossings from the ROaDS Tool as an index of safe wildlife passage for each of the 5 data sets:

- Grizzly Bear Crossings (IGBST)
- Elk Crossings (FWP)
- Pronghorn Crossings (FWP)
- ROaDS Tool: Wildlife Crossings (Citizen Science)
- ROaDS Tool: Wildlife Crossings (Systematic Surveys)

Using the elk and pronghorn telemetry data, we converted locations into movement paths by assuming straight-line travel between consecutive telemetry fixes, limiting our analysis to fixes separated by less than eight hours to minimize potential deviation from assumed straight-line paths. We then determined where inferred movement paths intersected the road network (i.e., approximate locations of elk and pronghorn crossings).

For each data set, we calculated the number of paths intersecting the road or recorded number of wildlife crossings for each segment. The native values from each data set were then normalized (i.e., rescaled from 0 to 1). Using the within-category weights in Table 4, we developed a Wildlife Movement Importance Index calculated from the weighted mean of the normalized values across the data sets.

Habitat Suitability/Connectivity Prioritization Characteristic: We generated indices for the Habitat Suitability/Connectivity Prioritization Characteristic by extracting the maximum value (e.g., highest suitability, maximum connectivity value) of the pixels overlapping each road segment in each data set:

- Potential grizzly bear passage: We calculated the maximum index value of potential passage rates for grizzly bears overlapping each road segment (Peck et al. 2017) as an index of importance for facilitating regional connectivity for grizzly bears.
- Grizzly bear habitat (Craighead 2006): We calculated the maximum suitability value of the pixels overlapping each road segment as an index of importance for grizzly bear habitat.
- Northern Rockies black bear connectivity (Cushman, Lewis, and Landguth 2013): We calculated the maximum connectivity value of the pixels overlapping each road segment from Cushman, Lewis, and Landguth (2013) as an index of importance for black bear connectivity.
- Bison summer habitat (Shamon et al. 2022) and winter habitat (Brock in prep.) suitability: We calculated the maximum habitat suitability value of the pixels overlapping each road segment to the south of RM 16.0 as an index of importance for bison winter and summer habitat. Bison habitat suitability was restricted to where bison have freedom to roam.
- Wolverine habitat effectiveness: We calculated the maximum value from Brock et al. (2006) of the pixels overlapping each road segment as an index of importance for wolverine habitat.
- Bighorn sheep habitat effectiveness: We calculated the maximum value from Brock et al. (2006) of the pixels overlapping each road segment as an index of importance for bighorn sheep habitat.
- Sage grouse winter, nesting, and brood habitat (3 data sets): We calculated the maximum value from Brock et al. (2006) of the pixels overlapping each road segment as an index of importance for sage grouse winter, nesting, and brood habitat.
- Boreal toad habitat effectiveness: We calculated the maximum value from Brock et al. (2006) of the pixels overlapping each road segment as an index of importance for boreal toad habitat.
- Riparian climate corridors: We calculated the maximum resiliency index value from Krosby et al. (2018) of any riparian zones intersecting each road segment as an index of potential importance for climate change adaptation.
- Ecological connectivity: We calculated the maximum connectivity value from Dickson et al. (2016) of the landscape pixels overlapping each road segment as an index of importance for multi-species connectivity.

We then normalized the values from each data set (i.e., rescaled from 0 to 1). Using the within-category weights in Table 4, we developed a Habitat Suitability/Connectivity Importance Index calculated from the weighted mean of the normalized values across the data sets.

4.3.2 Composite Indices of Road Segment Importance

To identify high-priority sites for field evaluation, we calculated the weighted mean of each segment's importance index values across all four Prioritization Characteristics as a composite index, such that*:*

$$(\text{WVC Importance Index} * 50\%) + (\text{Wildlife Observation Importance Index} * 15\%) + (\text{Wildlife Crossing Road Importance Index} * 25\%) + (\text{Suitability/Connectivity Importance Index} * 10\%) = \text{Composite Index}$$

We then calculated a Moving Window Average for each 0.10-mile segment by taking the average of the resulting Composite Index for each segment with the indices for the five segments to either side of each segment.

We then selected the highest priority segments by taking the Top 20% highest composite index values from the Moving Window Average. This approach tends to select segments with high index values across multiple characteristics but may overlook segments that are extremely important for a single characteristic, such as those segments at high risk of wildlife vehicle collisions, despite having lower composite index values. To capture these WVC outliers, we added two stretches of US 89 identified as priority WVC segments for field evaluation. We also extended some of the areas to capture nearby WVC outliers in the top 10%.

4.4 Data Gaps, Limitations, and General Assumptions

The analysis within this Assessment is based on available data. Not all data sets are comprehensive; some are collected opportunistically (including both MDT and ROaDS Tool carcass data), and the data sets are skewed towards large mammals and charismatic species such as elk and grizzly bears. Further, some basic assumptions have been made throughout the document as information is still being learned about the ways in which wildlife interact with roads and transportation. Some data gaps, limitations, and general assumptions of this report that require further research to better assess their impact are described below:

- **Underreporting:** The primary carcass data available for this study are from MDT maintenance removal of wildlife carcasses along roadsides and citizen science efforts. These data sets are opportunistically—rather than systematically—collected and are likely to represent only a fraction of the animals hit and killed along roads. These data sets are also skewed towards large animals that can be easily seen when driving along a highway (> 90% of all MDT carcass data are deer). In addition to not accounting for smaller wildlife, these data likely underrepresent large species such as deer and elk that may not die on a road surface or immediately next to a road after being hit. Studies that document underreporting of WVCs have found up to 8.5 times more animals hit on roads than reported (Donaldson 2017). In Montana, while crashes reported to law enforcement have nearly doubled over the last 10 years, the number of wildlife carcasses removed from roads has declined (Figure 1). This is likely due to changes in search and reporting procedures, rather than fewer wild animals being hit on Montana's roads. This factor is important to consider in cost-benefit analysis for constructing wildlife accommodation measures [Section 9] because cost-benefit thresholds are based upon carcass data.

- **Gaps in Existing Wildlife Movement Data:** Individual, GPS-collared wildlife provide the primary wildlife movement data available for the study. These data were only available for three species: elk, pronghorn, and grizzly bears. Collar data for an expanded group of species could help to better inform potential locations for wildlife accommodations.

- **Traffic Volumes:** Studies of the impact of traffic volumes on wildlife crossing behavior and WVC risk are limited in number. For moose, Seiler (2003) found a non-linear relationship between traffic volumes and a) WVCs and b) the barrier effect of a highway. The highest rates of WVCs were at moderate traffic volumes (2,500-10,000 vehicles per day; Figure 9), with the road posing nearly a complete barrier for safe wildlife crossings between 10,000 and 15,000 vehicles per day. A recent study in Wyoming (Riginos 2022) found traffic volumes above 15,000 AADT pose a complete barrier to wildlife movement.

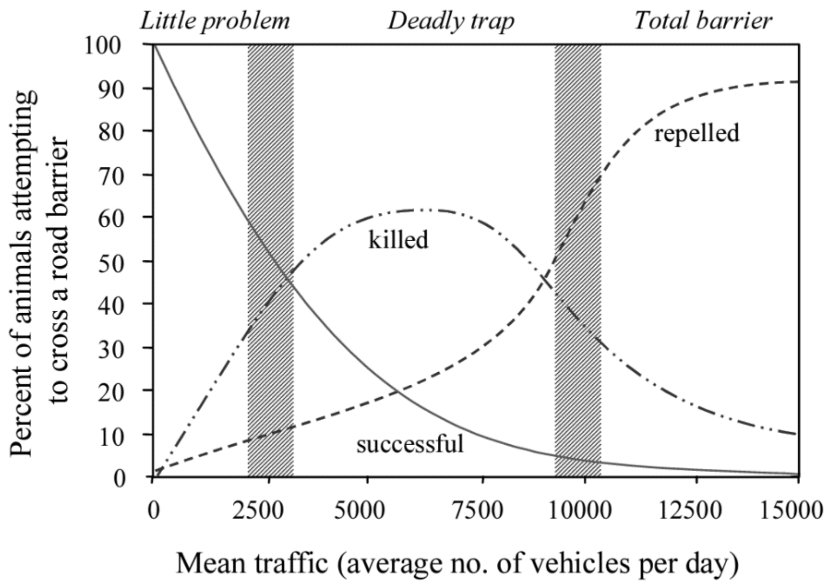


Figure 9. The Relationship between Average Daily Traffic, WVCs, and the Barrier Effect of a Road (from Seiler 2003)

Some species-specific studies have described hourly traffic thresholds. A study in northwest Montana found traffic volumes over 100 vehicles per hour to be a substantial barrier to grizzly bear movement (Waller and Servheen 2005; Waller and Miller 2015). For mule deer, a study in western Wyoming found traffic volume over 120 vehicles per hour to be a substantial barrier when less than 60 seconds between vehicles exist (Riginos et al. 2018). These finer-scale studies illustrate the degree to which a road poses a barrier. For this Assessment, the available traffic volume data are Annual Average Daily Traffic (AADT), which is an average across the full year that does not account for temporal (day/night) or seasonal (winter/summer) variations. The US 89 road corridor is highly influenced by temporal and seasonal variations. AADT is not adequate to determine when wildlife movements are likely to be impeded by traffic volume. Additional research is necessary to determine whether portions of US 89 have become a significant barrier to wildlife movement.

5. Results

5.1 Wildlife Road Crossing Importance Index

In the Wildlife Road Crossings Prioritization Characteristic, 52% (304/580) of segments have recorded safe passages, with the top 10% of these segments having index values of 0.558 or greater (Table 6). The total number of wildlife detected crossing roads is 5,046, with a maximum of 140 crossings in any one 0.10-mile segment (mean = 16.6, SD = 23.2). All data for the top 10 segments identified in the Wildlife Road Crossing Importance Index are shown in Table 6.

Table 4. Wildlife Road Crossing Importance Index: Top 10 0.10-mile segments

Road Segment ID	CitSci Crsgs	Sys Crsgs	Elk Crsgs	Prong Crsgs	Griz Crsgs	CitSci Normal-ized	Sys Normal-ized	Elk Normal-ized	Prong Normal-ized	Griz Normal-ized	Add Weighted N = (ElkCrsN*0.20) + (GrizCrsN*0.25) + (ProngCrsN*0.25) + (SysCrsN*0.15) + (CitSciCrsN*0.15)	Wildlife Crossings Importance Index
RM3.9	0	66	15	0	3	0.000	1.000	0.300	0.000	0.429	0.317	1.000
RM21.5	0	50	50	0	0	0.000	0.758	1.000	0.000	0.000	0.314	0.989
RM8.5	47	25	0	0	5	0.359	0.379	0.000	0.000	0.714	0.289	0.912
RM4.3	0	0	4	0	7	0.000	0.000	0.080	0.000	1.000	0.266	0.839
RM4.9	11	13	20	0	4	0.084	0.197	0.400	0.000	0.571	0.265	0.836
RM4.2	21	2	4	0	6	0.160	0.030	0.080	0.000	0.857	0.259	0.816
RM27.2	0	0	0	0	7	0.000	0.000	0.000	0.000	1.000	0.250	0.788
RM39.9	0	0	0	18	0	0.000	0.000	0.000	1.000	0.000	0.250	0.788
RM4.4	26	1	8	0	5	0.198	0.015	0.160	0.000	0.714	0.243	0.765
RM21.3	2	0	31	0	3	0.015	0.000	0.620	0.000	0.429	0.233	0.736

There are 1,969 elk crossing events observed from FWP collar data. Elk crossings represent 38% (1,969/5,046) of the total wildlife crossings, with a maximum of 50 elk crossings in any one segment (RM 21.5) and a mean of 3.39 (SD = 7.95). Collared elk crossings occur in 178 of the 580 0.10-mile segments. Roughly 40% (72/178) of these segments have $\geq$ 10 elk crossings and 38 have $\geq$ 20 elk crossings, most of which are between RM 2 to 3 and RM 17 to 22. About 58% (104/178) of these segments have $\leq$ 5 elk crossings.

There are 149 pronghorn crossing events from the collar data from FWP, with a maximum of 18 pronghorn crossings in any one segment (RM 39.9) and a mean of 0.26 (SD = 1.33). Collared pronghorn crossings occur in 49 of the 580 0.10-mile segments. About 48% (71/149) of the crossing events occur in two stretches, with 46 crossings occurring between RM 39.8 and RM 40.1, and 25 crossings occurring between RM 0.0 and RM 0.1.

There are 212 crossing events by 12 individual collared grizzly bears between 2008 – 2019, all to the south of RM 30. Grizzly bears make up 4% (212/5,046) of total crossings, with a maximum of 7 grizzly bear crossings (mean = 0.37, SD = 0.92) in 2 segments (i.e., RM 4.3 and RM 27.2). Grizzly bear crossings occur in 21% (121/580) of the 0.10-mile segments, with one-time crossing events in 62% (75/121) of these segments. Four individual bears contribute roughly 86% (183/212) of crossing events, with a male (GB A) having the most crossings at 86 events, followed by a female (GB B) with 35 events, a male (GB C) with 34 events, and a female (GB D) with 28 events (Figure 11).

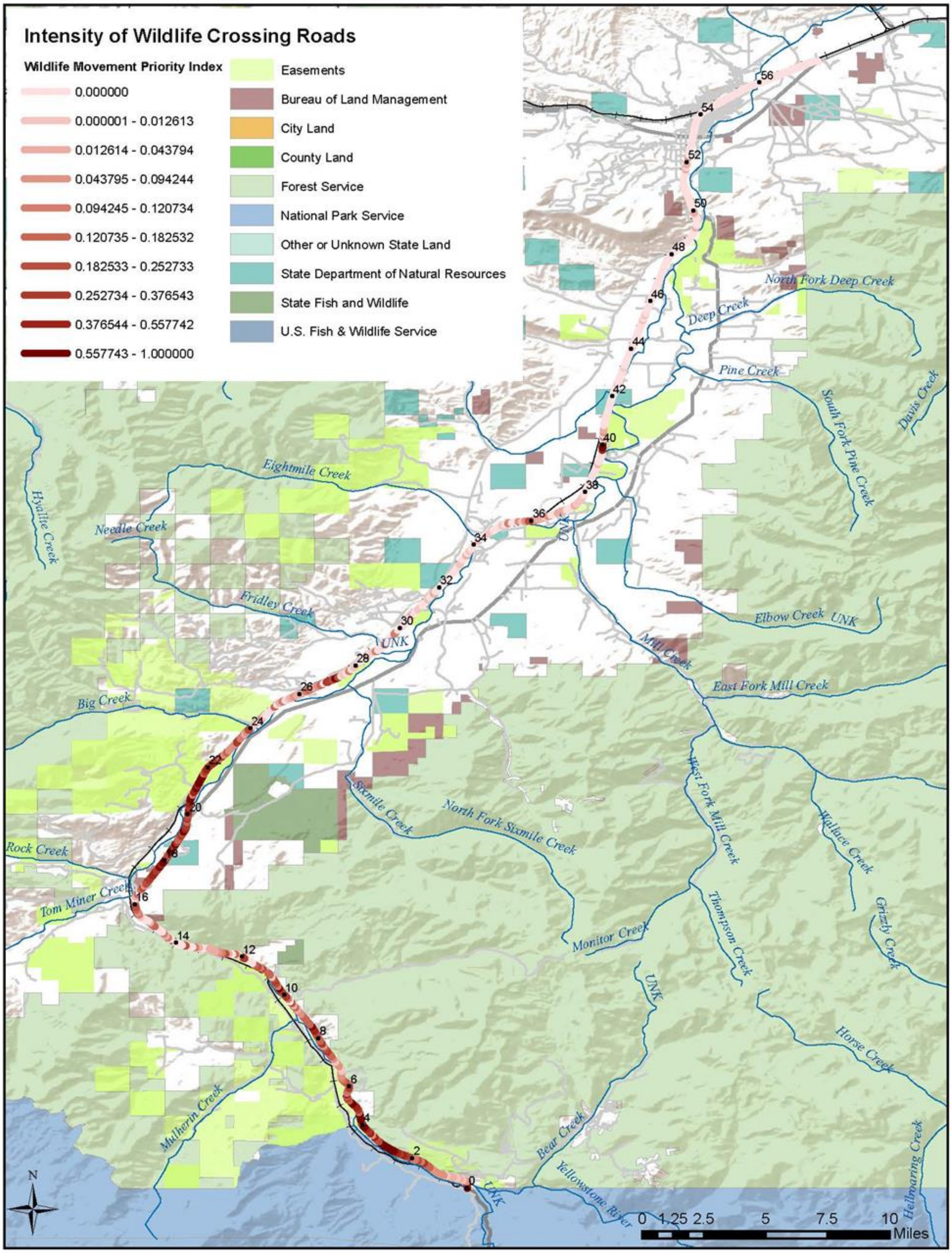


Figure 10. Intensity of Wildlife Crossing Roads in the Study Area

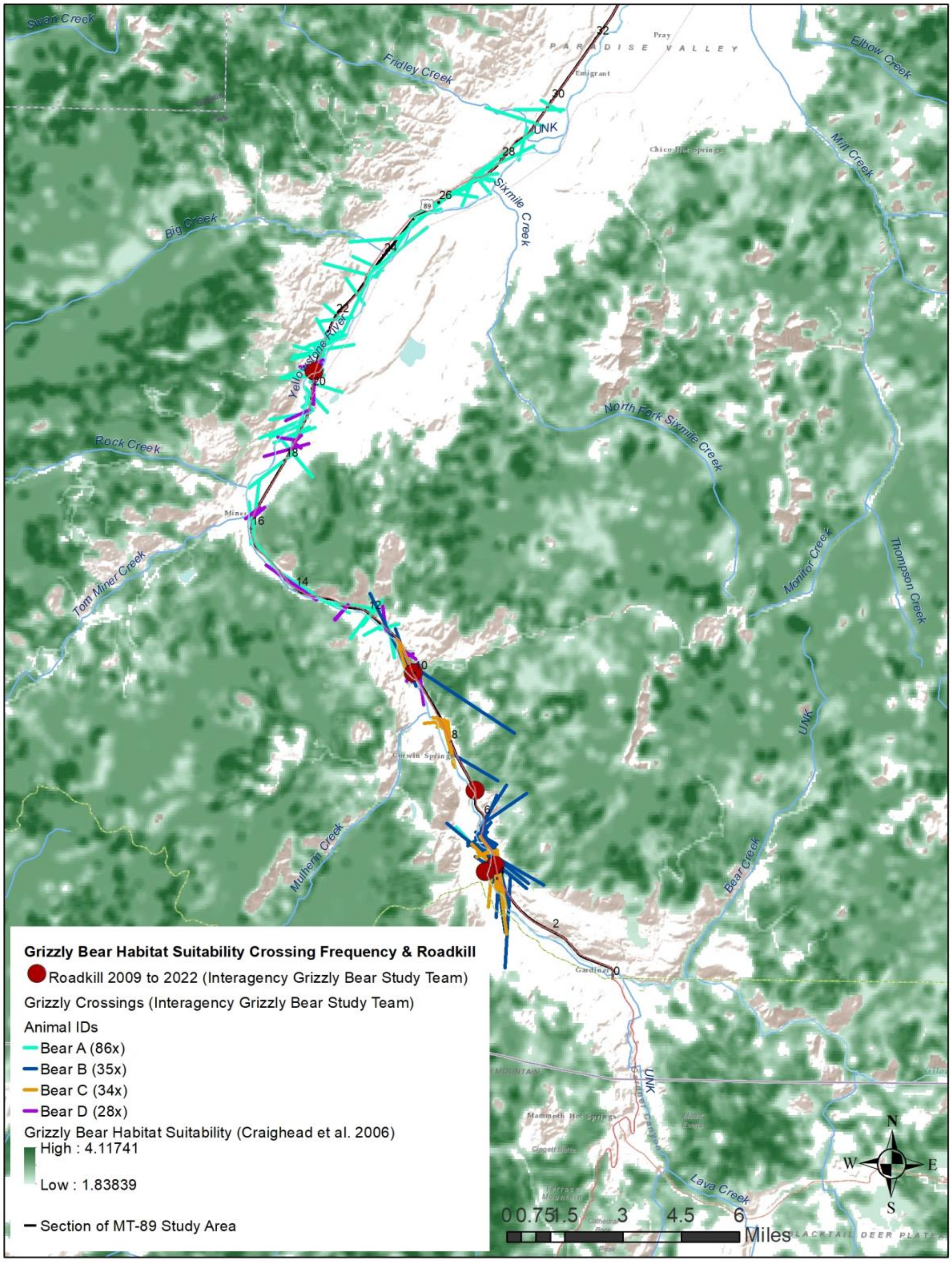


Figure 11. Grizzly Bear Habitat Suitability, Crossing Frequency, and Roadkill

There are 2,096 crossings in 186 events by other various species (e.g., elk, white-tailed deer, mule deer) recorded in the ROaDS Tool by citizen scientists in the study area. ROaDS Tool crossings make up 42% of total crossings (2,096/5,046) and are documented in 128 of the 0.10-mile segments, ranging from 1 to 131 crossings per event. A total of 35 segments had ≥ 20 crossings, 11 segments had ≥ 50 crossings, and 4 segments had ≥ 100 crossings (i.e., RM 10.3, RM 17.7, RM 17.9, and RM 20.4).

There are 620 crossings in 87 events by various species recorded in the ROaDS Tool through systematic surveys of the study area. Crossings were documented in 70 of the 580 segments, with a maximum of 66 crossings in any one segment (Mean 1.07; SD 5.22). There were 11 segments with > 20 crossings and 3 segments with > 45 crossings (i.e., RM 3.1, RM 3.9, and RM 21.5).

5.2 Wildlife Observation Importance Index

In the Wildlife Observations Near Roads Prioritization Characteristic, 76% (438/580) of segments had various species of wildlife recorded within 500 m of US 89 in the study area, with the top 10% of these segments having importance index values of 0.285 or greater (Table 7). The total number of wildlife observed is 239,461 with a maximum of 7,339 observations in any one 0.10-mile segment (mean = 412.86, SD = 788.44). All data for the top 10 segments identified in the Wildlife Observation Importance Index are shown in Table 7.

Data on collared elk from the National Park Service (NPS) collected between 2012 and 2021 make up roughly 29% (69,684/239,461) of the total wildlife observations within 500 m of US 89. The maximum observations in any one segment were 2724 (RM 6.2) with a mean of 120.14 (SD = 307.52). Elk observations from NPS occurred in 253 of the 580 0.10-mile segments, and all of these events were to the south of RM 28. Roughly 5% (13/2,536) of these segments had > 1,000 elk observations with all but one of these segments between RM 4.4 and RM 6.2; the other was RM 17.5. About 13% (32/253) of these segments had > 500 observations, most of which were between RM 1.8 and RM 6.2, while 9 of these segments were between RM 17.3 and RM 19.3.

FWP data on collared elk from 6 herds collected between 2002 and 2020 make up about 38% (92,010/239,461) of the total wildlife observations within 500 m of US 89. The maximum observations in any one segment were 2510 (RM 17.5) with a mean of 158.64 (SD = 370.85), which included individuals from four herds (Big Creek, Northern Yellowstone, Dome and Sixmile). Elk observations from FWP data occurred in 61% (351/580) of the 0.10-mile segments. Thirty of the segments had > 1,000 observations, all of which were between either RM 17.4 and RM 22.3 or RM 4.4 and RM 6.2.

FWP data on collared pronghorn antelope collected between 2020 and 2022 make up 26% (62,589/239,461) of the total wildlife observations within 500 m of US 89. The maximum number of observations in any one segment was 3,470 (RM 23.8) with a mean of 107.91 (SD = 323.21). Pronghorn observations occurred in 54% of the 0.10-mile segments. Five of the segments had > 2,000 observations, all of which were between either RM 23.7 and RM 23.8 or RM 6.2 and RM 6.5. Thirteen segments had > 1,000 observations, which occurred between RM 5.6 and RM 6.6 or between RM 21.2 and RM 23.9.

Table 5. Wildlife Observation Importance Index: top 10 0.10-mile segments

Road ID	ELK NPS #Obs	Prong #Obs	ELK FWP #Obs	Bighorn #Obs	Wolf #Obs	Griz #Obs	CitSci #Obs	Syst #Obs	Total #Obs	Elk NPS #Obs Normalized	Prong #Obs Normalized	Elk FWP #Obs Normalized	Bighorn #Obs Normalized	Wolf #Obs Normalized	Griz #Obs Normalized	CitSci #Obs Normalized	Sys #Obs Normalized	Add Weighted N = (ElkNPSObsN*0.10) + (ProngObsN*0.15) + (ElkMWObsN*0.15) + (BighornObsN*0.15)	Wildlife Observation Importance Index
RM6.2	2724	3082	1486	0	0	0	0	47	7339	1.000	0.888	0.592	0.000	0.000	0.000	0.000	0.099	0.337	1.000
RM17.5	1399	0	2510	0	0	1	60	344	4314	0.514	0.000	1.000	0.000	0.000	0.024	0.185	0.726	0.332	0.986
RM4.9	2590	3	1497	0	0	29	50	11	4180	0.951	0.001	0.596	0.000	0.000	0.690	0.154	0.023	0.307	0.912
RM5.0	1198	2	654	0	0	42	0	4	1900	0.440	0.001	0.261	0.000	0.000	1.000	0.000	0.008	0.234	0.696
RM18.4	690	0	2155	0	0	0	88	155	3088	0.253	0.000	0.859	0.000	0.000	0.000	0.272	0.327	0.230	0.684
RM6.3	1423	2678	782	7	0	1	10	0	4901	0.522	0.772	0.312	0.004	0.000	0.024	0.031	0.000	0.222	0.659
RM5.7	1521	1619	901	1	0	8	0	0	4050	0.558	0.467	0.359	0.001	0.000	0.190	0.000	0.000	0.208	0.618
RM4.8	2458	5	1361	0	0	4	12	53	3893	0.902	0.001	0.542	0.000	0.000	0.095	0.037	0.112	0.207	0.613
RM5.6	1729	1646	930	0	0	0	0	15	4320	0.635	0.474	0.371	0.000	0.000	0.000	0.000	0.032	0.195	0.579
RM17.6	767	4	1226	0	0	2	0	249	2248	0.282	0.001	0.488	0.000	0.000	0.048	0.000	0.525	0.188	0.557

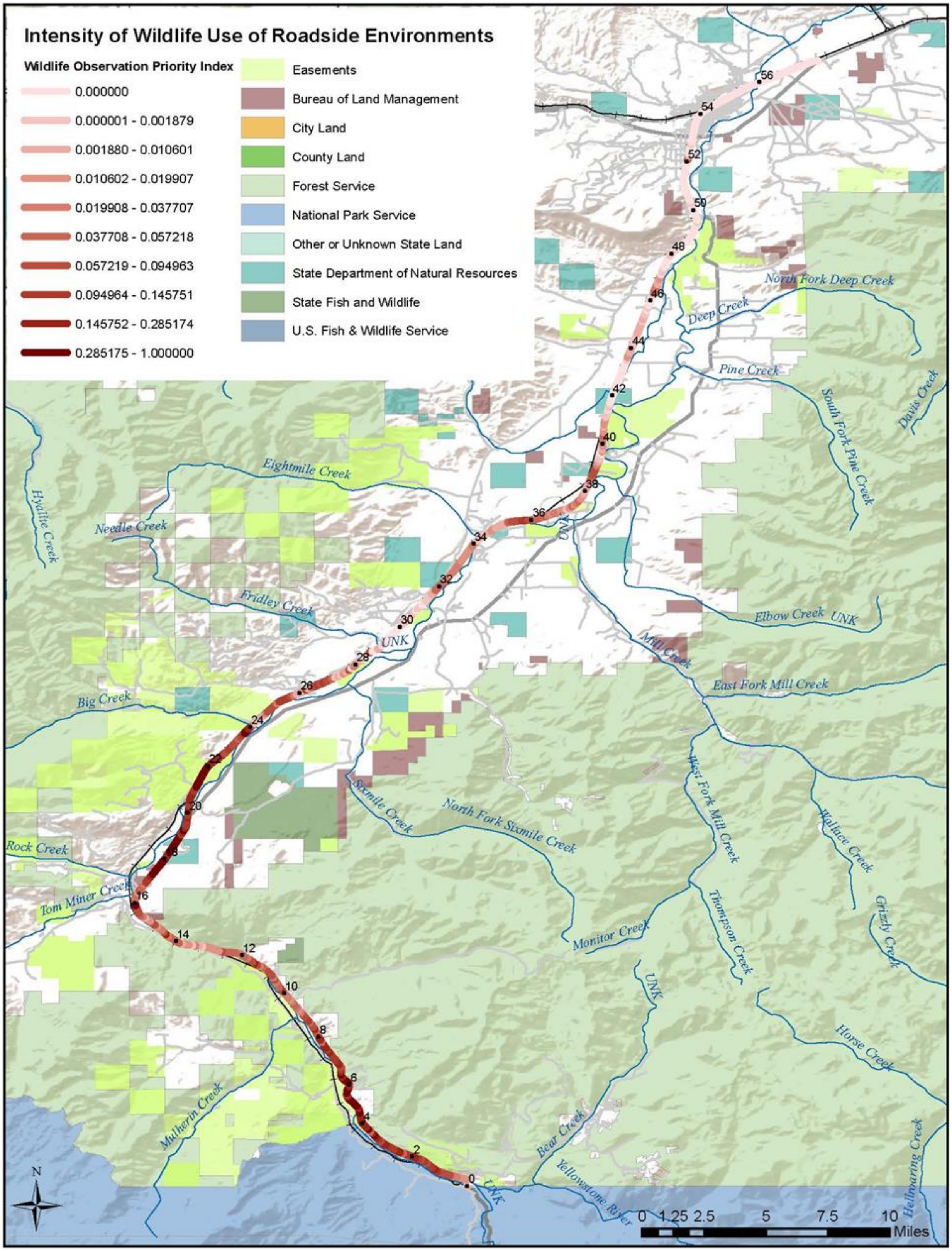


Figure 12. Intensity of Wildlife Use of Roadside Environments in the Study Area

FWP collar data for bighorn sheep collected between 2012 and 2015 comprised just 1.2% (2,975/239,461) of the total wildlife observations within 500 m of US 89. The maximum number of observations in any one segment was 1,702 in RM 15.9 (mean = 5.13; SD = 73.3), which was 57% (1702/2975) of the overall bighorn observations. Bighorn observations only occurred in 8.8% (51/580) of the 0.10-mile segments. In fact, 84% (2,492/2,975) of the bighorn observations were between RM 15.7 and RM 16.0.

Wolf collar data from FWP collected between 2021 and 2023 documented just 10 observations within 500 m of US 89 in two of the 0.10-mile segments. The maximum number of observations in any one segment was 9 in RM 52.1 (mean 0.02; SD 0.38) with the only other observation in the neighboring segment RM 52.2.

Collar data on grizzly bear repulsion events from IGBST collected between 2013 and 2019 comprised just 0.15% (360/239,461) of the total wildlife observations within 500 m of US 89. Grizzly bear observations occur in 18% (105/580) of the 0.10-mile segments. Eight of these segments had ≥ 10 observations accounting for 41% (149/360) of the total observations, with 84 of these observations occurring between RM 4.9 and RM 5.1. The greatest number of observations in any one segment was 42 (RM 5.0), with a mean of 0.62 (SD = 2.71).

There were 3,602 wildlife observations of various species (e.g., elk, white-tailed deer, mule deer) recorded by citizen scientists in the ROaDS Tool between 2020 and 2023. ROaDS Tool data make up 1.5% of total observations (3,602/239,461) and are documented in 143 of the 0.10-mile segments. The maximum number of observations in any one segment was 324 (RM 3.4), with a mean of 6.21 (SD = 23.21). There were 8 segments with > 100 observations recorded.

Systematic surveys between 2021 and 2023 using the ROaDS Tool comprised 3.4% (8231/239461) of the total wildlife observations and occurred in 38% 219/580 of the 0.10-mile segments. The main species recorded were elk, white-tailed deer, mule deer, bighorn sheep and bison. Twenty-three of these segments had > 100 observations, with 21 of these between RM 1.9 and RM 4.5 or RM 17.3 and RM 19.3. The maximum number of observations in any one segment was 474 (RM 4.1) with a mean of 14.19 (SD = 43.08).

5.3 Wildlife-Vehicle Collision Index

In the Wildlife-Vehicle Collision Prioritization Characteristic, 86% (500/580) of segments have at least one WVC (i.e., crash or carcass), with the top 10% of these segments having importance indices of 0.278 or greater (Table 8). The total number of WVCs (i.e., crash and carcass) across the 10 years analyzed is 2,392 with a maximum of 84 WVCs in any one 0.10-mile segment (mean = 4.12, SD = 5.3). RM segment 52.0 had the highest total count of WVCs. There were 45 segments with ≥ 10 WVCs and 193 segments with ≥ 5 WVCs over the 10-year period. All data for the top 10 segments identified in the Wildlife Vehicle Collision Importance Index are included in Table 8.

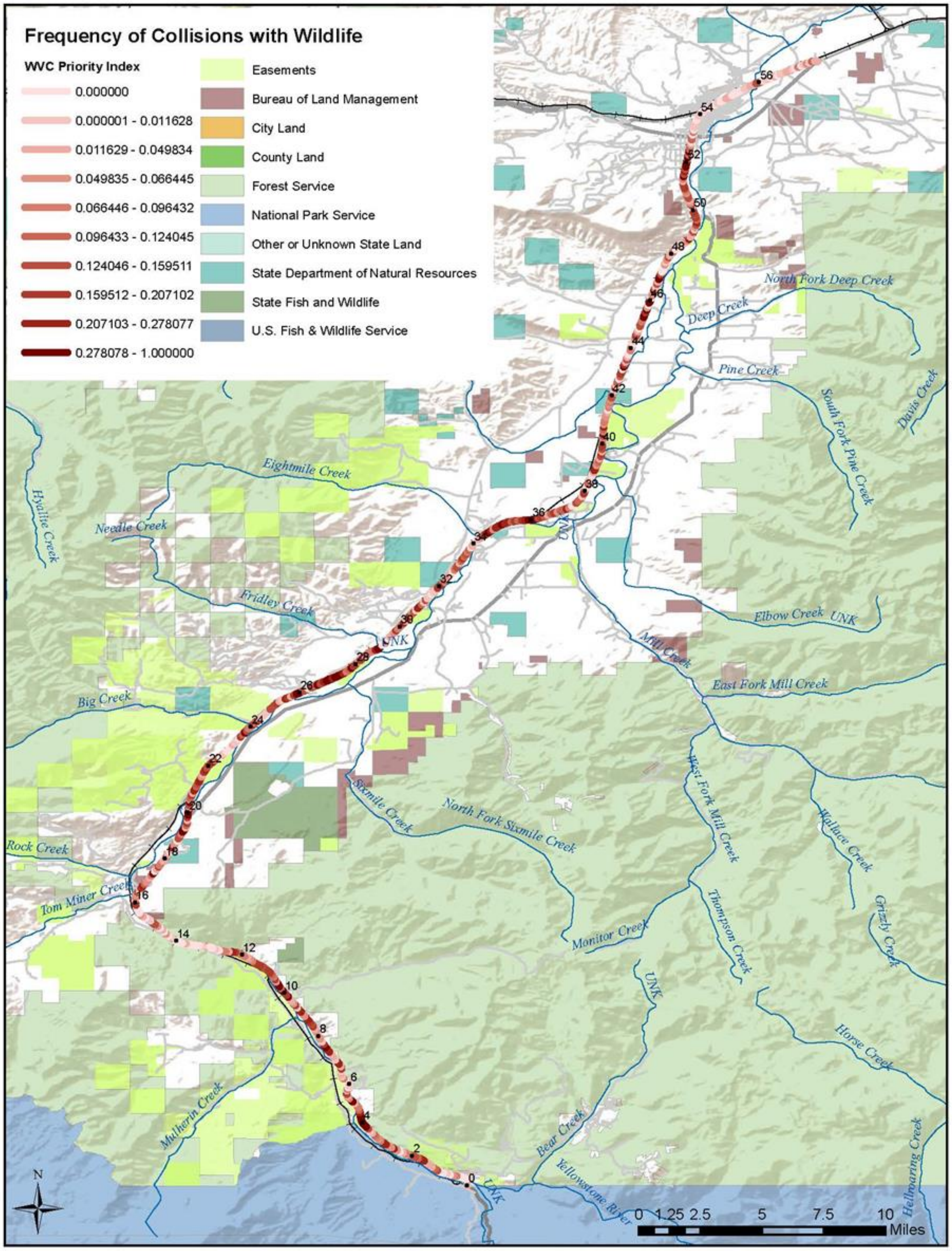


Figure 13. Frequency of Collisions with Wildlife in the Study Area based on Crash and Carcass Data

Table 6. Wildlife-Vehicle Collision Importance Index: Top 10 0.10-mile segments

Road ID	# Sys	# CitSci	# Salv	# Crash	# Carcass	# Griz	WVC Total	# Sys N	# CitSci N	# Salv N	# Crash N	# Carcass N	# Griz N	(SYS*0.20) + (CITSCI*0.05) + (SALV*0.05) + (CRASH*0.30) + (CARC*0.30) + (GRIZ*0.10) = WVC	WVC Importance Index
RM51.9	8	1	0	9	0	0	18	1.000	0.033	0.000	1.000	0.000	0.000	0.502	1.000
RM52.0	3	1	1	2	77	0	84	0.375	0.033	0.042	0.222	1.000	0.000	0.445	0.888
RM47.0	6	0	0	5	3	0	14	0.750	0.000	0.000	0.556	0.039	0.000	0.328	0.655
RM3.9	0	0	0	8	8	0	16	0.000	0.000	0.000	0.889	0.104	0.000	0.298	0.594
RM51.8	1	0	1	7	3	0	12	0.125	0.000	0.042	0.778	0.039	0.000	0.272	0.542
RM27.0	5	0	0	3	5	0	13	0.625	0.000	0.000	0.333	0.065	0.000	0.244	0.487
RM26.9	7	0	0	1	8	0	16	0.875	0.000	0.000	0.111	0.104	0.000	0.240	0.477
RM4.2	0	1	0	4	1	1	7	0.000	0.033	0.000	0.444	0.013	1.000	0.239	0.476
RM19.0	4	1	0	4	0	0	9	0.500	0.033	0.000	0.444	0.000	0.000	0.235	0.468
RM45.6	1	1	0	6	2	0	10	0.125	0.033	0.000	0.667	0.026	0.000	0.234	0.467

In the MDT crash data, 50% (292/580) of the segments have at least one crash. The total number of crashes across the 10 years analyzed is 532 with a maximum of 9 crashes in any one 0.10-mile segment (mean = 0.92, SD = 1.24). Road segments 51.9, 51.8, and 3.9 had the highest number of crashes. Roughly 52% (152/292) of the segments had just one crash, while 19% had 3 or more crashes.

In the MDT carcass data, 58% (339/580) of the segments had at least one carcass. The total number of carcasses across the 10 years analyzed is 1085 with a maximum of 77 carcasses in any one 0.10-mile segment (mean = 1.87, SD = 4.12). Road segment 52.0 had the highest total count of carcasses. Twelve segments had 10 or more carcasses.

From the FWP salvage data, 16% (90/580) of the segments had at least one or more carcasses, with 82 of these segments having just one carcass. The total number of carcasses over roughly a 2 ½ year period is 125, with a maximum of 24 carcasses in any one 0.10-mile segment (mean = 0.22, SD = 1.1). Road segment 57.8 had the highest total count of carcasses.

The Interagency Grizzly Bear Study Team (IGBST) has recorded five grizzly bears killed on US 89 between 2009 and 2022. All recorded roadkills occurred to the south of RM 21. All grizzly bear roadkills occurred in different road segments, however two of the 5 were recorded in neighboring segments (RM 4.2 and 4.3). Road segment 4.2 is included in the top 10 of the WVC Importance Index, as shown in Table 8.

The carcass data systematically collected using the ROaDS Tool over a roughly 2 ½-year period include a total of 412 events, with a maximum of 8 individual carcasses recorded in any one segment (mean = 0.71, SD = 1.08). These data were recorded on 44% (253/580) of the 0.10-mile segments, with 3 or more carcasses recorded in 37 of these segments.

The carcass data collected by citizen scientists using the ROaDS Tool over roughly the same time period include a total of 172 events. The total number of carcasses was 233, with a maximum of 30 individual carcasses recorded in any one segment (RM 2.0, mean = 0.40, SD = 1.60). These data are recorded on 135 0.10-mile segments.

WVCs in the study area exhibited seasonal trends, with deer species having the highest incidence from fall through spring. Mule deer had the biggest seasonal peaks with large increases in numbers during fall and spring. Elk collisions had the biggest peak from December through April, while most other species saw higher numbers of WVCs in the summer and Fall (Figure 14).

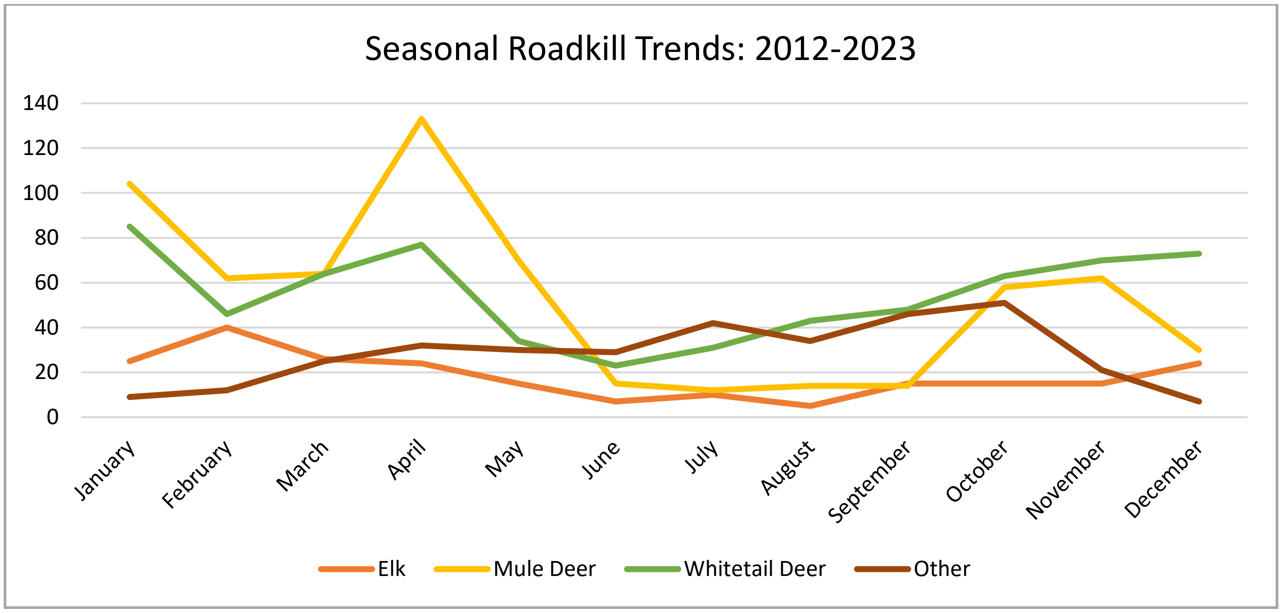


Figure 14. Seasonal roadkill trends based on available WVC data from 2012-2023.

5.4 Habitat Suitability/Connectivity Importance Index

Figure 13 shows the regional conservation importance of all segments in the study area as described by the Habitat Suitability/Connectivity Importance Index, with the top 10% having index values of 0.461 or greater. Table 9 highlights the top ten 0.10-mile segments with the highest values of this index, the majority of which are along the southern extent of US 89 south of RM 15.7, closer to Yellowstone National Park, with the highest value at RM 13.6. This is due to the expanse of relatively intact habitat surrounding the park compared to the matrix of public and private land under development pressure further north around Livingston. The average value of this index across all 580 0.10-mile segments is 0.25 (SD = 0.15), with lower values clustered around Livingston and, to some extent, Gardiner.

Table 7. Habitat Suitability/Connectivity Importance Index: Top 10 0.10-mile segments

Road ID	Bighorn * 0.10	Toad * 0.10	Wolv * 0.10	BisonW * 0.05	BisonS * 0.05	Griz * 0.10	GrsBrd * 0.033	GrsWtr * 0.034	GrsNst * 0.033	Dick * 0.10	Kros * 0.10	Peck * 0.10	Blkbr * 0.10	Weighted Average	Suit/Conn Importance Index 0-1
RM13.6	0.100	0.000	0.095	0.000	0.036	0.000	0.009	0.000	0.000	0.049	0.093	0.004	0.000	0.386	1.000
RM15.7	0.000	0.078	0.054	0.000	0.000	0.070	0.012	0.000	0.000	0.051	0.093	0.007	0.000	0.366	0.948
RM50.9	0.085	0.085	0.046	0.000	0.000	0.000	0.011	0.000	0.000	0.072	0.000	0.047	0.000	0.347	0.898
RM13.4	0.032	0.000	0.088	0.044	0.034	0.000	0.010	0.000	0.000	0.024	0.093	0.003	0.000	0.329	0.853
RM15.4	0.098	0.000	0.000	0.044	0.031	0.000	0.015	0.000	0.000	0.030	0.093	0.006	0.000	0.318	0.823
RM10.0	0.000	0.079	0.000	0.000	0.000	0.076	0.000	0.000	0.000	0.064	0.072	0.009	0.000	0.300	0.777
RM13.9	0.035	0.000	0.096	0.000	0.000	0.000	0.000	0.000	0.000	0.049	0.093	0.004	0.000	0.276	0.715
RM7.1	0.094	0.000	0.041	0.000	0.000	0.000	0.021	0.020	0.025	0.062	0.000	0.003	0.000	0.265	0.686
RM50.6	0.061	0.027	0.054	0.000	0.000	0.000	0.013	0.000	0.000	0.073	0.000	0.031	0.000	0.259	0.669
RM14.7	0.080	0.000	0.039	0.042	0.031	0.000	0.000	0.000	0.000	0.060	0.000	0.004	0.000	0.257	0.664

The Habitat Suitability/Connectivity Importance Index is derived from 13 different data sets (Table 3), most of which are species-specific. Table 8 provides summary statistics for the normalized values of each of the habitat suitability/connectivity model inputs. We highlight the results of two of the model inputs that are species-neutral (Figure 14). The information from Dickson et al. (2016), which is based on current ecological flows of connectivity among large, protected areas in the western U.S., shows the southern part of the study area to be much more permeable. The most highly permeable areas along US 89 are RM 31.8 to 32.4, RM 20.8 to 21.3, RM 22.8 to 23.1, RM 23.5 to 24.6, and RM 50.1 to 50.5, which all have connectivity values above 0.80. The average connectivity value along the US 89 is 0.44 (SD = 0.23). The top 10% of the riparian climate corridors delineated in Krosby et al. (2018) that intersect with US 89 are largely associated with the Yellowstone River that meanders along the highway. However, the highest rank is RM 24.0, where Big Creek flows into the Yellowstone River.

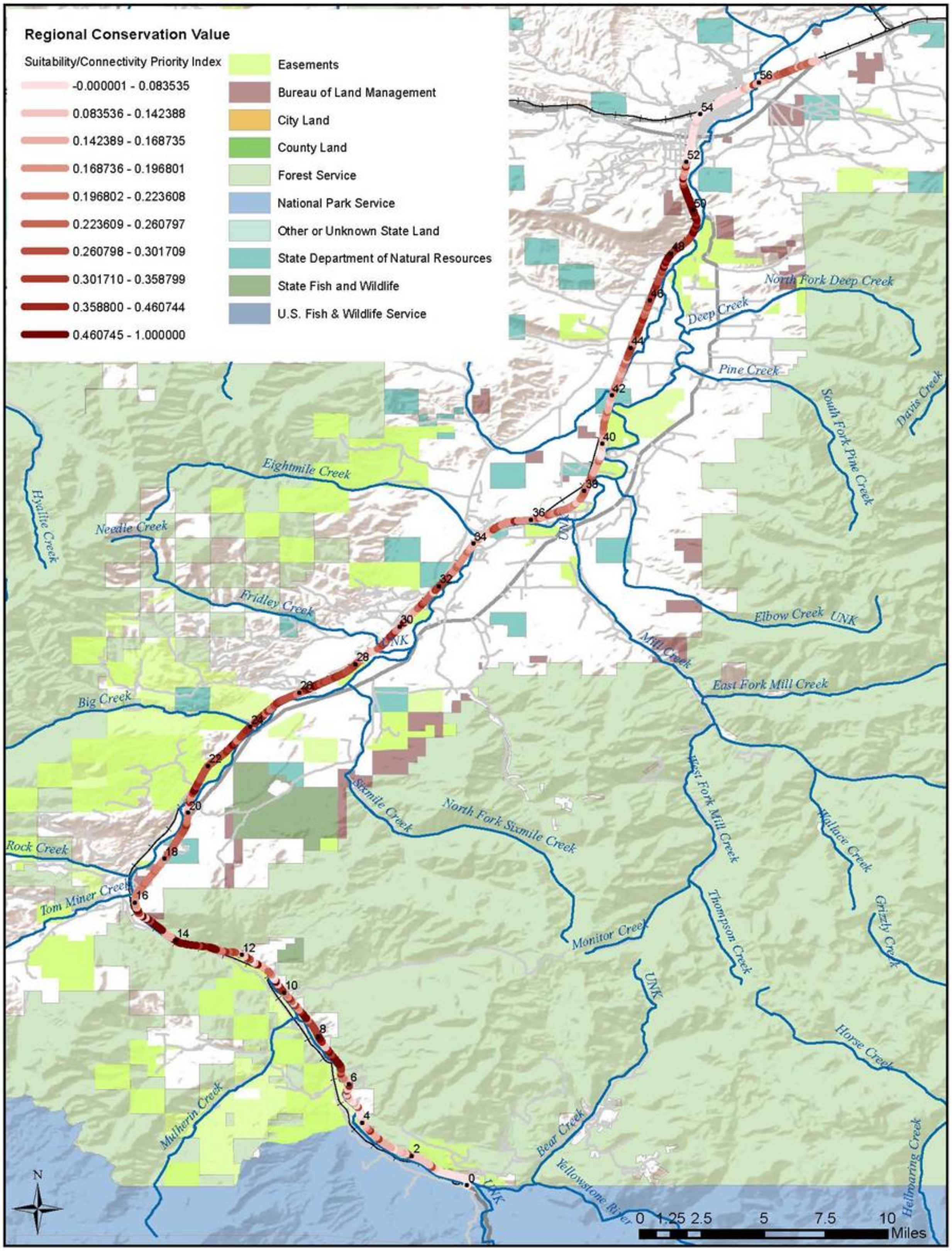
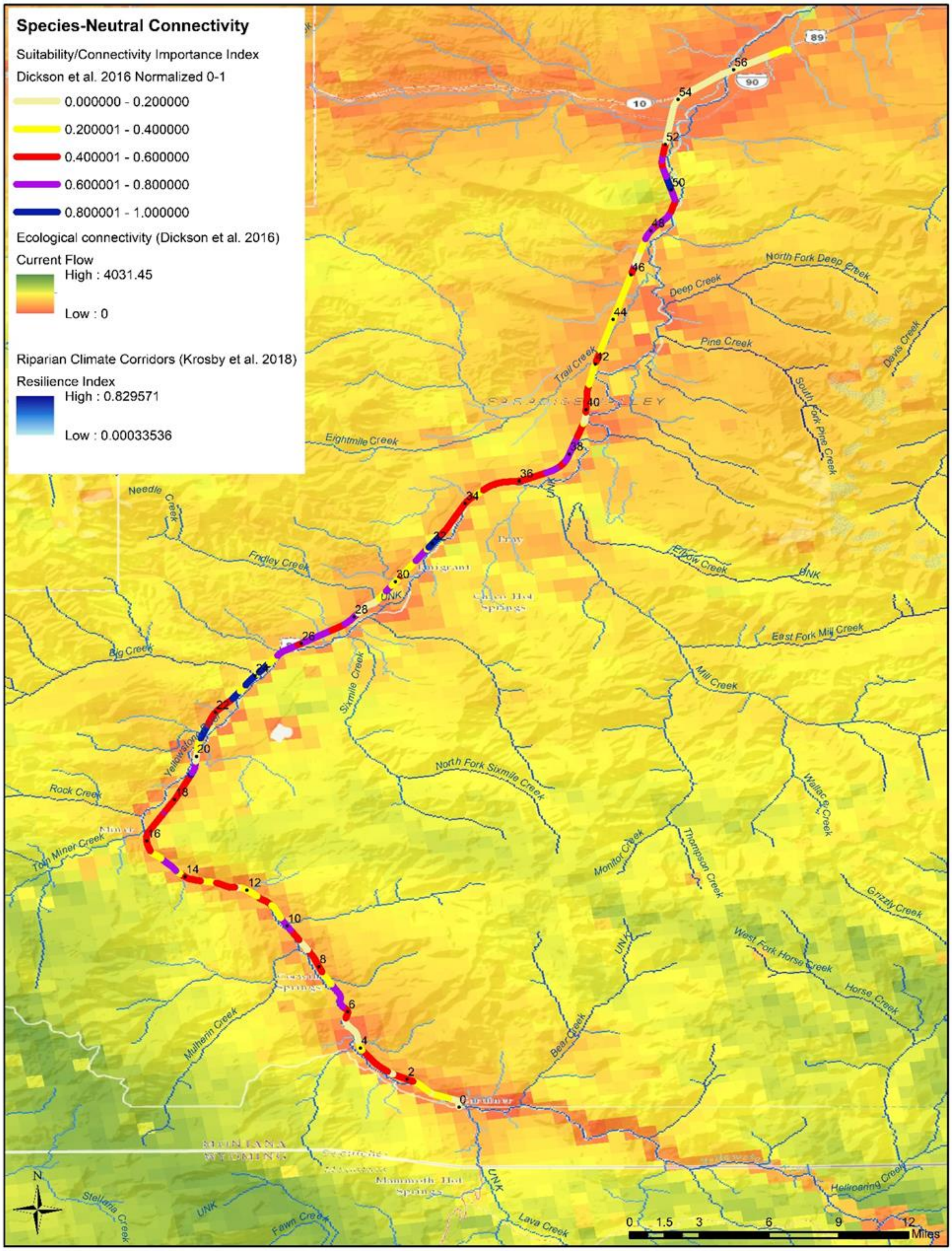


Figure 13. Regional Conservation Value



Species-Neutral Connectivity
Suitability/Connectivity Importance Index
Dickson et al. 2016 Normalized 0-1
0.000000 - 0.200000
0.200001 - 0.400000
0.400001 - 0.600000
0.600001 - 0.800000
0.800001 - 1.000000
Ecological connectivity (Dickson et al. 2016)
Current Flow
High : 4031.45
Low : 0
Riparian Climate Corridors (Krosby et al. 2018)
Resilience Index
High : 0.829571
Low : 0.00033536
North Fork Deep Creek
Deep Creek
Pine Creek
Davis Creek
South Fork Pine Creek
Trail Creek
Eightmile Creek
Needle Creek
Fridley Creek
Elbow Creek
East Fork Mill Creek
Big Creek
Mill Creek
Sixmile Creek
North Fork Sixmile Creek
Rock Creek
Tom Miner Creek
Yellowstone
Wallace Creek
Monitor Creek
Thompson Creek
Grizzly Creek
West Fork Horse Creek
Horse Creek
Mulherin Creek
Bear Creek
Hellroaring Creek
Stellaria Creek
Fawn Creek
Lava Creek
UNK
0 1.5 3 6 9 12 Miles

Table 8. Summary Statistics on Normalized Values for Habitat Suitability/Connectivity Model Inputs

Data Input	Min	Max	Mean	SD	No. of Segments with Values	Highest Value Segment or Range of Segments
Ecological Connectivity	0	1	0.443	0.225	574	RM 31.8 to 32.4
Riparian Climate Corridors	0	1	0.035	0.160	34	RM 24.0; RM 13.4 to 13.7
Boreal Toad Habitat Effectiveness	0	1	0.049	0.166	57	RM 47.4; RM 30.0
Sage grouse Potential Brood Habitat	0	1	0.229	0.279	260	RM 21.3 to 22.3
Sage Grouse Winter Habitat Suitability	0	1	0.056	0.193	47	RM 26.2 to 26.6
Sage Grouse Potential Nesting Habitat	0	1	0.029	0.121	43	RM 26.2 to 26.5; RM 7.0 to 7.5; RM 8.3 to 9.2
Bighorn Sheep Habitat Effectiveness	0	1	0.068	0.216	60	Rm 49.0; RM 13.6 to 13.7
Bison Winter Habitat Suitability	0	1	0.040	0.186	26	RM 5.6; RM14.6 to 15.0
Bison Summer Habitat Suitability	0	1	0.031	0.151	24	RM 8.8 to 9.0; RM 14.8 to 15.0
Wolverine Habitat Effectiveness	0	1	0.019	0.110	23	RM 13.4 to 13.9
Northern Rockies Black Bear Connectivity	0	1	0.014	0.094	125	RM 50.1 to 50.5
Grizzly Bear Habitat Suitability	0	1	0.021	0.133	15	RM 8.8 to 9.1
Potential Grizzly Bear Passage	-0.00001	0.999	0.214	0.193	580	RM 45.2 to 45.3; RM 44.6 to 44.9

5.5 Priority Composite Index

Figure 15 provides an overview of how each of the 580 0.10-mile road segments evaluated ranks in the Priority Composite Index. The top 10% of the 580 segments analyzed on US 89 have index values between 0.442 and 1. Table 11 provides detailed rankings of the top 10% of the 0.10-mile road segments along US 89 with the highest Priority Composite Index values. The 0.10-mile segment with the highest value was RM 3.9. The average Priority Composite Index value of all 580 0.10-mile segments is 0.21 (SD = 0.16).

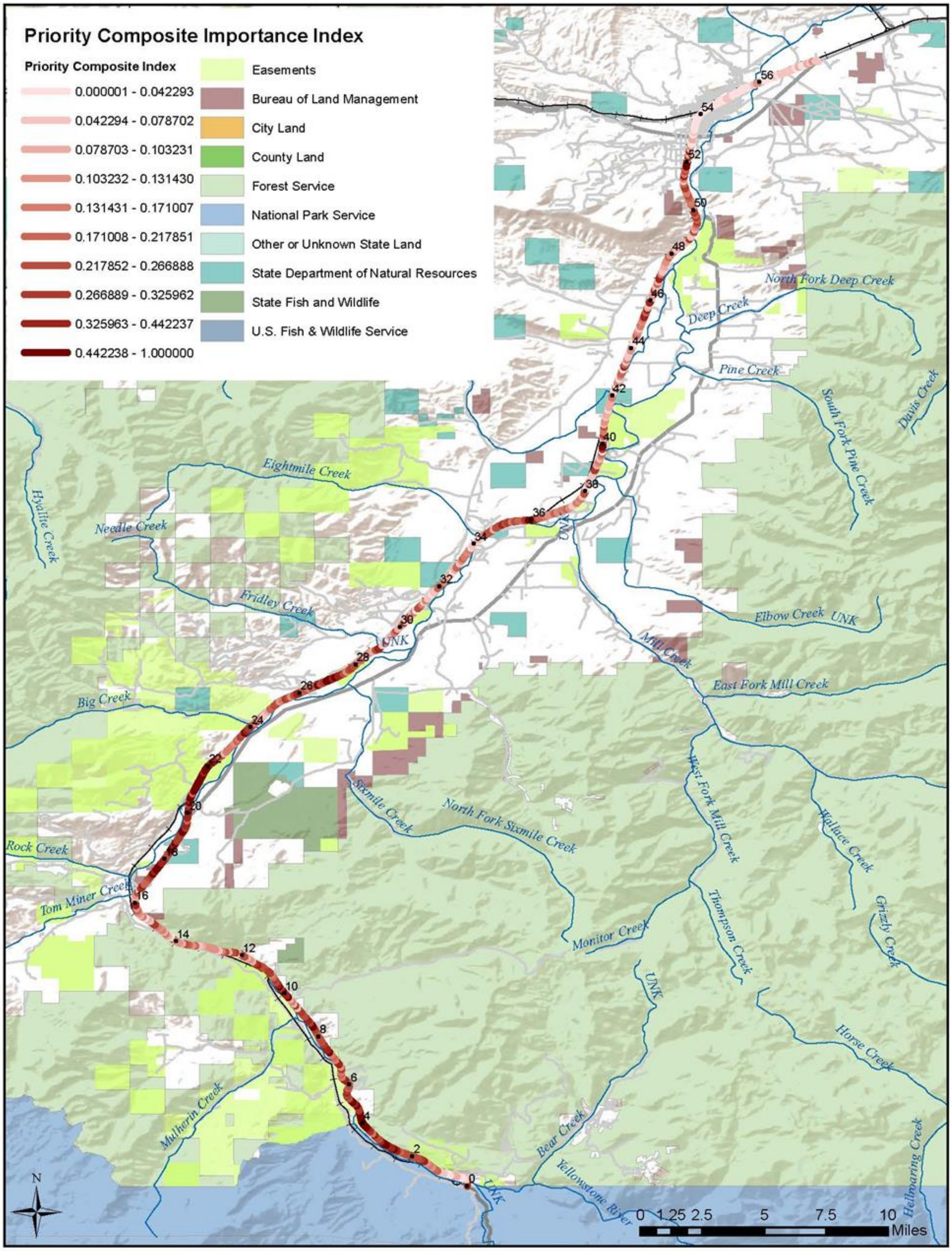


Figure 15. Priority Composite Indices for US 89

Table 9. Top 10% 0.10-mile Road Segments on US-191 for the Priority Composite Index

Road Segment ID	Wildlife Observation Importance Index (WOII)	Suitability / Connectivity Importance Index (SCII)	Wildlife Movement Importance Index (WMII)	WVC Importance Index (WVCII)	WOII * 0.15	SCII * 0.10	WMII * 0.25	WVCII * 0.50	(WMII*0.25) + (WOII*0.15) + (SCII*0.10) + (WVCII*0.50) = Composite Index	Priority Composite Index 0-1
RM3.9	0.152	0.132	1.000	0.594	0.023	0.013	0.250	0.297	0.583	1.000
RM51.9	0.000	0.187	0.043	1.000	0.000	0.019	0.011	0.500	0.529	0.908
RM4.9	0.912	0.047	0.836	0.350	0.137	0.005	0.209	0.175	0.525	0.901
RM4.2	0.228	0.119	0.816	0.476	0.034	0.012	0.204	0.238	0.488	0.838
RM52.0	0.007	0.255	0.000	0.888	0.001	0.025	0.000	0.444	0.470	0.807
RM19.0	0.131	0.224	0.558	0.468	0.020	0.022	0.139	0.234	0.416	0.713
RM4.3	0.162	0.005	0.839	0.357	0.024	0.000	0.210	0.179	0.413	0.708
RM19.3	0.465	0.287	0.579	0.334	0.070	0.029	0.145	0.167	0.411	0.704
RM21.4	0.436	0.272	0.720	0.261	0.065	0.027	0.180	0.131	0.403	0.691
RM21.3	0.346	0.376	0.736	0.251	0.052	0.038	0.184	0.126	0.399	0.684
RM4.4	0.531	0.040	0.765	0.242	0.080	0.004	0.191	0.121	0.396	0.679
RM18.5	0.539	0.232	0.605	0.274	0.081	0.023	0.151	0.137	0.392	0.672
RM20.4	0.134	0.366	0.502	0.393	0.020	0.037	0.126	0.197	0.379	0.649
RM27.2	0.000	0.411	0.788	0.280	0.000	0.041	0.197	0.140	0.378	0.649
RM10.3	0.053	0.455	0.586	0.334	0.008	0.046	0.146	0.167	0.367	0.629
RM21.5	0.397	0.279	0.989	0.060	0.060	0.028	0.247	0.030	0.365	0.625
RM22.0	0.425	0.292	0.566	0.252	0.064	0.029	0.141	0.126	0.361	0.618
RM4.0	0.219	0.130	0.711	0.272	0.033	0.013	0.178	0.136	0.360	0.616
RM47.0	0.000	0.216	0.000	0.655	0.000	0.022	0.000	0.327	0.349	0.598
RM8.5	0.090	0.337	0.912	0.143	0.014	0.034	0.228	0.071	0.347	0.594
RM26.9	0.088	0.275	0.254	0.477	0.013	0.028	0.064	0.239	0.343	0.588
RM20.1	0.160	0.188	0.389	0.390	0.024	0.019	0.097	0.195	0.335	0.574
RM17.3	0.371	0.223	0.396	0.300	0.056	0.022	0.099	0.150	0.327	0.560
RM18.4	0.684	0.230	0.643	0.050	0.103	0.023	0.161	0.025	0.311	0.533
RM51.8	0.000	0.390	0.000	0.542	0.000	0.039	0.000	0.271	0.310	0.531
RM2.9	0.180	0.161	0.600	0.230	0.027	0.016	0.150	0.115	0.308	0.528
RM27.0	0.035	0.261	0.120	0.487	0.005	0.026	0.030	0.244	0.305	0.522
RM2.6	0.129	0.079	0.607	0.248	0.019	0.008	0.152	0.124	0.303	0.519

RM22.2	0.285	0.268	0.382	0.270	0.043	0.027	0.096	0.135	0.300	0.514
RM3.8	0.219	0.167	0.418	0.287	0.033	0.017	0.104	0.143	0.297	0.509
RM21.0	0.267	0.375	0.377	0.249	0.040	0.037	0.094	0.125	0.296	0.507
RM21.9	0.480	0.296	0.467	0.156	0.072	0.030	0.117	0.078	0.296	0.507
RM39.9	0.012	0.136	0.788	0.167	0.002	0.014	0.197	0.084	0.296	0.507
RM21.2	0.386	0.369	0.516	0.141	0.058	0.037	0.129	0.070	0.294	0.504
RM18.7	0.527	0.235	0.630	0.066	0.079	0.024	0.158	0.033	0.293	0.502
RM10.1	0.064	0.438	0.228	0.365	0.010	0.044	0.057	0.183	0.293	0.502
RM35.9	0.090	0.176	0.195	0.415	0.014	0.018	0.049	0.208	0.288	0.492
RM21.8	0.430	0.264	0.302	0.240	0.064	0.026	0.075	0.120	0.286	0.490
RM4.1	0.538	0.123	0.199	0.287	0.081	0.012	0.050	0.143	0.286	0.490
RM5.0	0.696	0.089	0.381	0.153	0.104	0.009	0.095	0.076	0.285	0.488
RM20.9	0.107	0.491	0.443	0.217	0.016	0.049	0.111	0.109	0.284	0.487
RM20.7	0.237	0.184	0.577	0.169	0.035	0.018	0.144	0.085	0.283	0.485
RM2.0	0.135	0.117	0.646	0.173	0.020	0.012	0.162	0.086	0.280	0.479
RM20.6	0.223	0.183	0.711	0.100	0.033	0.018	0.178	0.050	0.279	0.478
RM19.2	0.215	0.293	0.222	0.322	0.032	0.029	0.055	0.161	0.278	0.476
RM21.1	0.297	0.310	0.566	0.120	0.045	0.031	0.141	0.060	0.277	0.474
RM23.7	0.385	0.359	0.038	0.342	0.058	0.036	0.009	0.171	0.274	0.469
RM7.4	0.274	0.535	0.173	0.261	0.041	0.054	0.043	0.131	0.268	0.460
RM17.5	0.986	0.201	0.350	0.022	0.148	0.020	0.087	0.011	0.267	0.456
RM17.0	0.168	0.213	0.597	0.141	0.025	0.021	0.149	0.070	0.266	0.455
RM8.4	0.067	0.316	0.494	0.202	0.010	0.032	0.123	0.101	0.266	0.455
RM26.6	0.127	0.444	0.086	0.359	0.019	0.044	0.022	0.179	0.264	0.453
RM17.6	0.557	0.214	0.362	0.136	0.083	0.021	0.091	0.068	0.264	0.451
RM9.8	0.026	0.185	0.113	0.424	0.004	0.018	0.028	0.212	0.263	0.450
RM17.7	0.412	0.211	0.575	0.070	0.062	0.021	0.144	0.035	0.262	0.448
RM21.6	0.430	0.281	0.572	0.050	0.065	0.028	0.143	0.025	0.260	0.446
RM12.0	0.040	0.320	0.000	0.444	0.006	0.032	0.000	0.222	0.260	0.445
RM4.7	0.512	0.000	0.539	0.094	0.077	0.000	0.135	0.047	0.258	0.442
RM5.5	0.329	0.090	0.452	0.174	0.049	0.009	0.113	0.087	0.258	0.442

5.6 Identified Priority Sites

We used a MWA to smooth the results of the Priority Composite Index described in the previous section to identify areas of highway with consistently elevated values for field evaluation. The general rationale for using a MWA approach is three-fold: (1) averaging helps to lessen the effects of any spatial error in the recording of specific locations (e.g., WVCs); (2) the 0.1-mile segments used as units of analysis are small, and the counts for wildlife crossings, crash, carcass, or observations for any single segment are more likely to be influenced by statistical sampling noise than are the counts for a group of consecutive segments; and (3) from a mitigation perspective, it can be useful to identify longer stretches with elevated values (e.g., high WVCs) than to identify short individual segments with the highest WVCs (e.g., when considering mitigation measures designed to reduce WVCs at more than a point location, such as fencing).

The top 20% of all 580 0.10-mile segments identified by the MWA on US 89 are clustered in 7 locations (Figure 16). The top 20% of MWA segments analyzed have index values between 0.314 and 0.603. These seven locations are:

- Gardiner Airport from RM 2.3 to RM 5.4
- Corwin Springs from RM 7.6 to RM 10.5
- Dome Mountain from RM 17.1 to RM 22.4
- Merriman from RM 25.9 to RM 29.3
- Mill Creek from RM 34.6 to RM 37.0
- Pine Creek from RM 43.2 to RM 47.0
- Livingston South from RM 51.4 to 52.4

Table 10. Overall Average Scores for All Sites

Site	Wildlife Observation Importance Index	Suitability/ Connectivity Importance Index	Wildlife Movement Importance Index	WVC Importance Index	Composite of Road Segment Importance	Moving Window Average
1-Gardiner Airport	0.287	0.143	0.458	0.156	0.428	0.430
2-Corwin Springs	0.074	0.346	0.214	0.162	0.308	0.303
3-Dome Mountain	0.311	0.255	0.437	0.147	0.437	0.430
4-Merriman	0.027	0.274	0.085	0.197	0.258	0.253
5-Mill Creek	0.040	0.210	0.038	0.204	0.235	0.227
6-Pine Creek	0.006	0.284	0.001	0.136	0.166	0.154
7-Livingston South	0.014	0.158	0.011	0.387	0.366	0.326

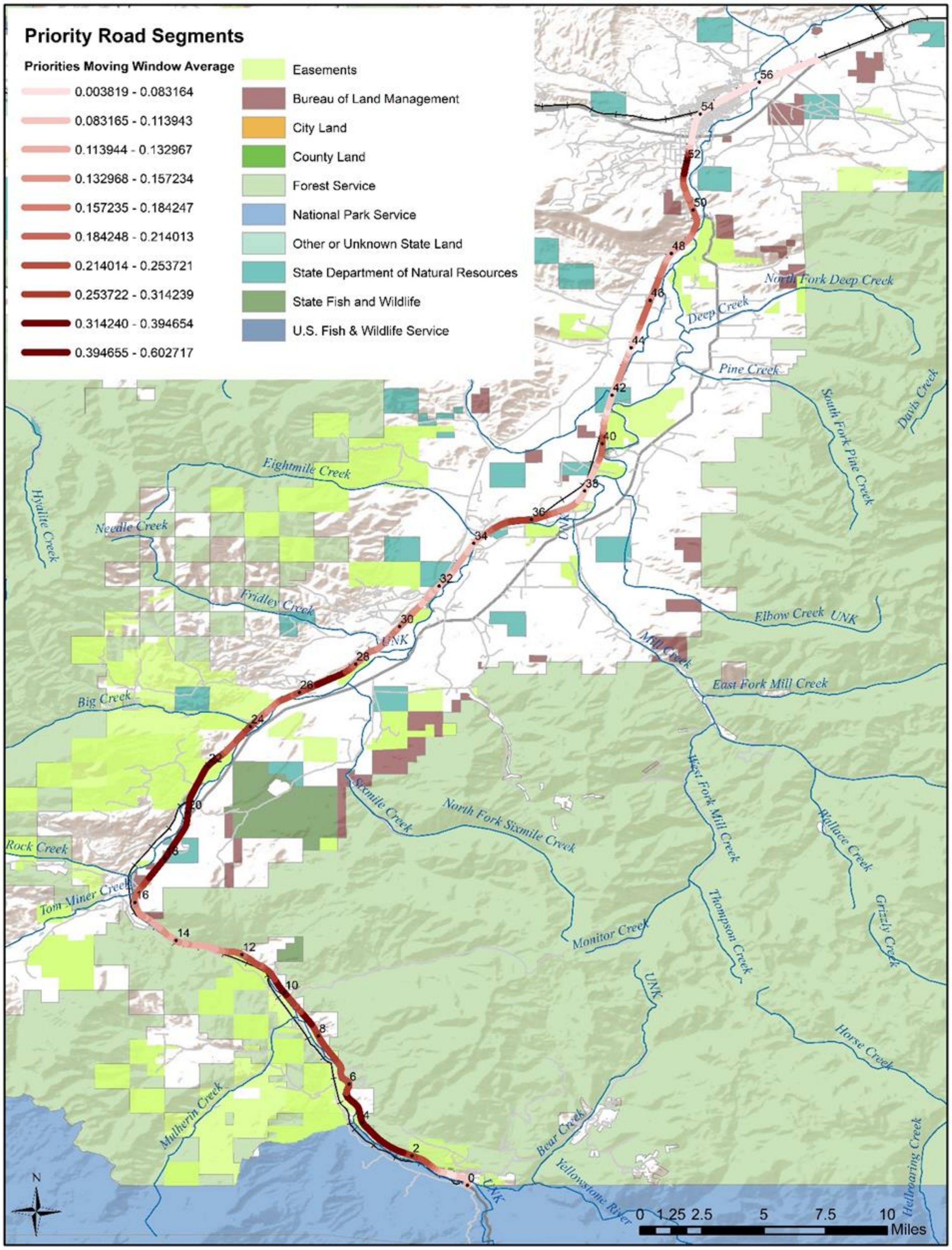


Figure 16. Priority Road Areas for Field Evaluations

6. Site Visits and Field Evaluation

All priority stretches identified through the spatial analysis were visited in the field and evaluated for potential wildlife accommodations June 20-21, 2023. The authors of this report and an interdisciplinary Technical Advisory Committee of biologists, transportation ecologists, engineers, planners, and other experts drove each priority stretch, looking for the most suitable locations within each stretch to further evaluate opportunities for potential wildlife accommodations. Our Technical Advisory Team includes the following individuals:

- Liz Fairbank - Center for Large Landscape Conservation
- Braden Hance - Center for Large Landscape Conservation
- Daniel Anderson - Yellowstone Safe Passages/The Common Ground Project
- Max Hjortsberg - Park County Environmental Council
- Blakeley Adkins - Greater Yellowstone Coalition
- Michelle Zizian - Yellowstone Safe Passages
- Pat Todd - National Parks Conservation Association
- Marcel Huijser - Western Transportation Institute, Montana State University
- Damon Fick - Western Transportation Institute, Montana State University
- Matthew Bell - Western Transportation Institute, Montana State University
- Deb Wambach -Montana Department of Transportation
- Dave Gates - Montana Department of Transportation
- Michael Yarnall - MT Fish Wildlife and Parks
- Mike McGrath - U.S. Fish and Wildlife Service
- Dan Stahler - Yellowstone National Park
- Matthew Strizich - Federal Highway Administration
- Lenora Dombro - U.S. Forest Service
- Michael Thom - U.S. Forest Service
- Frank van Manen - Interagency Grizzly Bear Study Team
- Peter Brown - AMB West Ranches
- Ashton Bunce - Montana Freshwater Partners
- Leah Swartz - Montana Freshwater Partners
- Wendy Weaver – Montana Freshwater Partners

To assist in ranking sites for mitigation priority, we developed a field evaluation matrix. The matrix was used to evaluate each site by assigning a score from 1 (low priority) to 5 (high priority) for each of the following 9 criteria:

1. **Wildlife-vehicle collision risk:** Frequency of collisions with wildlife
2. **Wildlife crossing roads:** Intensity of wildlife crossing roads
3. **Live wildlife near roads:** Intensity of wildlife use of roadside environments
4. **Regional conservation value:** Contribution to regional conservation (if mitigated) by serving as a movement corridor or high-quality wildlife habitat at the regional scale
5. **Land security:** Presence/absence of “secured” land (e.g., state, federal, private conservation easement) on both sides of the road to allow for effective crossing structures

6. **Local conservation value:** Contribution to regional conservation (if mitigated) by serving as a movement corridor or high-quality wildlife habitat at the local scale
7. **Mitigation options:** Type and engineering feasibility of mitigation measures that could be implemented
8. **Barrier effect:** Degree of negative impact on wildlife movement potential due to high traffic volume, non-wildlife-friendly fencing, or other adjacent linear features.
9. **Vulnerability:** Potential for future increase in AVC risk or negative impact to wildlife due to increased speed limit, traffic volume, road width, or number of lanes

Criteria 1-5 were scored before the field evaluation based on data analysis (and confirmed or adjusted by local and regional experts during the field evaluation), while criteria 6-9 were scored in the field by the researchers and the Technical Advisory Team. At the end of the field evaluation, each site was assigned an overall score (from 1 to 5) based on the average from each of the 9 evaluation criteria.

For scoring the criteria based on data analysis (see 1-4 above), the researchers used categories based on the mean percentiles for each priority stretch to give a score from 1 (low priority) to 5 (high priority). The scoring categories for the criteria based on data analysis are described in Table 13 below.

Table 11. The categories used to score the criteria based on data analysis.

Score	Percentile Categories	Description
5	95-100%	The 5% of stretches with the highest index values
4	75-94.9%	The next 20% of stretches with the highest index values
3	50-74.9%	The next 25% of stretches with the highest index values
2	25-49.9%	The next 25% of stretches with the highest index values
1	<24.9%	The 25% of stretches with the lowest index values

The “land security” criterion was also scored prior to the field evaluation but was adjusted by the Technical Advisory Team if deemed necessary. The scoring for this criterion is described below:

1. Housing or industrial/commercial development on both sides of site (or adjacent/nearby)
2. Housing or industrial/commercial development on one side of site, privately owned open space on other side (with unsecured easements)
3. Privately owned open space lands on both sides, but without conservation easements
4. Public lands (federal, state, or tribal) or private land with a conservation easement on one side of the site, open space on other side (without conservation easements)
5. Public lands (federal, state, or tribal) or private lands with a conservation easement on both sides

For scoring criteria (6-9) based on the field evaluation, the researchers and team of experts ranked each criterion with a score from 1 (low priority) to 5 (high priority). These scores are based on expert opinion from the Technical Advisory Team.

The resulting priority scores are as follows:

Table 12. Priority Sites and Scores

Site	WVC Risk	Live Wildlife Crossing Road	Live Wildlife near Road	Regional Cons. Value	Land Security	Local Cons. Value	Wildlife Accommo dation Options	Barrier Effect	Vulner-ability	Overall Average Score	Priority Rank
Gardiner Airport	3	5	4	2	4	5	3	1	3	3.33	2
Corwin Springs	2	4	1	4	3	5	2	1	3	2.78	3*
Dome Mountain	2	5	5	2	4	5	4	2	3	3.56	1
Merriman	2	4	1	2	3	4	3	2	4	2.78	3*
Mill Creek	2	1	1	2	2	2	3	3	4	2.22	6
Pine Creek	3	1	1	2	2	2	2	4	5	2.44	5
Livingston South	5	1	1	2	1	3	2	5	4	2.67	4

* indicates a tie

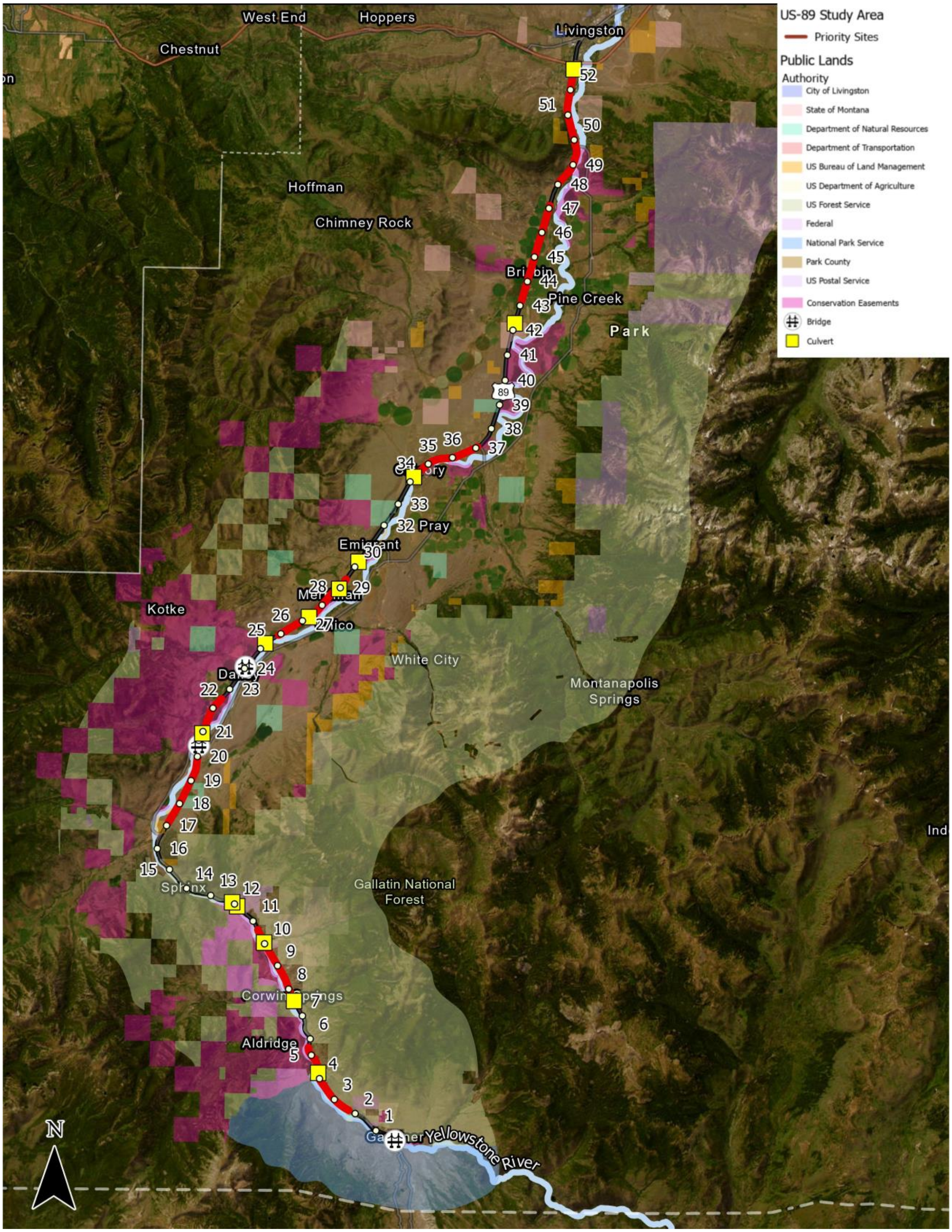


Figure 15. Map of Priority Sites along US 89 from Livingston to Gardiner

7. Priority Sites and Recommendations

7.1 Gardiner Airport

Location: RM 2.3-5.4
Traffic Volume (AADT): 2,853
Priority Rank: 2

Table 13. Gardiner Airport Carcass Data, all sources, 2012-2021

Carcass Data: Gardiner Airport RM 2.3 - 5.4												
Mule Deer	White-tailed Deer	Elk	Grizzly Bear	Bison	Mountain Lion	Coyote	Other	Unknown deer	Striped Skunk	Red Fox	Black Bear	**Total**
79	5	30	2	1	0	1	3	4	0	0	0	**125**

The Gardiner Airport Priority Site, located just 2 miles north of the town of Gardiner near the regional airport, is the southernmost priority site in our study area and is the closest site to Yellowstone National Park (YNP). The lands adjacent to this site are home to all the wildlife species present inside of the park. There is heavy wildlife movement back and forth across the highway for many wildlife species, including the sizeable "town elk" herd that resides primarily in and around the town of Gardiner. The site is within a bison tolerance zone, and bison are present during certain times of the year. Forty-five wildlife-vehicle collisions (WVCs) were reported to law enforcement from 2012-2021. In addition, 125 wild animal carcasses have been recorded, including two grizzly bears (Table 15). This site contains the 0.10-mile segment (RM 3.8) with the highest composite score of any 0.10-mile segment identified (Table 16).

An overpass is recommended at this site just south of RM 4 (see conceptual rendering in Section 10). This structure could provide an important connection between YNP and the U.S. Forest Service lands to the east through a private parcel that is protected with a conservation easement. There is also an important crossing location for elk migration just north of the Gardiner airport (RM 2.5-3.0), where a structure may also be warranted to continue to facilitate elk movement, especially if this corridor becomes fenced. The area north of the Gardiner airport has secure public land on both sides of the highway. These structures could be combined and connected with wildlife exclusion fencing to treat the full priority area. An overpass is the preferred structure type due to the need to provide connectivity for grizzly bears, including family groups, as well as elk, pronghorn, and bison. In addition to the structure(s), which would provide safe passage across the highway, fencing will be needed to keep wildlife off the highway, reduce WVCs, and guide animals toward safe crossing opportunities. The fence ends will need treatments, such as electrified mats, to keep animals from entering the fenced road corridor. Electrified mats, or other treatments (e.g., gates, guards), will be needed at all access roads and driveways for the same reason. Wildlife will continue to cross the highway on the road surface where they are not fenced out, particularly the habituated "town elk." Animal detection systems at the fence end zone will be needed to warn drivers of wildlife approaching the road and avoid a potential concentration of WVCs where the fencing ends.

The culvert at Little Trail Creek north of RM 4 is a potential fish barrier [Section 8]. Upsizing and improving the culvert would provide connectivity for aquatic species as well as small and medium sized mammals. The culvert, if improved, could complement the larger overpass structure(s) and could be tied into the fencing. The Gardiner Airport, at the southern end of the priority site, has improvements currently being planned, and any efforts to improve the highway here should be coordinated with potential improvements to the airport.

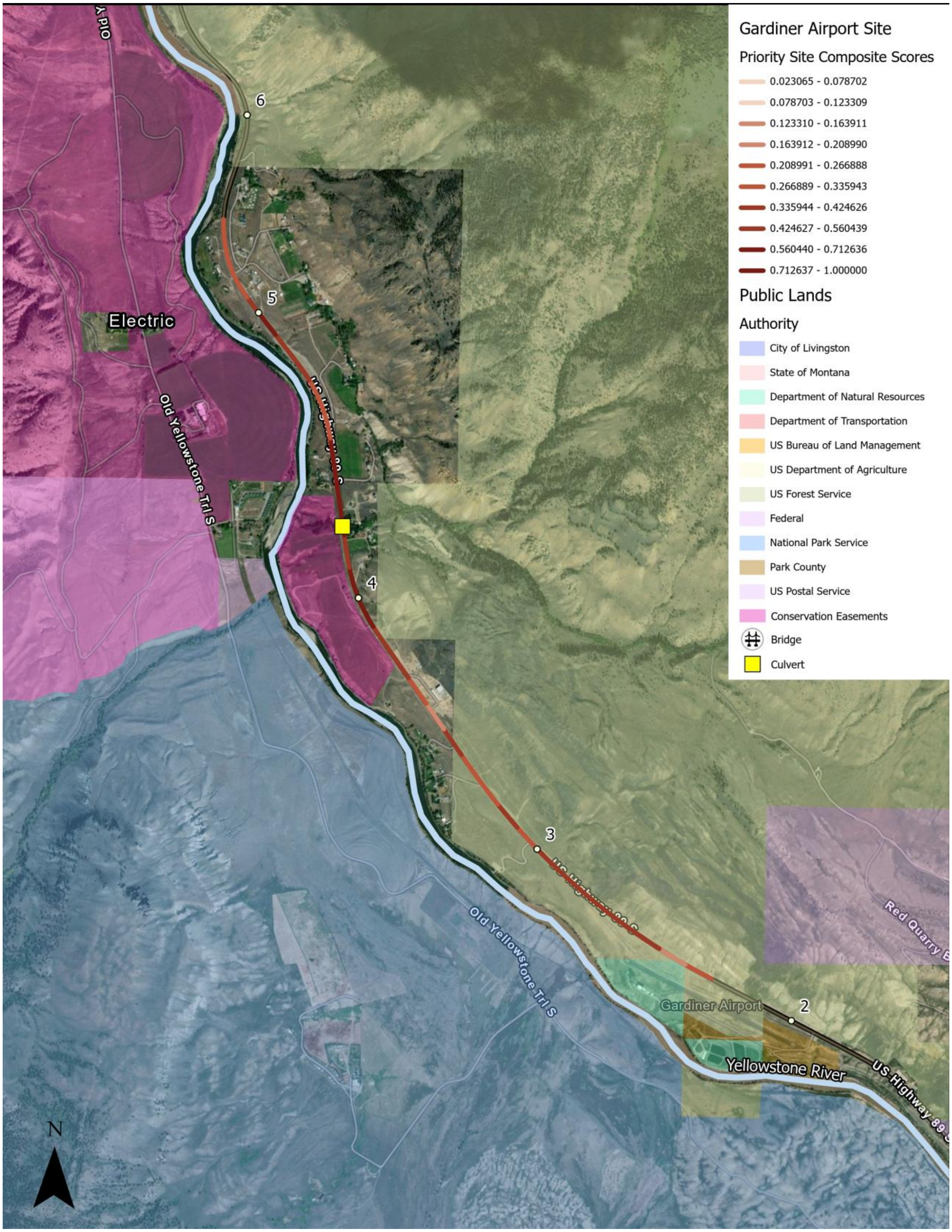


Figure 16. Map of Gardiner Airport Priority Site

Table 14. Scores for each 0.1-mile segment in the Gardiner Airport Priority Site

Gardiner Airport (RM 2.3-5.4)						
Road Mile Reference	**Wildlife Observation Importance Index**	**Suitability/ Connectivity Importance Index**	**Wildlife Movement Importance Index**	**WVC Importance Index**	**Composite of Road Segment Importance**	**Moving Window Average**
RM2.3	0.051	0.160	0.440	0.016	0.242	0.318
RM2.4	0.153	0.118	0.277	0.000	0.177	0.344
RM2.5	0.189	0.142	0.555	0.058	0.359	0.351
RM2.6	0.129	0.079	0.607	0.248	0.519	0.340
RM2.7	0.131	0.162	0.599	0.066	0.374	0.342
RM2.8	0.114	0.162	0.646	0.065	0.389	0.345
RM2.9	0.180	0.161	0.600	0.230	0.528	0.362
RM3.0	0.090	0.162	0.296	0.183	0.333	0.358
RM3.1	0.057	0.161	0.578	0.073	0.352	0.352
RM3.2	0.138	0.347	0.246	0.065	0.255	0.340
RM3.3	0.283	0.156	0.233	0.073	0.261	0.352
RM3.4	0.449	0.158	0.436	0.120	0.431	0.408
RM3.5	0.176	0.156	0.094	0.027	0.134	0.416
RM3.6	0.048	0.389	0.477	0.011	0.292	0.430
RM3.7	0.358	0.236	0.334	0.133	0.389	0.474
RM3.8	0.219	0.167	0.418	0.287	0.509	0.515
RM3.9	0.152	0.132	1.000	0.594	1.000	0.553
RM4.0	0.219	0.130	0.711	0.272	0.616	0.539
RM4.1	0.538	0.123	0.199	0.287	0.490	0.555
RM4.2	0.228	0.119	0.816	0.476	0.838	0.568
RM4.3	0.162	0.005	0.839	0.357	0.708	0.567
RM4.4	0.531	0.040	0.765	0.242	0.679	0.603
RM4.5	0.394	0.010	0.163	0.122	0.276	0.556
RM4.6	0.222	0.265	0.326	0.074	0.305	0.527
RM4.7	0.512	0.000	0.539	0.094	0.442	0.502
RM4.8	0.613	0.147	0.401	0.023	0.374	0.452
RM4.9	0.912	0.047	0.836	0.350	0.901	0.408
RM5.0	0.696	0.089	0.381	0.153	0.488	0.387
RM5.1	0.542	0.091	0.187	0.074	0.298	0.388
RM5.2	0.290	0.092	0.163	0.066	0.216	0.390
RM5.3	0.281	0.265	0.340	0.023	0.282	0.367
RM5.4	0.141	0.090	0.138	0.141	0.230	0.356
Site Average	0.287	0.143	0.458	0.156	0.428	0.430

7.2 Corwin Springs

Location: 7.6-10.5
Traffic Volume (AADT): 2,853
Priority Rank: 3 (tied with Merriman Site)

Table 15. Carcass data for the Corwin Springs Priority Site, all sources, 2012-2021

Carcass Data: Corwin Springs RM 7.6 - 10.5												
Mule Deer	White-tailed Deer	Elk	Grizzly Bear	Bison	Mountain Lion	Coyote	Other	Unknown deer	Striped Skunk	Red Fox	Black Bear	**Total**
95	2	24	1	1	2	4	3	3	0	0	0	**135**

The Corwin Springs site is located about 2 miles north of the Gardiner Airport site and has had 33 crashes with wildlife reported to law enforcement from 2012-2021. In addition, there have been 135 wildlife carcasses recorded, primarily mule deer and elk, as well as a grizzly bear, a bison, and two mountain lions, among other species (Table 17). Many species of wildlife are frequently crossing the highway at this site, with the highest concentration of recorded wildlife road crossings at RM 8.5 (Table 18).

There are two existing structures within or bordering this priority site that accommodate water flows from Bassett and Cedar Creeks: 1) An existing 5-ft-diameter round, corrugated, metal culvert at Bassett Creek (RM 7.5; Section 8) that could potentially be replaced with a larger structure to accommodate terrestrial wildlife movement while providing co-benefits for aquatic organism passage as well as infrastructure resiliency, as the structure does not currently cover the bankfull width of the creek [Section 8]; and 2) An existing large (16-ft-wide, 12-ft-tall) box culvert at Cedar Creek (RM 10) that likely does not provide dry passage for terrestrial wildlife except at low stream flows. Although this structure was replaced to accommodate native fish passage in 2014[Section 8], this culvert could be replaced with a span bridge to leave room for riparian habitat and dry pathways, allowing terrestrial wildlife to pass safely underneath the highway. If culverts were replaced with suitable structures for terrestrial wildlife, fencing could be added to keep animals off the road and guide them to safe passage locations.

Cedar Creek is a large tributary of the Yellowstone River flowing out of the Absaroka Mountains. There are many recorded grizzly bear crossings here as well as one grizzly bear mortality on the highway at RM 10.0. The area adjacent to the existing culvert at Cedar Creek (RM 10.0) has the highest habitat suitability/connectivity score of any 0.10-mile highway segment within this priority area, followed by the three segments from RM 8.8-9.0 (Table 18). The highest ranking 0.10-mile segments in terms of the Composite Road Segment Importance scores were RM 10.3 and RM 8.5 respectively (Table 18).

There is also a section of highway north of the intersection with Cinnabar Basin Road at Yellowstone Hot Springs (~RM 7.7) that is built upon fill that could provide an opportunity to construct a wildlife underpass such as a large culvert or span bridge (see conceptual rendering in Section 10) to allow wildlife to pass safely beneath the highway. Fencing would be needed on either side of the structure(s) to keep wildlife off the highway, reduce WVCs, and guide animals toward safe crossing opportunities. The structures could complement each other and be connected with fencing that would also extend past the structures on either side. Fence ends and access roads/intersections would need to be treated with electrified mats or other measures to keep wildlife from entering the fenced road corridor. Unfortunately, this area is complicated by the bison quarantine facility on the east side of the highway (approximately RM 8.1-8.4). In addition, most of this section of highway has private land parcels on either one or both sides of the highway, which may need to be conserved with easements for a project to move forward at this site.

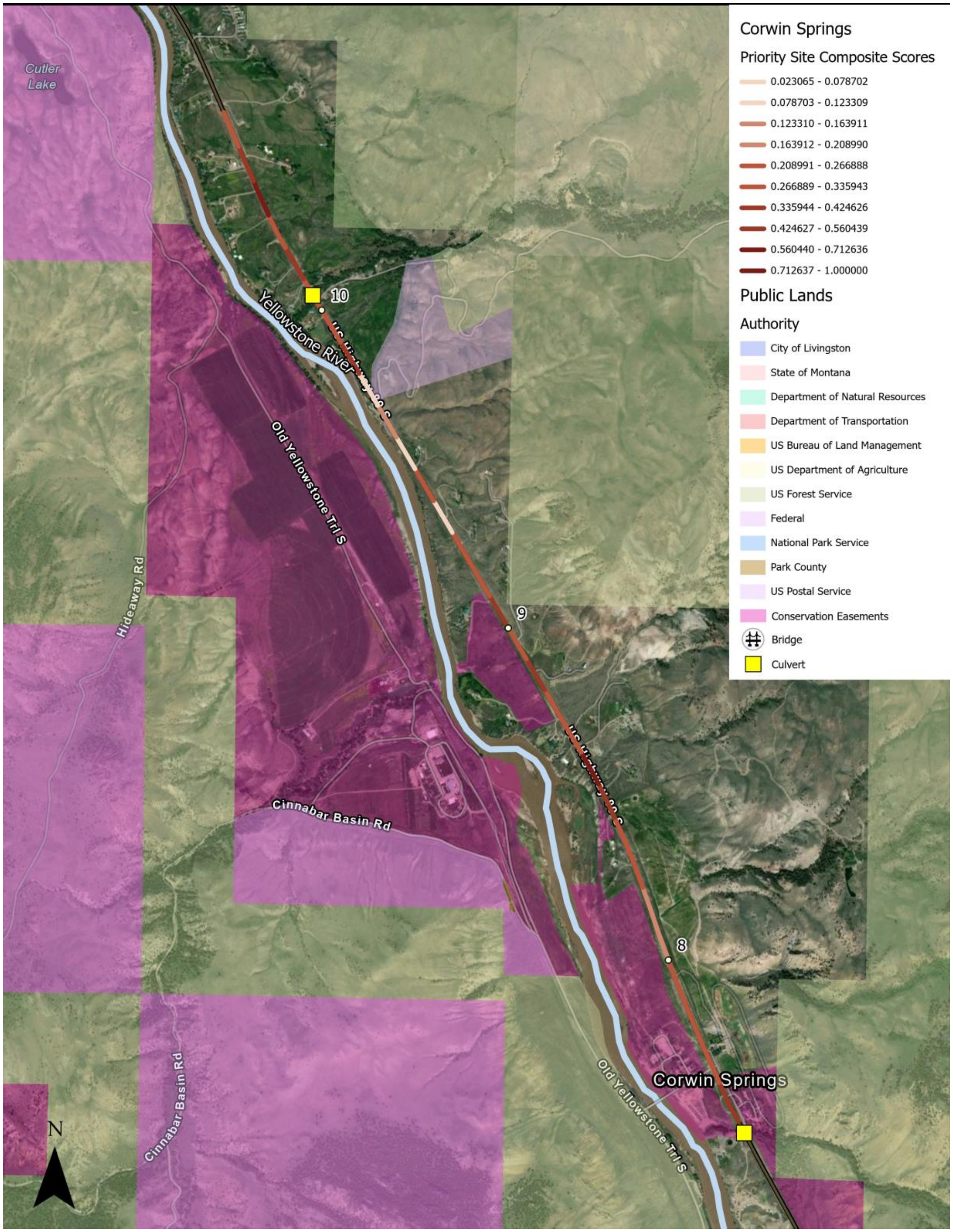


Figure 17. Map of the Corwin Springs Priority Site

Table 16. Scores for each 0.1-mile segment in the Corwin Springs Priority Site

Corwin Springs (RM 7.6-10.5)						
Road Mile Reference	**Wildlife Observation Importance Index**	**Suitability/ Connectivity Importance Index**	**Wildlife Movement Importance Index**	**WVC Importance Index**	**Composite of Road Segment Importance**	**Moving Window Average**
RM7.6	0.216	0.097	0.242	0.282	0.417	0.267
RM7.7	0.240	0.097	0.088	0.203	0.290	0.272
RM7.8	0.046	0.362	0.366	0.004	0.233	0.282
RM7.9	0.183	0.510	0.134	0.066	0.247	0.310
RM8.0	0.034	0.392	0.185	0.004	0.157	0.322
RM8.1	0.054	0.366	0.200	0.031	0.188	0.310
RM8.2	0.055	0.309	0.248	0.061	0.224	0.302
RM8.3	0.177	0.315	0.450	0.016	0.305	0.314
RM8.4	0.067	0.316	0.494	0.202	0.455	0.313
RM8.5	0.090	0.337	0.912	0.143	0.594	0.330
RM8.6	0.042	0.320	0.170	0.193	0.303	0.344
RM8.7	0.134	0.203	0.158	0.222	0.326	0.355
RM8.8	0.123	0.578	0.145	0.271	0.425	0.340
RM8.9	0.079	0.552	0.141	0.056	0.223	0.339
RM9.0	0.035	0.638	0.113	0.312	0.433	0.306
RM9.1	0.033	0.457	0.047	0.236	0.308	0.266
RM9.2	0.019	0.190	0.087	0.278	0.312	0.246
RM9.3	0.034	0.176	0.014	0.011	0.053	0.258
RM9.4	0.057	0.331	0.152	0.189	0.298	0.249
RM9.5	0.050	0.137	0.014	0.058	0.090	0.258
RM9.6	0.022	0.237	0.225	0.020	0.158	0.264
RM9.7	0.019	0.363	0.000	0.023	0.085	0.264
RM9.8	0.026	0.185	0.113	0.424	0.450	0.293
RM9.9	0.032	0.205	0.338	0.166	0.329	0.319
RM10.0	0.030	0.777	0.007	0.203	0.317	0.313
RM10.1	0.064	0.438	0.228	0.365	0.502	0.334
RM10.2	0.139	0.384	0.261	0.116	0.312	0.338
RM10.3	0.053	0.455	0.586	0.334	0.629	0.344
RM10.4	0.040	0.136	0.113	0.305	0.342	0.329
RM10.5	0.034	0.528	0.196	0.061	0.234	0.321
Site Average	0.074	0.346	0.214	0.162	0.308	0.303

7.3 Dome Mountain

Location: RM 17.1-22.4
Traffic Volume (AADT): 1,547
Priority Rank: 1

Table 17. Carcass data for the Dome Mountain Priority Site, all sources, 2012-2021

Carcass Data: Dome Mountain RM 17.1 - 22.4												
Mule Deer	White-tailed Deer	Elk	Grizzly Bear	Bison	Mountain Lion	Coyote	Other	Unknown deer	Striped Skunk	Red Fox	Black Bear	**Total**
30	9	64	1	0	1	3	8	10	23	0	0	**149**

The Dome Mountain Priority Site runs from the Carbella Fishing Access Site to north of the southern intersection of US 89 and East River Road. This site has had 74 crashes with wildlife reported to law enforcement from 2012-2021. In addition, there have been 149 carcasses recorded, primarily elk and mule deer (Table 19). This area is located in an important current and historical movement corridor for wildlife and is adjacent to the Dailey Lake Wildlife Management Area. Animals here frequently move back and forth across the highway to access the Yellowstone River, forage opportunities, upland habitat, and cover. Driving this section of highway is popularly known as "running the gauntlet" due to the sheer volume of animals, especially elk, crossing the road.

The 0.10-mile segments with the highest scores for WVCs in this site are RM 19.0, 20.4, and 20.1 respectively. The 0.10-mile segments with the highest Composite of Road Segment Importance scores were RM 19.0 and 19.3, followed by the 3 segments from RM 21.3-21.5. RM 21.3-21.5 also had some of the highest Wildlife Movement Importance Index scores, followed by RM 17.9 (Table 20).

There are two existing structures within this priority area, including the large bridge spanning the Yellowstone River at Point of Rocks (RM 20.5) and a corrugated metal arch culvert at Donahue Creek (RM 21.0). The Point of Rocks bridge provides a safe wildlife crossing opportunity beneath the road on the southern riverbank where YSP trail camera data have shown use by elk, moose, mule deer, white-tailed deer, grizzly bears, coyotes, bobcats, coyotes, fox, raccoons, and skunks. However, bridge abutments on the northern side of the bridge are protected by steep, large rip-rap boulders that extend into the river, blocking most species moving along the riverbank from being able to safely cross under the bridge along the north bank of the river. The grizzly bear mortality in this site was recorded at the north end of the Point of Rocks bridge. This bridge was damaged in the 2022 flooding of the Yellowstone River, and the structure could be replaced and upsized with a longer bridge to accommodate the floodplain, make the infrastructure more resilient to future flooding events, and provide safe passage and connectivity for terrestrial wildlife on both sides of the river. The culvert at Donahue Creek could also be replaced with a larger structure that would accommodate the floodplain as well as provide safe passage for small to medium sized terrestrial species.

There are also three potential locations within this priority site where overpasses are recommended to accommodate safe passage across the road for elk and other species, including grizzly bears and pronghorn. The best location appears to be at RM 19.5-19.6, where the topography lends itself to this type of structure due to a road cut with higher ground on both sides of the highway. This location is adjacent to unprotected private land and would require voluntary land conservation efforts to move forward. Another potential option is to place the overpass further south, where there is currently public state land on both sides of the road from ~RM 17.9-18.2. Another good location for a potential overpass to accommodate elk, pronghorn, and other species is between RM 21.3-22.0 where there are frequent crossings by elk and deer, several recorded crossings by grizzly bears, and where pronghorn frequently approach the road, though there are relatively few recorded pronghorn crossings. This area is adjacent to private lands that are protected under conservation easements. Any of these wildlife crossing structures would require fencing to keep wildlife off the highway, reduce WVCs, and guide wildlife towards the safe crossing opportunity provided by the structures. Fence ends and access roads would also need electrified mats or other treatments to keep wildlife from entering the fenced road corridor. Ultimately, a combination of measures, including bridge replacement and upsizing at Point of Rocks, upsizing of the Donahue Creek culvert, and construction of one or more overpasses, all combined with fencing and fence end/access road treatments, would be the ideal treatment at this top priority site. This strategy would effectively reduce collisions while maintaining connectivity and wildlife movement across this important and historical wildlife migration corridor between Dome Mountain and the surrounding lands and the Yellowstone River.

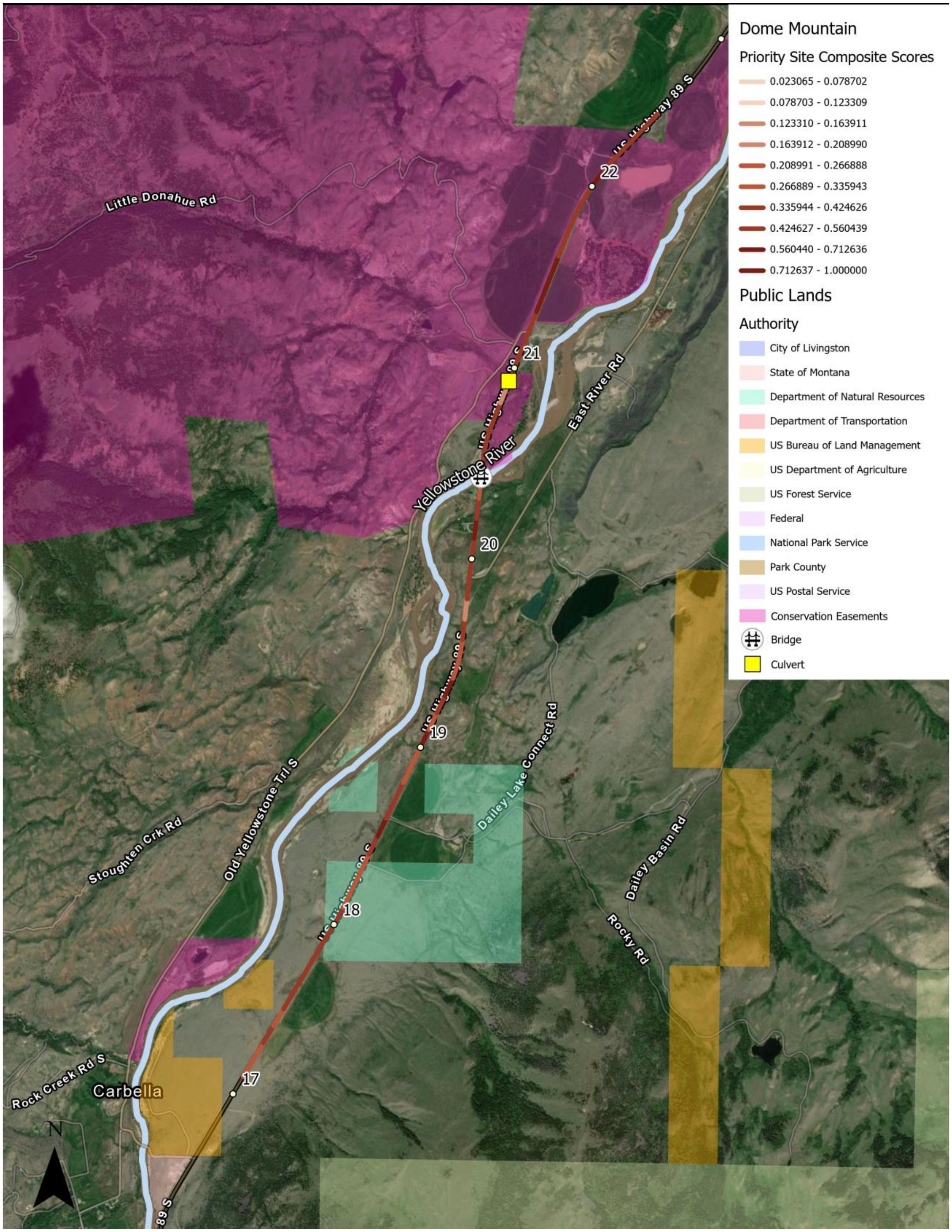


Figure 18. Map of the Dome Mountain Priority Site

Table 18. Scores for each 0.1-mile segment in the Dome Mountain Priority Site

Dome Mountain (RM 17.1-22.4)						
Road Mile Reference	**Wildlife Observation Importance Index**	**Suitability/ Connectivity Importance Index**	**Wildlife Movement Importance Index**	**WVC Importance Index**	**Composite of Road Segment Importance**	**Moving Window Average**
RM17.1	0.137	0.214	0.326	0.019	0.227	0.346
RM17.2	0.203	0.219	0.377	0.071	0.311	0.362
RM17.3	0.371	0.223	0.396	0.300	0.560	0.367
RM17.4	0.472	0.246	0.404	0.000	0.335	0.389
RM17.5	0.986	0.201	0.350	0.022	0.456	0.410
RM17.6	0.557	0.214	0.362	0.136	0.451	0.389
RM17.7	0.412	0.211	0.575	0.070	0.448	0.388
RM17.8	0.371	0.187	0.508	0.082	0.415	0.388
RM17.9	0.287	0.186	0.686	0.020	0.416	0.386
RM18.0	0.417	0.274	0.526	0.066	0.436	0.416
RM18.1	0.165	0.212	0.184	0.074	0.220	0.406
RM18.2	0.159	0.229	0.241	0.050	0.225	0.411
RM18.3	0.485	0.234	0.339	0.000	0.309	0.398
RM18.4	0.684	0.230	0.643	0.050	0.533	0.387
RM18.5	0.539	0.232	0.605	0.274	0.672	0.414
RM18.6	0.381	0.239	0.355	0.066	0.347	0.402
RM18.7	0.527	0.235	0.630	0.066	0.502	0.425
RM18.8	0.457	0.225	0.352	0.000	0.306	0.468
RM18.9	0.293	0.224	0.132	0.148	0.296	0.470
RM19.0	0.131	0.224	0.558	0.468	0.713	0.452
RM19.1	0.138	0.232	0.327	0.093	0.294	0.427
RM19.2	0.215	0.293	0.222	0.322	0.476	0.411
RM19.3	0.465	0.287	0.579	0.334	0.704	0.403
RM19.4	0.239	0.284	0.475	0.016	0.326	0.415
RM19.5	0.135	0.423	0.281	0.123	0.332	0.423
RM19.6	0.110	0.249	0.376	0.194	0.397	0.410
RM19.7	0.127	0.222	0.155	0.050	0.179	0.415
RM19.8	0.280	0.221	0.315	0.193	0.409	0.401
RM19.9	0.135	0.204	0.240	0.315	0.441	0.396
RM20.0	0.108	0.196	0.545	0.100	0.379	0.399
RM20.1	0.160	0.188	0.389	0.390	0.574	0.412
RM20.2	0.183	0.141	0.527	0.057	0.345	0.420
RM20.3	0.128	0.134	0.345	0.140	0.322	0.421
RM20.4	0.134	0.366	0.502	0.393	0.649	0.428
RM20.5	0.189	0.259	0.465	0.078	0.358	0.434
RM20.6	0.223	0.183	0.711	0.100	0.478	0.442
RM20.7	0.237	0.184	0.577	0.169	0.485	0.436
RM20.8	0.172	0.325	0.103	0.050	0.185	0.467
RM20.9	0.107	0.491	0.443	0.217	0.487	0.500
RM21.0	0.267	0.375	0.377	0.249	0.507	0.498
RM21.1	0.297	0.310	0.566	0.120	0.474	0.506
RM21.2	0.386	0.369	0.516	0.141	0.504	0.497
RM21.3	0.346	0.376	0.736	0.251	0.684	0.498
RM21.4	0.436	0.272	0.720	0.261	0.691	0.527
RM21.5	0.397	0.279	0.989	0.060	0.625	0.539
RM21.6	0.430	0.281	0.572	0.050	0.446	0.532
RM21.7	0.366	0.283	0.183	0.186	0.379	0.535
RM21.8	0.430	0.264	0.302	0.240	0.490	0.522
RM21.9	0.480	0.296	0.467	0.156	0.507	0.492
RM22.0	0.425	0.292	0.566	0.252	0.618	0.445
RM22.1	0.252	0.283	0.328	0.206	0.430	0.412
RM22.2	0.285	0.268	0.382	0.270	0.514	0.380
RM22.3	0.277	0.261	0.439	0.065	0.359	0.361
RM22.4	0.197	0.224	0.336	0.140	0.352	0.328
Site Average	0.311	0.255	0.437	0.147	0.437	0.430

7.4 Merriman

Location: RM 25.9-29.3
Traffic Volume (AADT): 1547
Priority Rank: 3 (tied with Corwin Springs)

Table 19. Carcass data for the Merriman Priority Site, all sources, 2012-2021

Carcass Data: Merriman RM 25.9 - 29.3													
Mule Deer	White-tailed Deer	Elk	Grizzly Bear	Bison	Mountain Lion	Coyote	Other	Unknown deer	Striped Skunk	Red Fox	Black Bear	Moose	**Total**
51	73	8	1	0	0	1	4	24	9	1	0	1	**173**

The Merriman Priority Site is located just a couple miles south of the town of Emigrant. This site had 55 crashes with wildlife reported to law enforcement from 2012-2021. In addition, 173 wildlife carcasses have been recorded, mostly white-tailed and mule deer. This site also has the only moose carcass recorded in the study area during this time period. The 0.10-mile segments in this site with the highest Composite Importance Index scores were 27.2, 26.9, and 27.0 respectively. The 0.10-mile segments with the highest WVC Importance Index scores were 26.9 and 27.0 (Table 22).

While wildlife accommodation options are somewhat limited at this site, there are a few small, existing structures here that could be upgraded to accommodate movement by some species, including deer. There is an existing culvert at Dry Creek just south of the priority area that could be expanded, though the outlet would not be an ideal location for wildlife due to its location on a steep bank right next to the river. There is a small stockpass that could be expanded to provide safe passage beneath the road for some wildlife and improve its intended purpose of moving cattle across the highway. Finally, there is a culvert at Fridley Creek (RM 28.75), though it was not evaluated because it is not accessible from the right-of-way.

In addition to the potential to improve the few existing structures here, there is one location where an overpass may be feasible in the area around RM 27, which had some of the highest WVC and Composite scores within the site. Although an overpass is not necessarily needed to be suitable for the target species (primarily deer), the topography of the road and its surroundings means it is likely the only feasible option, as the roadbed is not much higher than the surrounding landscape, making the potential vertical clearance of an underpass too low to be suitable for most large mammals. A structure here would also need fencing to keep wildlife off the highway, reduce WVCs, and guide animals to the safe crossing opportunity. Animal detection systems could also be implemented here either as fence end treatments, or as a stand-alone WVC reduction measure.

There is also a location at RM26 that should be seriously considered for future underpass or culvert projects. The site has private land to the northwest that is permanently protected with conservation easements, and there is state-owned property between the roadway and the Yellowstone River. Montana Fish, Wildlife & Parks (FWP) is currently proposing the development of a day-use-only river access site with limited parking and recreational opportunities on the southeast portion of the roadway. Topography at the site could allow for a potential culvert or small underpass. A structure here would also need fencing to keep wildlife off the highway, reduce WVCs, and guide animals to the safe crossing opportunity. Depending on the exact location of the structure, an existing gas line and gravel road access points to and from the recreation area may impede construction of a wildlife accommodation measure. RM26 has the potential to provide safer driving conditions, recreation, and reduced WVCs.

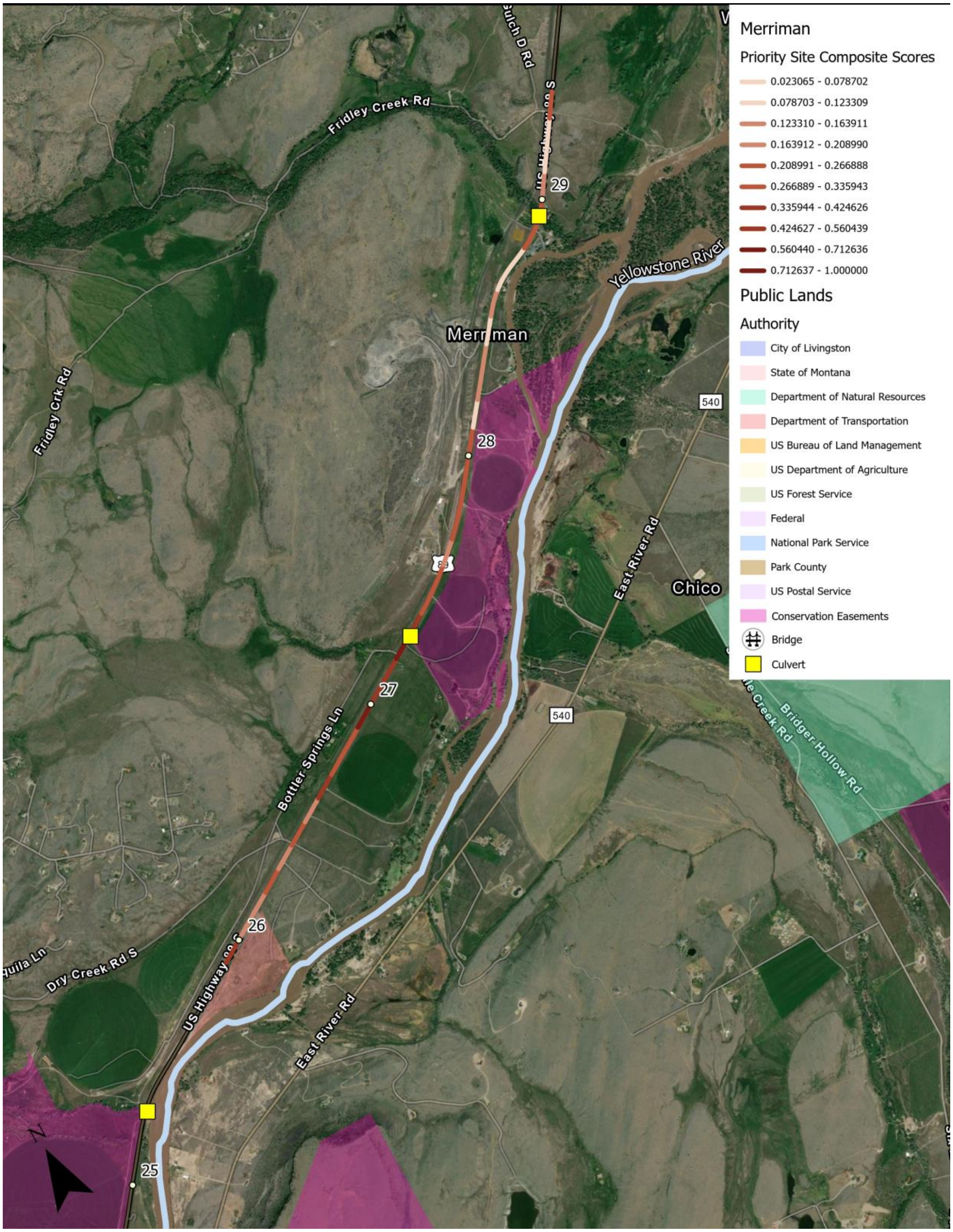


Figure 19. Map of the Merriman Priority Site

Table 20. Score for each 0.1-mile segment within the Merriman Priority Site

Merriman (RM 25.9-29.3)						
Road Mile Reference	**Wildlife Observation Importance Index**	**Suitability/ Connectivity Importance Index**	**Wildlife Movement Importance Index**	**WVC Importance Index**	**Composite of Road Segment Importance**	**Moving Window Average**
RM25.9	0.004	0.209	0.025	0.353	0.350	0.225
RM26.0	0.013	0.254	0.113	0.123	0.199	0.231
RM26.1	0.002	0.239	0.044	0.147	0.185	0.243
RM26.2	0.097	0.452	0.113	0.133	0.263	0.242
RM26.3	0.006	0.467	0.164	0.000	0.150	0.259
RM26.4	0.022	0.253	0.113	0.190	0.259	0.292
RM26.5	0.076	0.488	0.043	0.098	0.204	0.307
RM26.6	0.127	0.444	0.086	0.359	0.453	0.324
RM26.7	0.087	0.275	0.141	0.138	0.248	0.366
RM26.8	0.112	0.331	0.000	0.264	0.310	0.378
RM26.9	0.088	0.275	0.254	0.477	0.588	0.394
RM27.0	0.035	0.261	0.120	0.487	0.522	0.395
RM27.1	0.046	0.274	0.250	0.247	0.377	0.388
RM27.2	0.000	0.411	0.788	0.280	0.649	0.366
RM27.3	0.004	0.328	0.229	0.279	0.394	0.370
RM27.4	0.000	0.356	0.000	0.317	0.332	0.364
RM27.5	0.014	0.316	0.007	0.240	0.266	0.332
RM27.6	0.006	0.291	0.000	0.090	0.127	0.294
RM27.7	0.070	0.279	0.113	0.124	0.219	0.277
RM27.8	0.000	0.279	0.000	0.285	0.291	0.235
RM27.9	0.036	0.307	0.007	0.206	0.240	0.206
RM28.0	0.020	0.288	0.000	0.214	0.236	0.195
RM28.1	0.009	0.288	0.007	0.061	0.105	0.181
RM28.2	0.003	0.223	0.000	0.177	0.189	0.177
RM28.3	0.000	0.132	0.000	0.189	0.184	0.180
RM28.4	0.000	0.138	0.000	0.065	0.078	0.184
RM28.5	0.001	0.148	0.113	0.158	0.208	0.178
RM28.6	0.064	0.150	0.000	0.082	0.111	0.162
RM28.7	0.000	0.123	0.004	0.074	0.085	0.161
RM28.8	0.000	0.131	0.113	0.216	0.255	0.170
RM28.9	0.011	0.232	0.000	0.343	0.336	0.157
RM29.0	0.000	0.134	0.000	0.179	0.175	0.158
RM29.1	0.000	0.312	0.000	0.000	0.052	0.148
RM29.2	0.005	0.284	0.113	0.000	0.097	0.153
RM29.3	0.000	0.204	0.000	0.303	0.294	0.169
Site Average	0.027	0.274	0.085	0.197	0.258	0.253

7.5 Mill Creek

Location: RM 34.0-37.0
Traffic Volume (AADT): 2,911
Priority Rank: 6

Table 21. Carcass data for the Mill Creek Priority Site, all sources, 2012-2021

Carcass Data: Mill Creek RM 34.1 - 37.0												
Mule Deer	White-tailed Deer	Elk	Grizzly Bear	Bison	Mountain Lion	Coyote	Other	Unknown deer	Striped Skunk	Red Fox	Black Bear	**Total**
46	74	5	0	0	0	0	15	6	3	5	0	**154**

The Mill Creek Priority Site is located a few miles north of the town of Emigrant and was identified primarily due to WVC risk with deer. This site has had 36 wildlife-related crashes reported to law enforcement from 2012-2021. There have also been 118 carcasses recorded, comprised primarily of white-tailed and mule deer. The site was originally identified as RM 34.6-37.0; however, upon visiting the site in the field the most promising wildlife accommodation opportunity is to replace the large culvert at Eightmile Creek (RM 34.1) with a larger span bridge structure. The site was thus expanded to include that location. This retrofit would provide riparian habitat on either side of the creek as well as dry walkways for wildlife. This could be done in combination with removing non-functional barbed wired fencing adjacent to the Grey Owl Fishing Access Site, and stream and riparian restoration from upstream of the structure to the Yellowstone River.

Another potential measure to reduce WVCs in their most prevalent area around RM 36 would be to use fencing in combination with animal detection systems to keep wildlife off the highway and provide an improved crossing location through an "at-grade" crosswalk where drivers would be warned if an animal was approaching the highway. Artificial lighting might also be integrated into the animal detection system, turning on when animals are detected to make them more visible to drivers at night. Though an underpass structure would be warranted here due to WVCs, construction is not feasible because the area is located on a curve with a cottonwood grove on the east side of the highway and a canal on the west side.

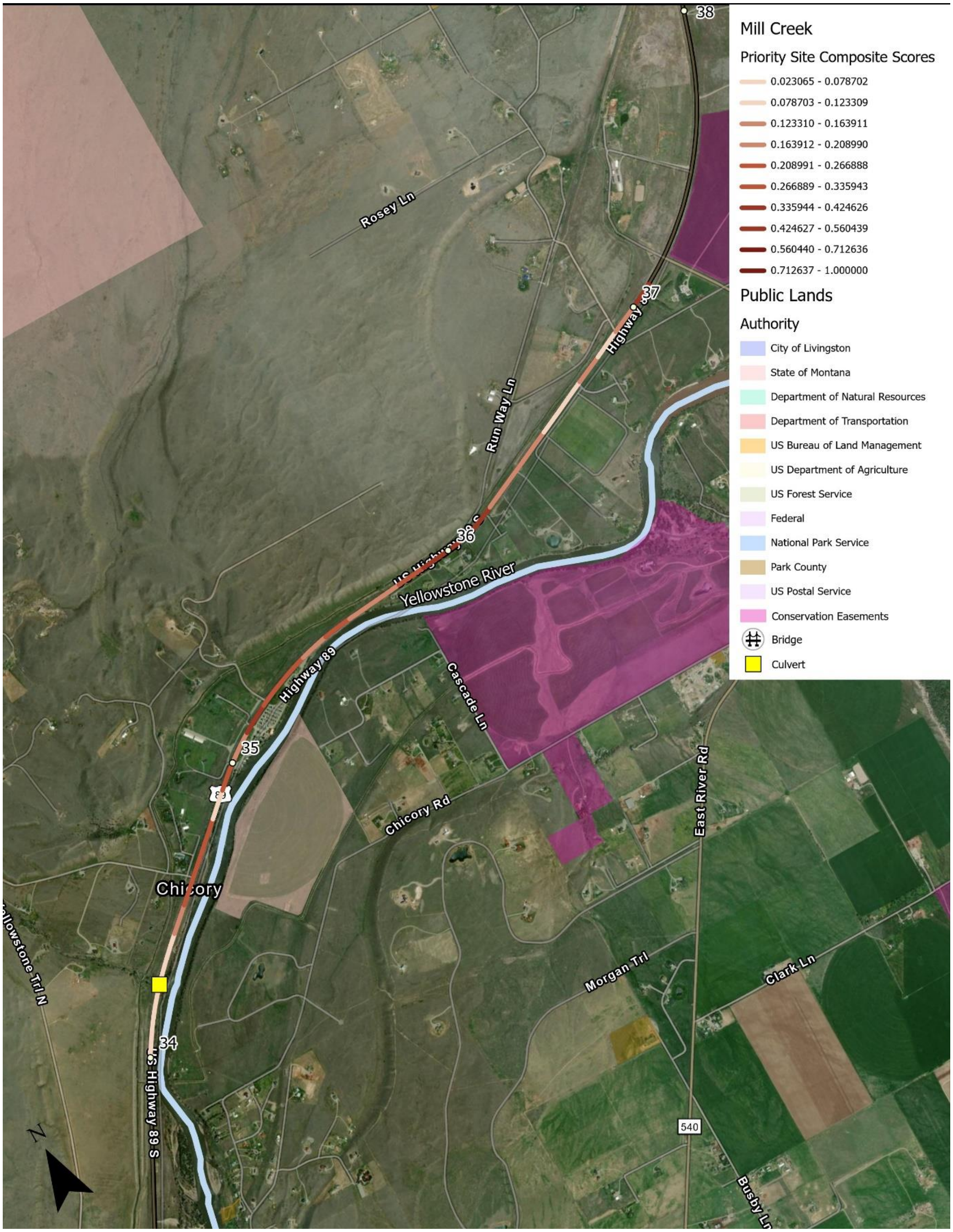


Figure 20. Map of the Mill Creek Priority Site

Table 22. Score for each 0.1-mile segment within the Mill Creek Priority Site

Mill Creek (RM 34.6-37.0)						
Road Mile Reference	**Wildlife Observation Importance Index**	**Suitability/ Connectivity Importance Index**	**Wildlife Movement Importance Index**	**WVC Importance Index**	**Composite of Road Segment Importance**	**Moving Window Average**
RM34.6	0.008	0.102	0.013	0.282	0.266	0.173
RM34.7	0.018	0.150	0.013	0.233	0.234	0.195
RM34.8	0.013	0.304	0.000	0.058	0.103	0.213
RM34.9	0.010	0.301	0.000	0.220	0.242	0.220
RM35.0	0.010	0.215	0.000	0.113	0.135	0.231
RM35.1	0.006	0.192	0.013	0.390	0.373	0.227
RM35.2	0.002	0.178	0.000	0.277	0.267	0.222
RM35.3	0.039	0.173	0.100	0.247	0.293	0.229
RM35.4	0.077	0.194	0.000	0.112	0.147	0.265
RM35.5	0.066	0.406	0.000	0.189	0.248	0.276
RM35.6	0.090	0.177	0.082	0.124	0.193	0.300
RM35.7	0.107	0.177	0.013	0.164	0.202	0.284
RM35.8	0.100	0.176	0.088	0.264	0.318	0.279
RM35.9	0.090	0.176	0.195	0.415	0.492	0.266
RM36.0	0.041	0.172	0.080	0.339	0.364	0.263
RM36.1	0.041	0.172	0.088	0.381	0.403	0.252
RM36.2	0.047	0.290	0.025	0.147	0.197	0.251
RM36.3	0.056	0.162	0.025	0.182	0.207	0.244
RM36.4	0.043	0.157	0.013	0.124	0.148	0.229
RM36.5	0.032	0.302	0.088	0.027	0.119	0.216
RM36.6	0.019	0.199	0.000	0.100	0.123	0.202
RM36.7	0.032	0.191	0.000	0.177	0.191	0.176
RM36.8	0.035	0.272	0.029	0.066	0.123	0.162
RM36.9	0.012	0.200	0.025	0.123	0.152	0.147
RM37.0	0.001	0.200	0.054	0.334	0.344	0.147
Site Average	0.0398	0.2095	0.0376	0.2035	0.2354	0.2267

7.6 Pine Creek

Location: RM 43.2-47.0
Traffic Volume (AADT): 3,271
Priority Rank: 5

Table 23. Carcass data for the Pine Creek Priority Site, all sources, 2012-2021

Carcass Data: Pine Creek RM 43.2 - 47.0												
Mule Deer	White-tailed Deer	Elk	Grizzly Bear	Bison	Mountain Lion	Coyote	Other	Unknown deer	Striped Skunk	Red Fox	Black Bear	**Total**
18	93	1	0	0	0	0	12	13	7	0	0	**144**

The Pine Creek Priority Site is in an open, relatively flat area surrounded by irrigated agriculture on private land. This site has had 49 crashes with wildlife reported to law enforcement from 2012-2021. This site has also had 144 carcasses recorded, consisting primarily of white-tailed deer. There is one existing culvert at RM 42.2, but there is only ~4ft of vertical clearance and no dry passage for terrestrial species. This entire stretch of highway is fairly level with the surrounding landscape. To improve the culvert or provide new underpass structures for wildlife, such as deer, the entire roadbed would need to be built up substantially. While this is possible, it would be very costly, and the site is not located in an area where connectivity for wildlife is as high of a concern as in other locations. There are also many access roads and driveways along this stretch of highway, which complicates the deployment of fencing and animal detection systems. One recommendation for wildlife movement in the area is to update the right-of-way fence to be wildlife friendly, as deer are frequently moving back and forth across the highway, though this would not greatly reduce the risk of WVC.

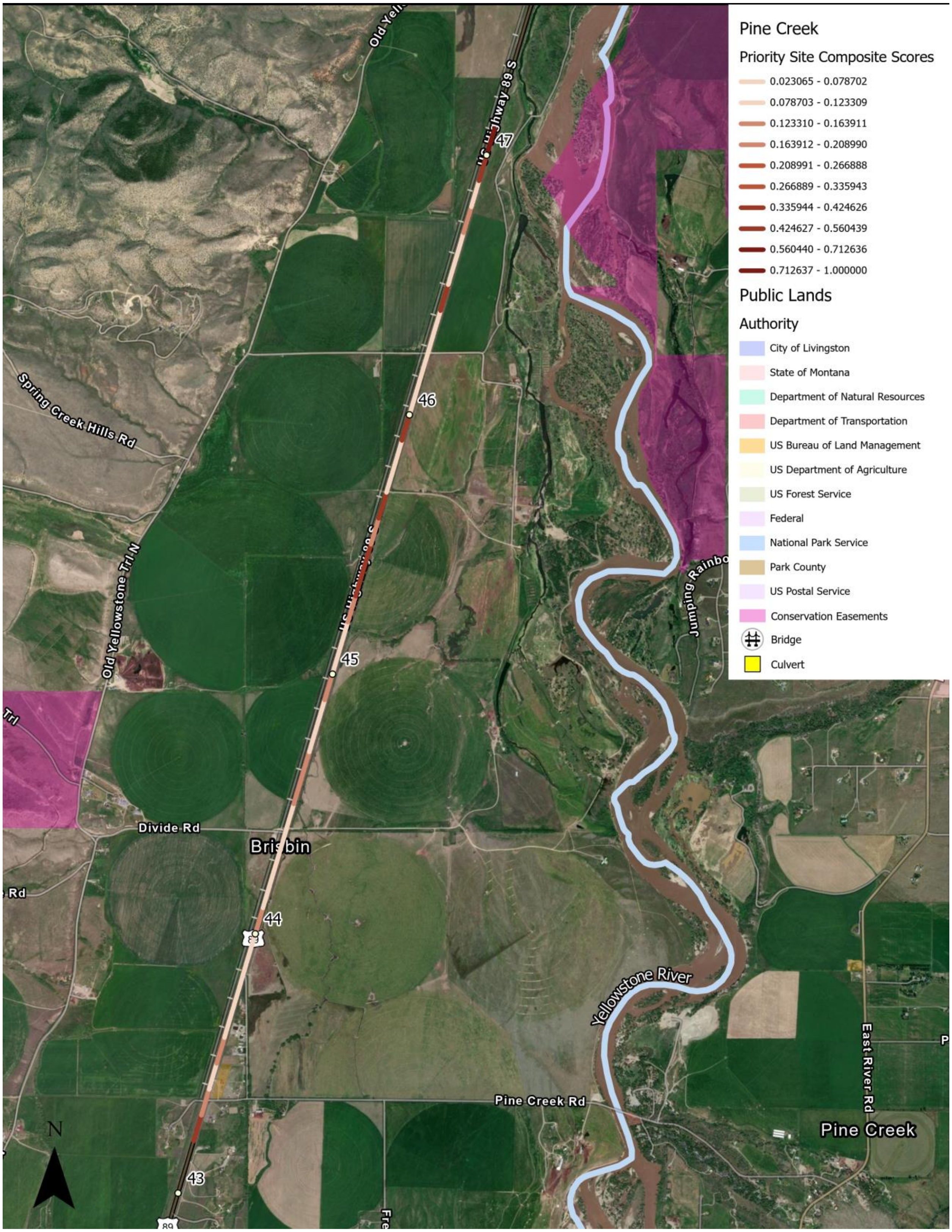


Figure 21. Map of the Pine Creek Priority Site

Table 24. Score for each 0.1-mile segment within the Pine Creek Priority Site

Site 6 Pine Creek (RM 43.2-47)						
Road Mile Reference	**Wildlife Observation Importance Index**	**Suitability/ Connectivity Importance Index**	**Wildlife Movement Importance Index**	**WVC Importance Index**	**Composite of Road Segment Importance**	**Moving Window Average**
RM43.2	0.000	0.197	0.004	0.363	0.346	0.133
RM43.3	0.000	0.251	0.000	0.164	0.182	0.135
RM43.4	0.000	0.227	0.000	0.016	0.050	0.134
RM43.5	0.001	0.165	0.000	0.160	0.164	0.128
RM43.6	0.013	0.269	0.000	0.016	0.061	0.114
RM43.7	0.013	0.279	0.000	0.000	0.049	0.114
RM43.8	0.007	0.323	0.000	0.000	0.055	0.086
RM43.9	0.008	0.328	0.000	0.071	0.117	0.079
RM44.0	0.009	0.232	0.000	0.121	0.144	0.090
RM44.1	0.002	0.306	0.007	0.004	0.058	0.090
RM44.2	0.002	0.185	0.000	0.000	0.030	0.094
RM44.3	0.000	0.184	0.000	0.003	0.033	0.095
RM44.4	0.000	0.200	0.000	0.082	0.103	0.105
RM44.5	0.002	0.200	0.000	0.169	0.179	0.103
RM44.6	0.003	0.325	0.000	0.120	0.158	0.101
RM44.7	0.004	0.372	0.000	0.050	0.106	0.108
RM44.8	0.002	0.401	0.000	0.000	0.068	0.138
RM44.9	0.003	0.331	0.000	0.124	0.162	0.169
RM45.0	0.002	0.263	0.000	0.062	0.097	0.177
RM45.1	0.001	0.265	0.000	0.086	0.118	0.200
RM45.2	0.004	0.388	0.013	0.074	0.135	0.195
RM45.3	0.002	0.437	0.000	0.331	0.358	0.189
RM45.4	0.001	0.237	0.013	0.379	0.370	0.214
RM45.5	0.000	0.237	0.000	0.183	0.196	0.209
RM45.6	0.000	0.218	0.000	0.467	0.437	0.204
RM45.7	0.001	0.279	0.000	0.058	0.096	0.204
RM45.8	0.000	0.261	0.000	0.000	0.043	0.198
RM45.9	0.000	0.265	0.000	0.347	0.342	0.202
RM46.0	0.000	0.263	0.000	0.073	0.106	0.179
RM46.1	0.000	0.263	0.000	0.000	0.043	0.168
RM46.2	0.001	0.327	0.000	0.070	0.114	0.145
RM46.3	0.017	0.324	0.000	0.019	0.074	0.145
RM46.4	0.056	0.404	0.000	0.365	0.396	0.177
RM46.5	0.024	0.302	0.000	0.074	0.120	0.200
RM46.6	0.034	0.390	0.000	0.003	0.077	0.205
RM46.7	0.010	0.399	0.000	0.137	0.187	0.206
RM46.8	0.007	0.275	0.000	0.050	0.090	0.200
RM46.9	0.012	0.272	0.000	0.406	0.396	0.202
RM47.0	0.000	0.216	0.000	0.655	0.598	0.175
Site Average	0.006	0.284	0.001	0.136	0.166	0.154

7.7 Livingston South

Location: RM 48.0-52.4
Traffic Volume (AADT): 4,679
Priority Rank: 4

Table 25. Carcass data for the Livingston South Priority Site, all sources, 2012-2021

Carcass Data: Livingston South RM 48.0 - 52.4												
Mule Deer	White-tailed Deer	Elk	Grizzly Bear	Bison	Mountain Lion	Coyote	Other	Unknown deer	Striped Skunk	Red Fox	Black Bear	**Total**
18	245	1	0	0	0	0	6	3	8	2	2	**285**

The Livingston South priority area is located on the southern end of the city of Livingston. This site was originally identified as being from RM 51.4-52.4, however due to the high connectivity values, continued WVC risk, and better engineering options, the site was extended south to RM 48.0. This area is complex, as it has many access roads and driveways, and higher traffic volumes than the rest of the sites due to its proximity to Livingston. There have been 35 wildlife-related crashes at this site from 2012-2021. There have also been 285 wildlife carcasses recorded, consisting mainly of deer. For the area of biggest WVC concern, around RM 52, an animal detection system, potentially combined with fencing, may be the only feasible option to reduce WVCs. In the area with high connectivity value (RM 48-51), where the Wineglass hills come down closest to the Yellowstone River and the Absaroka Mountains, there are locations where the road is built up on fill as it passes through low-lying wetland and riparian areas. This provides a potential opportunity for underpass structures, like span bridges, to be built to allow for safe wildlife passage beneath the road corridor to allow wildlife to move from the Wineglass hills to the Yellowstone River and to the vast public lands in the Absaroka Mountains. These underpasses could be connected by fencing where appropriate and potentially be integrated into the animal detection system further north.

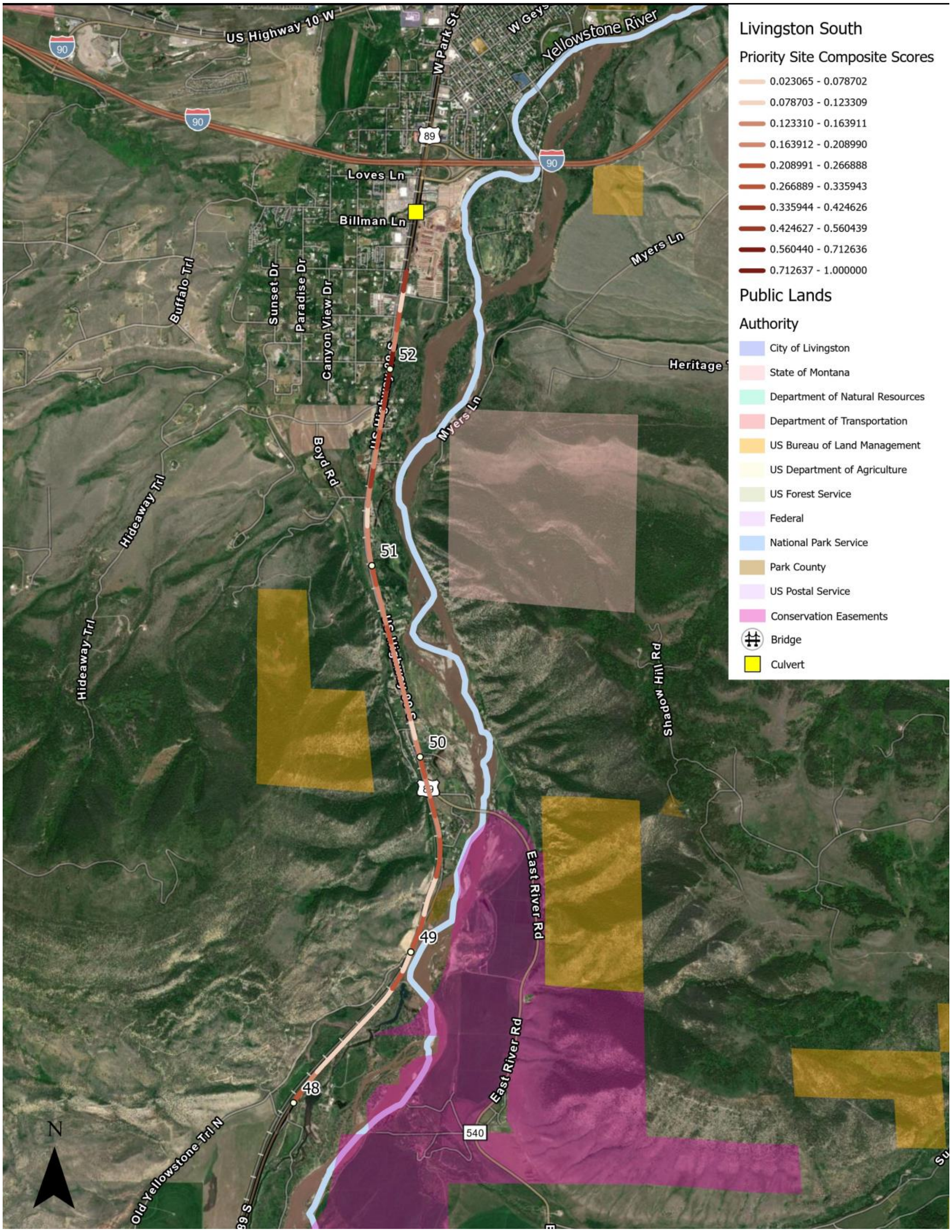


Figure 22. Map of Livingston South Priority Site

Table 26. Scores for each 0.1-mile segment in the Livingston South Priority Site

Livingston South (RM 51.4-52.4)						
Road Mile Reference	**Wildlife Observation Importance Index**	**Suitability/ Connectivity Importance Index**	**Wildlife Movement Importance Index**	**WVC Importance Index**	**Composite of Road Segment Importance**	**Moving Window Average**
RM51.4	0.000	0.191	0.000	0.366	0.346	0.292
RM51.5	0.000	0.191	0.000	0.143	0.154	0.338
RM51.6	0.000	0.145	0.000	0.227	0.218	0.332
RM51.7	0.000	0.171	0.025	0.156	0.173	0.339
RM51.8	0.000	0.390	0.000	0.542	0.531	0.343
RM51.9	0.000	0.187	0.043	1.000	0.908	0.366
RM52.0	0.007	0.255	0.000	0.888	0.807	0.343
RM52.1	0.137	0.052	0.000	0.098	0.126	0.339
RM52.2	0.015	0.052	0.050	0.284	0.277	0.321
RM52.3	0.000	0.051	0.000	0.100	0.092	0.305
RM52.4	0.000	0.051	0.000	0.453	0.396	0.265
Site Average	0.014	0.158	0.011	0.387	0.366	0.326

8. Aquatic Organism Passage Assessment

8.1 Introduction

Roads can impact aquatic ecosystems by impeding movement of aquatic organisms, altering surface and subsurface hydrology, blocking or altering transport of sediment and wood, and restricting the natural process of channel migration in streams and rivers. Improperly designed crossing structures can increase the risk of damage to human infrastructure and property during floods. Upgrading road-stream crossings to enhance connectivity can help mitigate these impacts. Between Livingston, MT and Gardiner, MT, US 89 parallels the Yellowstone River and crosses numerous tributaries. Existing crossing structures range from small, corrugated metal culverts to large bridges spanning the Yellowstone River. Montana Freshwater Partners performed a review of relevant peer-reviewed literature, reports, and maps and conducted an initial field assessment of existing crossing structures to generate recommendations for projects to improve aquatic organism passage, floodplain management, and infrastructure resilience.

8.2 Aquatic Species Occurring within Assessment Area

The Paradise Valley and Gardiner Basin are home to both native and non-native fish species, as well as several native amphibians. Semi-aquatic and terrestrial mammals and reptiles also utilize riparian areas as movement corridors and will often cross roads using stream conveyance structures (culverts and bridges).

8.2.1 Fish

The Upper Yellowstone River, known for its exceptional fishing opportunities, is home to a diverse range of fish species, both native and non-native. Table 29 summarizes species known to occupy the Upper Yellowstone and indicates whether they are native or non-native, and if they are a species of concern.

Among these species, Yellowstone cutthroat trout (YCT) stand out as an iconic native fish of management and conservation concern due to their declining range and population, and economic and ecologic importance. YCT spawn in the spring and early summer, typically after flows begin to decline following peak runoff. YCT exhibit three primary life history patterns: resident, fluvial, and adfluvial. Resident fish occupy their natal tributary streams for their entire life cycle, while fluvial fish spend the majority of their life cycle in larger streams and rivers, returning to their natal tributary streams to spawn and rear. Similarly, adfluvial fish spend the majority of their life cycle in lakes, migrating to their natal tributary streams to spawn and rear. Maintaining and restoring connectivity between the mainstem Yellowstone River and its tributaries is vital for the conservation of the fluvial life history pattern. Because US 89 crosses near the mouth of streams in the Paradise Valley, ineffective stream conveyance structures have the potential to sever connectivity for miles of potential habitat upstream.

Hybridization between YCT and non-native rainbow trout is one of the biggest threats to the species' persistence (Endicott et al. 2016, Al-Chokhachy et al. 2021). To safeguard genetically pure populations of YCT in it may be necessary to maintain or design barriers that prevent upstream movement of rainbow trout and other non-native species into areas occupied by YCT. Prior to initiating any road-stream crossing project, it will be important to consult with Montana Fish, Wildlife & Parks fisheries biologists to ensure the project is aligned with their management objectives regarding aquatic organism passage or barrier design.

Table 27. Fish species occurring in the Upper Yellowstone Watershed

Common Name	Scientific Name	Native/Non-Native	Status
Yellowstone cutthroat trout	*Oncorhynchus clarkii bouvieri*	Native	Montana species of concern (S2)
Mountain whitefish	*Prosopium williamsoni*	Native	
Rocky Mountain sculpin	*Cottus bondi*	Native	
Longnose dace	*Rhinichthys cataractae*	Native	
Mountain sucker	*Catostomus platyrhynchus*	Native	
Longnose sucker	*Catostomus catostomus*	Native	
White sucker	*Catostomus commersonii*	Native	
Rainbow trout	*Oncorhynchus mykiss*	Non-native	
Brook trout	*Salvelinus fontinalis*	Non-native	
Brown trout	*Salmo trutta*	Non-native	

8.2.2 Amphibians and Reptiles

Four species of amphibians and seven species of reptiles are known to occur within the Paradise Valley (MTNHP). Table 30 summarizes species known to occupy the Upper Yellowstone and indicates whether they are native or non-native and if they are a species of concern.

To our knowledge there has been no systematic survey of amphibians or reptiles in the Paradise Valley, so we know little about where they occur and whether there is a high incidence of mortality due to vehicle collisions on US 89. Because amphibians and reptiles are small bodied and slow moving, they often go unnoticed by drivers. In some areas, roads can be a leading cause of mortality and population fragmentation (Andrews et al. 2008). All four amphibian species that occur within the assessment area migrate to ponds and wetlands to breed in the spring. After metamorphosis, juveniles emerge from their natal ponds in the summer. These annual migration periods probably represent the most likely times for amphibians to be crossing the road in large numbers. Because there is limited wetland habitat along US 89, the effects of the road on amphibians in this region are likely to be negligible or very localized. Even so, upgrading road-stream crossing structures to larger sized structures that accommodate the natural stream and floodplain would benefit amphibians and reptiles traveling along riparian corridors.

Table 28. Amphibian species known to occur in the Paradise Valley

Common Name	Scientific Name	Native/Non-Native	Status
Western toad	*Anaxyrus boreas*	Native	Montana species of concern (S2)
Columbia spotted frog	*Rana luteiventris*	Native	
Boreal chorus frog	*Pseudacris maculata*	Native	
Western tiger salamander	*Ambystoma mavortium*	Native	
Bullsnake	*Pituophis catenifer*	Native	
Prairie rattlesnake	*Crotalus viridis*	Native	
Rubber boa	*Charina bottae*	Native	
Common garter snake	*Thamnophis sirtalis*	Native	
Terrestrial garter snake	*Thamnophis elegans*	Native	
Sagebrush lizard	*Sceloporus graciosus*	Native	
Painted turtle	*Chrysemys picta*	Native	

8.2.3 Mammals

Semi-aquatic mammals like beavers, otters, and muskrats—and many species of terrestrial mammals—often use riparian corridors as daily or seasonal movement and migration pathways (Hilty and Merenlender 2004). Intact riparian corridors provide access to water, cover, food, and protection from predators. Riparian corridors may be particularly important as linkages between intact terrestrial habitat patches as changes to land-use and climate change accelerate (Fremier et al. 2015, Krosby et al. 2018). A recent study that modeled areas of likely grizzly bear connectivity between core populations found that bears are likely to use riparian corridors to cross open landscapes like the Paradise Valley (Sells et al. 2023). Undersized or improperly designed stream conveyance structures can force animals to leave the stream banks and travel up and over the road, risking vehicle collision. Smaller mammals like beavers, skunks, raccoons, and coyotes often go uncounted during roadkill surveys and, as a result, they are likely underrepresented in the data available for US 89 (Plante et al. 2019). Some mammal species (beavers, otters, raccoons, etc.) will swim through culverts, but other, more terrestrial species require dry stream banks, ramps inside the culverts, or continuous dry substrate through the structure that connect to banks upstream and downstream to use road-stream crossing structures.

8.3 Infrastructure Resilience and Stream/River Function

Rivers and streams are naturally dynamic, moving laterally across their floodplains over time and overtopping their banks during floods (Skidmore and Wheaton 2022). Roads and undersized or poorly designed crossing structures can disrupt these natural processes, causing streams to become channelized, incised, and oversimplified and increasing the risk of costly infrastructure damage during floods. Bridges and culverts that are upsized and designed to allow for wildlife passage are usually better able to accommodate stream and floodplain function due to their larger size and capacity. They also make infrastructure more resilient to extreme weather events, like flooding, that are likely to occur with increasing frequency and severity due to climate change (Hostetler et al. 2021).

The 2022 record-breaking flood on the Upper Yellowstone highlights the need for climate-resilient infrastructure in Park County. In addition to extensive private property damage, public infrastructure, including roads and bridges, were also affected. A preliminary summary of the flood by FEMA reports that they have spent almost $25,000,000 to date on public assistance (mostly to repair roads, bridges, and other public infrastructure). This number doesn't include the cost of individual assistance to landowners, lost business and tax revenue, or other expenses. Notable infrastructure that was damaged or destroyed on or adjacent to the US 89 corridor included:

- Point of Rocks Bridge was partially washed out, becoming impassible until an emergency repair could be completed.
- Carbella bridge was completely destroyed and washed out by the flood.
- Numerous fishing access sites were damaged or destroyed.
- Many U.S. Forest Service roads and bridges were washed out.
- Numerous stretches of road in Yellowstone National Park were washed out.
- US- 89 Railroad Bridge over the Yellowstone River northeast of Livingston was severely damaged, which led to a season-long river closure and demolition of the bridge.

Fortunately, the majority of US 89 through the Paradise Valley is located well outside the Yellowstone River floodplain and channel migration zone, meaning that the effect of the road on the river is fairly small and localized (USACE 2015). While many bridges cross the Yellowstone River in the Paradise Valley, most are county bridges and outside the scope of this assessment. Point of Rocks and Gardiner Bridges are the only bridges on US 89 within the assessment area (see descriptions below).

Despite the relatively low impact of US 89 on the Yellowstone River through the assessment area, the highway does cross numerous tributaries and undersized crossings have contributed to a reduction in stream and floodplain health and riparian function. These stream crossings are described below.

8.4 Survey of Existing Road-Stream Crossings

8.4.1 Methodology

Montana Freshwater Partners' (MFP) staff conducted a high-level field assessment of stream and river crossings within the assessment area along US 89 between Livingston and Gardiner. Crossings were identified using the national hydrography dataset and most irrigation ditches and unnamed ephemeral drainages were excluded.

Field data was collected over two days on May 16th, 2023, and June 1st, 2023. Flows in tributaries were moderate to high during the field assessment. MFP used a protocol developed by the Southeastern Aquatics Resource

Partnership to collect basic measurements at each crossing location (SARP 2019). The advantage of this assessment protocol is that data can be fed into a publicly accessible, nationwide prioritization tool that is currently being expanded into the western United States (https://aquaticbarriers.org/priority/barriers/).

Data collected at each crossing included crossing type and shape, alignment, stream bankfull width, constriction, presence of a tailwater scour pool, condition of riparian vegetation, culvert dimensions (width and height), outlet drop to water surface, outlet drop to stream bottom, evidence of undermining, structure substrate type and coverage, whether or not the water depth and velocity at the crossing matches the natural stream reaches, and whether the culvert offers dry passage for terrestrial wildlife. Full data sheets are available in Appendix A. Because of time and safety limitations, we did not measure culvert slope or length.

8.4.2 US 89 Perennial Stream and River Crossings

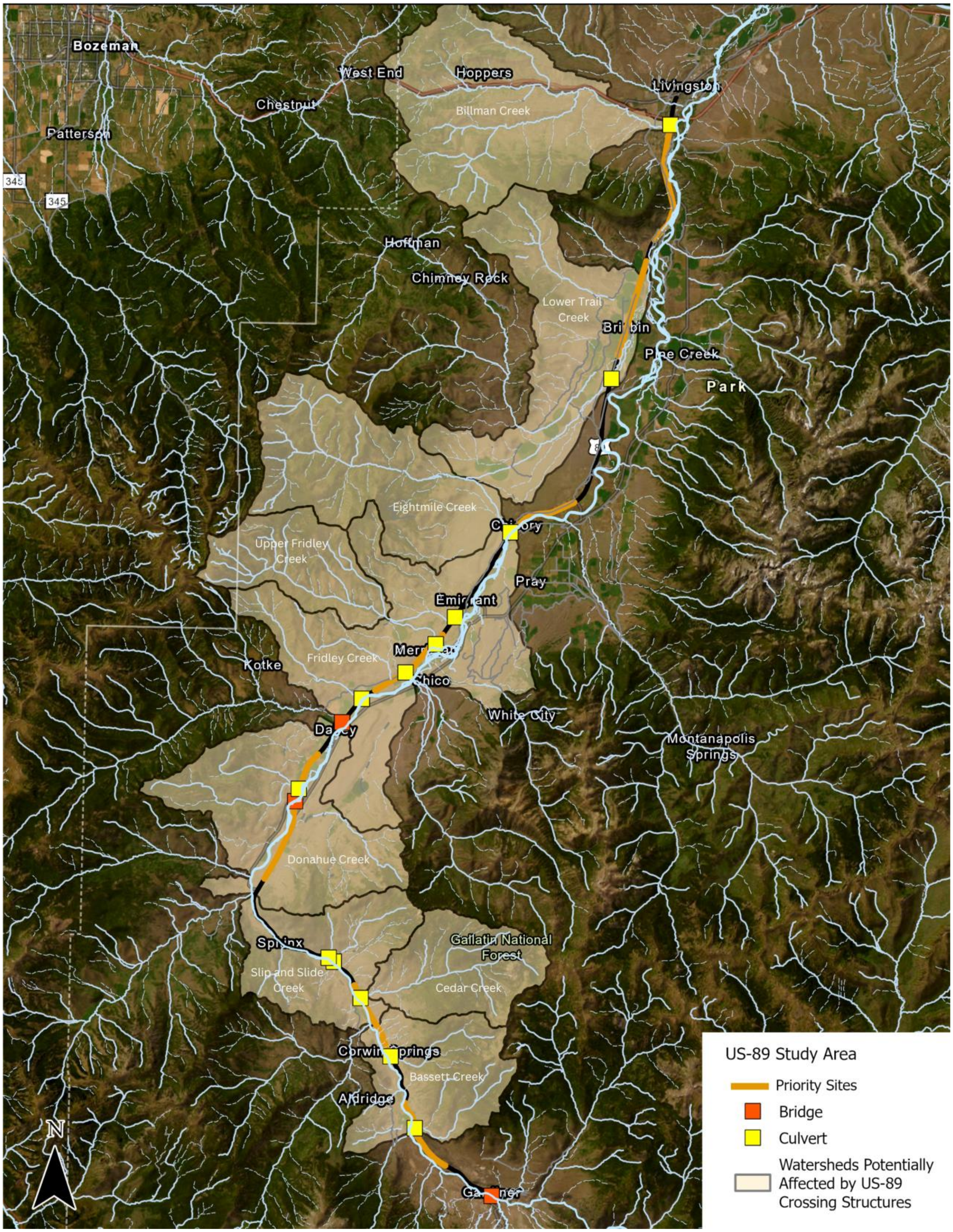


Figure 23. Map of major drainages, existing bridges and culverts, and priority sites along US 89

Table 29. Selected dimensions of culverts surveyed by Montana Freshwater Partners for YSP

Name	Approx. Mile Marker	Structure Shape	Structure Material	Alignment	Constriction	Stream Bankful Width	Structure Width	Structure Height	Outlet Drop to Water Surface	Outlet Drop to Stream Bed	Substrate Type? Structure Substrate Matches Stream?	Water depth matches stream?	Dry passage?
Little Trail Creek	4.25	Round culvert	Corregated metal	Flow- aligned	Spans only bankfull/ active channel	5' (estimated)	7'	5'10"	6"	1'3"	No - no natural substrate in culvert	Yes	No
Bassett Creek	7.5	Round culvert	Corregated metal	Flow- aligned	Spans only bankfull/ active channel	8' 4"	4'9"	5"	NA	NA	No - no natural substrate in culvert	No- shallower	No
Cedar Creek	10	Box culvert	Concrete	Flow- aligned	Spans only bankfull/ active channel	12'	16'	11'	NA	NA	Cobbles - matches stream	Yes	Yes at lower flows
Slip and Slide Creek	11.75	Box culvert	Concrete	Flow- aligned	Moderate	6' 7"	5'	3' 5"	NA	NA	Silt (only in downstream half of culvert, steeper upstream portion has no natural substrate)	No- shallower	No
Joe Brown Creek	12	Round culvert	Corregated metal	Flow- aligned	Spans only bankfull/ active channel	1' 5"	2' 5"	2' 3"	NA	NA	Some cobbles (<25% coverage)	Yes	No
Donahue Creek	21	Open bottom arch culvert	Corregated metal	Flow- aligned	Spans only bankfull/ active channel	7' 4"	6' 8"	3' 11"	NA	NA	Gravels and cobbles (matches stream)	Yes	No
Big Creek	24	Bridge with abutments and side slopes	Concrete	Flow- aligned	Spans full channel and banks	Water was too high to cross	50' (estimated)	8' (estimated)	NA	NA	Gravels and cobbles (matches stream)	Yes	Yes
Dry Creek	25.25	Elliptical culvert	Corregated metal	Flow- aligned	Spans only bankfull/ active channel	6'	11' "	7' 3.5"	2'	2' 9"	Gravels and cobbles (matches stream)	Yes	No
NF Fridley Creek	30.24	Open bottom arch culvert	Concrete	Flow- aligned	Moderate	8' 1"	5' 9"	3' 2"	NA	NA	Gravels (matches stream)	Yes	No
Eightmile Creek	34.25	Elliptical culvert	Corregated metal	Skewed	Moderate	22' 3"	13' 9"	8' 6"	4'	6'	No - no natural substrate in culvert	Yes	No
Trail Creek/ Ditch	42.25	Elliptical culvert	Corregated metal	Skewed	Spans only bankfull/ active channel	4' 9"	6'6"	4' 4"	NA	NA	Silt (matches stream)	Yes	No

1. Gardiner Bridge (MM 0)

US 89 crosses the Yellowstone River in the town of Gardiner. The river is naturally confined to a single thread channel in this reach with steep, tall banks. There are probably no opportunities to expand the bridge to increase floodplain connectivity, but there may be opportunities to retrofit the existing structure to improve dry passage for terrestrial wildlife under the bridge and through the town of Gardiner.

Figure 24 Gardiner bridge from river left looking towards river right (left) and from river right looking towards river left (right).

2. Little Trail Creek (MM 4.25)

Little Trail Creek is a small, steep tributary to the Yellowstone River originating in the Absaroka mountains. The stream drains an approximately 7.3-square-mile watershed above the US 89 crossing. No fisheries data was available from the FISHMT database, and according to FWP no surveys have been completed due to difficulties accessing private land. The US 89 crossing is a round culvert with no natural substrate. The culvert is 7' 3" wide and 5' 10" tall. The culvert accommodates the bankfull width of the stream but does not accommodate any of the floodplain and does not offer dry passage for terrestrial or semi-terrestrial species. The outlet of the culvert is perched 6" above the water surface and 15" above the stream bottom, likely presenting a barrier at least for some species and/or life stages of fish (Figure 26). The culvert outlet is being actively undermined and steep eroding banks are present directly downstream of the culvert. A second culvert is located directly downstream of the US 89 crossing that was not evaluated. Little Trail Creek is located within the Gardiner Airport Priority Site [Section 7].

Figure 25 Little Trail Creek outlet structure (left) and looking downstream from outlet structure (right).

3. Bassett Creek (MM 7.5)

Bassett Creek is a small, steep tributary to the Yellowstone River originating in the Absaroka mountains. The stream drains an approximately 8.8-square-mile watershed above the US 89 crossing. Brook trout and Yellowstone cutthroat trout were detected during electrofishing surveys in 1991 and 2015 above the US 89 crossing (FISHMT Database, accessed 2023). The US 89 crossing is a very long, round culvert with a slope break in the middle. The culvert is 4' 9" wide and 5' tall. The upstream portion of the culvert is steep and fast, with no natural substrate, while the downstream portion is lower gradient with deep, slow water. The outlet is not perched. At some flows and for some species or life stages of fish, the upstream portion of the culvert is likely a passage barrier, though the adjacent landowner has observed fish running through the culvert in the spring. In the early spring, adult Yellowstone cutthroat trout often stage near the mouth of the Bassett Creek waiting for the Yellowstone River to rise to allow for their migration to spawning grounds (Scott Optiz, personal communication). The culvert offers no dry passage for terrestrial or semi-terrestrial species. There is some undermining/bank erosion occurring around the inlet, and there is a berm on river right downstream of the culvert. Bassett Creek is at the very southern end of the Corwin Springs Priority Site [Section 7].

Figure 26 Bassett Creek culvert inlet (left) showing steep portion of culvert with shallow, fast flows; and outlet (right) showing the lower gradient portion of the culvert with deep, slow flows.

4. Cedar Creek (MM 10)

Cedar Creek is a large tributary to the Yellowstone River originating in the Absaroka mountains. The stream drains an approximately 21.5-square-mile watershed above the US 89 crossing. Cedar Creek is an important spawning tributary for fluvial Yellowstone Cutthroat Trout (Byorth 1990, Endicott et al. 2013). The crossing structure under US 89 was replaced in 2014 to address condition issues and improve fish passage (Opitz 2015). Prior to this project, two side-by-side culverts limited access to Cedar Creek for YCT. The culverts were 148 feet long, 6.2 feet in diameter and were on a 4.4% slope. A fish ladder was installed on one of the culverts in 1981 in an attempt to improve access for fish, but over time the culvert outlets became perched and the culverts and fish ladder began to fail. Montana Department of Transportation replaced the culverts with a 16’ wide and 12’ tall concrete box culvert to improve fish passage and allow for more natural movement of sediment through the structure. In 2015, Montana Fish, Wildlife & Parks conducted a telemetry and redd count study and confirmed that fish, including YCT, were able to pass through the new structure and spawn upstream (Opitz 2015). The structure appears to be performing very well, with substrate, gradient, and depth closely matching the stream up and downstream. At high flows, the entire culvert bottom is covered with water (Figure 28), but the structure probably offers dry passage for terrestrial and semi-terrestrial organisms at low to moderate flows. The potential to retrofit the existing structure to improve dry passage should be evaluated. Cedar Creek is located at the northern end of the Corwin Springs Priority Site[Section 7].

Figure 27 Cedar Creek culvert inlet (left) and stream upstream of culvert (right).

5. Slip and Slide Creek (MM 11.75):

Slip and Slide Creek is a small, steep tributary to the Yellowstone River originating in the Absaroka mountains. The stream drains an approximately 6.8-square-mile watershed above the US 89 crossing. According to the FISHMT database, rainbow trout have been detected during multiple electrofishing surveys of Slip and Slide Creek. The U.S. Forest Service (USFS recently acquired 538 acres directly to the east of US 89, so the entire creek is now under public ownership. Historically, the creek was dammed to form three ponds upstream of the highway that were stocked with rainbow trout. These ponds have been drained to eliminate the invasive curly-leaf pondweed and the USFS is now planning to remove the dams and conduct an extensive wetland restoration project in the area to improve fish and wildlife habitat. The US 89 crossing is a box culvert with a slope break in the middle. The upstream portion of the culvert is steep and fast, with no natural substrate, while the downstream portion is lower gradient with deep, slow water. At some flows and for some species/life stages of fish, the upstream portion of the culvert may act as a passage barrier. The culvert offers no dry passage for terrestrial or semi-terrestrial species. There is extensive beaver activity on both ends of the culvert. Beaver dams are directing water around the wingwalls of the culverts, which may lead to the culvert being undermined in the future. A second culvert under the USFS two track upstream of the US 89 culvert is perched, with a 2' drop from the outlet to the water surface. A beaver dam directly upstream of the culvert is creating another 2' drop at the inlet of this structure. Any work on the US 89 crossing should include an evaluation of this and other potential passage barriers upstream and close coordination with Montana Fish, Wildlife & Parks and the USFS. Slip and Slide Creek is located about a mile north of the Corwin Springs Priority Site[Section 7].

Figure 28 Slip and Slide Creek culvert inlet (left) showing extensive beaver activity and erosion around the culvert wingwall on river right. The image on the right is through the culvert from upstream to downstream, showing the slope break midway through.

6. Joe Brown Creek (MM 12)

Joe Brown Creek is a very small, steep tributary to the Yellowstone River originating in the Absaroka Mountains. The stream drains an approximately 1.4-square-mile watershed above the US 89 crossing. No fish were detected during an electrofishing survey in 2011 (FISHMT Database). The US 89 crossing is a round culvert that is sized for the bankfull width of the stream but does not accommodate any of the floodplain. The culvert offers no dry passage for terrestrial or semi-terrestrial species. The stream is naturally very steep in the vicinity of the US 89 crossing and is incising below the culvert where it has to lose a lot of elevation over a short distance to meet the Yellowstone. It is unclear whether fish are able to navigate the stretch of stream between the Yellowstone and US 89 (Scott Opitz, personal communication). This crossing is probably a lower priority given the small size of the watershed and apparent lack of fish. Joe Brown Creek is just north of Slip and Slide Creek and is located about a mile north of the Corwin Springs Priority Site[Section 7].

Figure 29 Joe Brown Creek US 89 culvert inlet (left) and outlet (right).

7. Point of Rocks Bridge (MM 20.5)

Point of Rocks Bridge is the only place in the Paradise Valley where US 89 crosses the Yellowstone River. The bridge approach section of the highway adjacent to the north end of Point of Rocks Bridge was breached during the 2022 floods (Figure 31) and MDT completed an emergency repair shortly afterwards (Figure 31, right photo). Large-diameter riprap was used to repair the bridge site, limiting the ability of terrestrial wildlife to pass underneath the bridge on river right. The bridge span does not accommodate the floodplain on either side of the river, which contributed to its failure during the flood. The bridge span could be extended in either or both directions to increase flood conveyance and wildlife passage. On river left and river right, the floodplain has robust riparian shrubs. Point of Rocks Bridge falls in the middle of the Dome Mountain Priority Area[Section 7].

Figure 30 Point of Rocks Bridge after 2022 flood (left), and after the emergency repair (right). Photo on the right is by Chris Boyer.

8. Donahue Creek (MM 21)

Donahue Creek is a tributary to the Yellowstone River originating in the Gallatin Mountains. The stream drains an approximately 11.7-square-mile watershed above the US 89 crossing. Yellowstone cutthroat trout were detected upstream of the highway crossing in 1991 (FISHMT Database). The US 89 crossing is an open-bottomed culvert that is sized to accommodate the bankfull width of the stream, but not the floodplain. The stream has been ditched/straightened both up and downstream of the crossing. Excavated material from the stream has been piled on either side creating two small berms/levees. Upstream of the culvert there is an old road grade which crosses the creek and old wooden bridge pilings remain. This acts to straighten the creek as it approaches the culvert. While natural gravels and cobbles cover the bottom of the culvert there are no resting areas for fish. This crossing could be improved with the addition of a few large boulders for fish refuge. The land surrounding the stream on both sides of the highway is already under conservation easement with the Montana Land Reliance, potentially making this a good location to couple stream restoration and floodplain reconnection work with a wildlife underpass. Donahue Creek falls within the Dome Mountain Priority Area[Section 7].

Figure 31 Donahue Creek culvert outlet (left) and Donahue Creek downstream of culvert (right).

9. Big Creek (MM 24)

Big Creek is a large tributary to the Yellowstone River originating in the Gallatin Mountains. The stream drains an approximately 69.9-square-mile watershed above the US 89 crossing. Yellowstone cutthroat trout, rainbow trout, brook trout, brown trout, and mountain whitefish have been detected during 17 surveys from 1974 to 2021 (FISHMT Database). Historically, Big Creek was often dewatered during the summer, but FWP secured a water lease beginning in 1999 to maintain instream flows (Endicott et al. 2013). The US 89 crossing structure is a bridge in good condition that accommodates the bankfull width of the stream and a portion of the floodplain. The structure provides dry passage for wildlife on river right, but on river left, riprap extends down to the water’s edge. During our site visit we observed deer, elk, and cow tracks under the bridge as well as a dead elk that had probably been struck by a car (Figure 33). This could be a good location to add fencing to guide animals to the existing structure. There has been extensive construction of berms and placement of large riprap on either side of the bridge and there may be opportunities to restore floodplain connectivity to improve fish and wildlife habitat in the lower reaches of Big Creek. Big Creek falls between the Dome Mountain and Merriman Priority Sites[Section 7].

Figure 32 Big Creek Bridge downstream looking upstream (left) and an elk carcass found under the bridge (right).

10. Dry Creek (MM 25.25)

Dry Creek is a small tributary to the Yellowstone River originating in the Gallatin Mountains. The stream drains an approximately 8-square-mile watershed above the US 89 crossing. There are very little fisheries data available for Dry Creek but brook trout, Yellowstone cutthroat trout, mountain whitefish, and rainbow trout have been detected in Dry Creek downstream of the US 89 crossing (FISHMT database). Additionally, a Yellowstone cutthroat trout/rainbow trout hybrid has been documented ascending Dry Creek during the spring during a telemetry study (DeRito 2010). As its name suggests, Dry Creek is an intermittent stream going dry in mid-to-late summer in most years. Dewatering is probably at least partially natural, though irrigation withdrawals also contribute (Scott Opitz, personal communication). Because of its intermittency, Dry Creek's value for fluvial Yellowstone cutthroat trout is unknown. The US 89 crossing structure is an 11' 6" wide and 7' tall elliptical culvert that is perched 2' above the water surface at the outlet (Figure 34, left). Upstream of the culvert there is an old bridge that constricts the channel as it approaches US 89. There is some undermining around the inlet of the culvert. During our site visit we observed a muskrat using the culvert to cross US 89, and there was a roadkilled deer carcass near the inlet. This could be a good location to pair stream restoration work with an upgrade to the crossing structure to improve fish and wildlife passage. Dry Creek is located just south of the Merriman Priority Site[Section 7].

Figure 33 Dry creek culvert outlet (left) and inlet (right).

11. Goldmeyer Creek/ Ditch (MM 27.25)

Goldmeyer Creek is a small stream originating In the Gallatin Mountains. According to FISHMT, eight electrofishing surveys of the upstream reaches of Goldmeyer Creek were conducted in 1981 and 1982. Brook trout, brown trout, rainbow trout, and Yellowstone cutthroat trout were all detected. Goldmeyer Creek is intercepted by an irrigation system and no longer reaches the Yellowstone River, so the lower reaches are probably of low value to fluvial trout. The ditch flows through a small concrete culvert under US 89 (Figure 35). This crossing is located within the Merriman Priority Site[Section 7].

Figure 34 Ditch that captures water from Goldmeyer Creek where it flows under US 89.

12. South Fork Fridley Creek (MM 28.75)

Fridley Creek is a small tributary to the Yellowstone River originating in the Gallatin Range and draining an approximately 21-square-mile watershed above the US 89 crossing. Yellowstone cutthroat, rainbow, Yellowstone cutthroat/rainbow trout hybrids and brook trout have been detected in Fridley Creek (FISHMT). We were not able to evaluate the US 89 crossing structure due to difficult access from the road. It would be worthwhile to look at this crossing in more detail because Fridley Creek is an important YCT tributary. Additionally, it may be possible to upgrade the crossing to serve as a terrestrial wildlife underpass because the roadbed is high above the creek in this location. South Fork Fridley Creek is located within the Merriman Priority Site[Section 7].

13. North Fork of Fridley Creek (MM 30.25)

About 3 miles from its mouth, Fridley Creek separates into two forks. The North Fork of Fridley Creek was disconnected from the Yellowstone River in the 1930s with construction of the Park Branch Canal. A project reconnecting the north fork to the Yellowstone River occurred in 2003 (Endicott et al. 2013). The goal of this project was to establish a fluvial Yellowstone cutthroat trout spawning run. There is extensive wetland habitat and beaver activity up and downstream of the US 89 crossing. The US 89 crossing is an open-bottomed, concrete culvert that does not accommodate the bankfull width of the stream and does not offer dry passage for terrestrial wildlife but is also not acting as a fish barrier (Figure 36). The North Fork Fridley Creek crossing is located just north of the Merriman Priority Site[Section 7].

Figure 35 Fridley Creek culvert inlet (left) and beaver dam against a fence upstream of culvert (right).

14. Eightmile Creek (MM 34.25)

Eightmile Creek is a large tributary to the Yellowstone River, originating in the Gallatin Mountains and draining an approximately 41-square-mile watershed above the US 89 crossing. According to the FISHMT database, brook trout, brown trout, cutthroat trout, mountain whitefish, and rainbow trout have all been detected during electrofishing surveys both above and below the US 89 crossing. Fluvial Yellowstone cutthroat trout have the potential to use Eightmile Creek as a spawning reach, and a single Yellowstone cutthroat was documented spawning above the US 89 crossing in the early 2000s (DeRito et al. 2004). Dewatering is a likely constraint on recruitment, as the lower two miles are chronically dewatered during the irrigation season (Endicott et al. 2013). The US 89 crossing is a large elliptical metal culvert with little to no natural substrate in the bottom of the culvert. The outlet is perched, with water falling onto a cascade of boulders. At some flows, this cascade likely forms a series of step pools that fish can navigate, but at other flows it probably functions as a fish barrier. The culvert span is narrower than the bankfull width of the stream, resulting in high velocity flows in the culvert. The upstream end of the culvert was being undermined by water eroding around the culvert, which was repaired in spring of 2023 using a combination of fill, riprap, topsoil, seed, and coir fabric. The culvert is not flow aligned, so this problem is likely to persist. Eightmile Creek falls within the Mill Creek Priority Area[Section 7].

Figure 36 Eightmile Creek culvert outlet (left) and Eightmile Creek upstream of US 89 crossing (right).

15. Trail Creek/ Ditch (MM 42.25)

Trail Creek is a large tributary to the Yellowstone River originating in the Gallatin Mountains. Trail Creek is intercepted by the Park Branch Canal and several smaller irrigation ditches before crossing US 89, and the stream no longer has connectivity to the Yellowstone River. These ditches cross US 89 in several places and we evaluated the crossing that seems closest to the historical alignment of Trail Creek (Figure 38). The US 89 crossing is a corrugated metal culvert with a silt-covered bottom. The culvert is sized for bankfull but does not accommodate any floodplain. This crossing falls just south of the Pine Creek Priority Area[Section 8].

Figure 37 Trail Creek/ Ditch crossing under US 89 (left) and ditch upstream of culvert (right).

16. Billman Creek (MM 52.75)

Billman Creek is a large tributary to the Yellowstone River, originating at Bozeman pass and draining an approximately 60-square-mile watershed above the US 89 crossing. Nearly the entire watershed falls within private lands and the stream is heavily impacted by development, infrastructure, and agriculture. Yellowstone cutthroat trout, rainbow trout, brook trout, brown trout, longnose sucker, white sucker, mountain whitefish, and sculpin have all been detected in Billman Creek during electrofishing surveys from 1974 to 2010 (FISHMT Database). The US 89 crossing structure is comprised of two side-by-side elliptical culverts. The culverts are not perched, and do not act as a fish barrier, but the river left culvert is plugged at the downstream end. The stream is incised in the vicinity of the culverts with over 8' tall vertical banks. Despite this, riparian vegetation has persisted. Downstream of the culverts, the stream is piped through a 600-fat-long pipe under the RY timber lot before it reaches the Yellowstone River. This pipe may limit this stream's accessibility to fluvial Yellowstone cutthroat trout and other species (Endicott et al. 2013). Because this crossing is hemmed in by development on all sides, this would be a challenging place to do a project. This crossing falls just north of the Livingston South Priority Area[Section 8].

Figure 38 Billman Creek culvert outlet (left) and Billman Creek upstream of US 89 crossing showing incision.

8.5 Conclusions and Recommendations

There are many opportunities along US 89 within the Paradise Valley and Gardiner Basin to upgrade road-stream crossing structures to allow for improved fish and other aquatic organism passage, terrestrial wildlife passage, and increased infrastructure resiliency to future flooding events. Out of the 16 crossing structures that we evaluated, at least six are likely partial or complete fish barriers. Since these crossings are located at the base of each tributary's watershed, these barriers may block access to miles of potential habitat.

Recommendations:

1. In areas where stream conveyance crossings through US 89 fall within identified priority areas for terrestrial wildlife passage, consider co-locating upgraded stream crossings with wildlife underpasses. As these structures are already located in riparian areas that are attractive to terrestrial wildlife, appropriately designed culverts and bridges can support the movement of both terrestrial and aquatic species.
2. When possible, crossing structures should be designed to accommodate the stream/river and full floodplain function.
3. Consult with Montana Fish, Wildlife & Parks fisheries staff prior to initiating any aquatic crossing project. Additional fisheries data may need to be collected and FWP may require project modifications to meet management objectives.

9. Cost-Benefit Analysis

9.1 Identifying and prioritizing road sections to address the impacts of roads and traffic on wildlife.

If one chooses to address collisions with large mammals because of a concern for human safety, data are needed on the locations where these types of collisions occur. Along most roads in North America there are two types of large animal-vehicle collision data that can help identify the "worst" road sections:

- **Crash data:** These data are typically collected by law enforcement personnel. For a crash to be entered into the database there is often a threshold (e.g., the minimum estimated vehicle repair cost is at least US $1,000 and/or there are human injuries and human fatalities) (Huijser et al. 2007).
- **Carcass data:** These data are typically collected by road maintenance crews when they remove carcasses of large mammals that are on the road or that are very visible from the road in the right-of-way and that are an immediate safety hazard or a distraction to drivers (Huijser et al. 2007). Note that carcass data are sometimes also collected or recorded by others, e.g., by personnel from natural resource management agencies, researchers, or the general public.

Both types of collision data tend to relate to large mammals only, and they can include both wild species and domesticated species (livestock or feral species). For North America, common large wild ungulates, especially white-tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*) and moose (*Alces americanus*) are the most numerous species in the crash and carcass data. Therefore, common large wild ungulates tend to drive the identification and prioritization of road sections where mitigation measures may be considered based on human safety. Medium-sized and small-sized mammals and other species groups such as amphibians, reptiles and birds are usually inconsistently recorded, or not recorded at all, by law enforcement or maintenance personnel (Huijser et al. 2007). Furthermore, crash data typically represent only a fraction (14-50%) of the carcass data, even if both data sets relate to large mammals only (Tardif and Associates Inc. 2003; Riley & Marcoux 2006; Donaldson & Lafon 2008). Finally, the carcass data are far from complete as well; animals that are not very visible from the road in the right-of-way may not be removed and may not get recorded. Wounded animals that make it beyond the right-of-way fence before they die are also usually not recorded at all. Carcass counts underestimate the true number of large mammals that are hit, and Lee et al. (2021) calculated a correction factor of 2.8 to achieve a more realistic number of carcasses.

If one chooses to reduce direct road mortality of wildlife species, regardless of the possible impacts for human safety, the concern can relate to any species, not just common, large mammal species. This means that the species can be large or small, and the species may be common or rare. There may be emphasis on reducing mass mortality (e.g., amphibians or reptiles), e.g., for ethical or cultural reasons, regardless of whether a species is endangered or threatened, or whether it has reduced population persistence in an area. There can also be emphasis on reducing direct road mortality, or reducing the probability of direct road mortality, for rare species, including species that have not yet been recorded as road mortality. This may especially apply to species for which direct road mortality is or can be suppressing their population survival probability in an area. Oftentimes, crash data collected by law enforcement personnel and carcass data collected by maintenance personnel are not suited to identify and prioritize the road sections where action should be considered first for small or rare species. Additional data collection may be warranted for small or rare species or species groups in specific areas. One may also conduct spatial analyses based on habitat suitability to identify and prioritize where mitigation measures may be warranted. Such analyses can relate to suitable habitat or potential population viability, regardless of whether the habitat is currently occupied by the species concerned.

One may also choose to reduce the barrier effect of roads and traffic for animals. This is especially relevant for wild species whose movements are not or should not be controlled or limited by people, and for species that would "benefit" from improved connectivity. In general, small and isolated populations have lower population viability than populations that are large and well connected. Reducing the barrier effect of roads and traffic can therefore improve population persistence for a species in an area. It is important to realize that the road sections where the barrier effect may need to be mitigated most urgently are not necessarily the same road sections where direct road mortality occurs most frequently. In fact, improved connectivity across roads may also be needed where there is no evidence of direct road mortality at all, potentially because the barrier effect is so substantial that animals do not even attempt to cross the road. Nonetheless, reducing the barrier effect on such locations may lead to a larger effective population size because the areas on opposite sides of a road would be better connected, thus resulting in a higher population survival probability. Furthermore, improving connectivity across roads may not only be based on the current distribution and movements of animals. It may also be based on conservation efforts that aim to restore habitat and movement corridors across the wider landscape, and on dispersal of individuals that move to far away areas. Dispersing animals may strengthen the viability of small and isolated populations, but they may also colonize or recolonize areas that are not currently occupied by that species. Besides improved population persistence, habitat connectivity across roads may also be required for species that have seasonal migration. This may involve small-scale movements (e.g., hundreds of meters for certain amphibian species that move between winter habitat and breeding habitat) or large-scale movements (e.g., hundreds of kilometers for certain ungulate species between winter and summer ranges). In some cases, there may be substantial, direct road mortality where roads bisect these seasonal migration corridors, but that is not necessarily the case.

One may also choose to address habitat loss, a decrease in habitat quality in a zone adjacent to the road, or the ecological functioning of rights-of-way, especially for invasive species. These concerns all require their own types of data to allow for the identification and prioritization of road sections that mitigation measures may need to be considered for. However, for this report, we only address animal-vehicle collisions (direct road mortality) and the barrier effect of roads and traffic for wildlife species.

In conclusion, if only wildlife-vehicle collision data collected by law enforcement personnel and road maintenance personal are used to identify and prioritize locations along highways that may require mitigation measures, then the concern is typically primarily with human safety and reducing collisions with common large mammal species (i.e., wild species, domestic species, or both, depending on the goals and objectives of the project). Road sections that may need to be mitigated for their impact on biological conservation may not be identified or prioritized at all if the "departure point" is human safety. Addressing direct road mortality for small or rare species may require other road mortality data sources, most likely very targeted efforts for specific species in specific areas. This may include road mortality surveys for small animal species at very low speed, e.g., on foot (Teixeira et al. 2013). Rare species are not only rarely encountered, but the carcasses may be removed (legally or illegally) by others before agency personnel, researchers, or citizen scientists come by. If the interest is to reduce road mortality of rare species, it becomes increasingly likely that reducing roadkill is not only or not primarily about human safety; it becomes more about biological conservation. In this context, it may be a good strategy to not only focus on current road mortality hot spots, but to also address historical roadkill hot spots that may have acted as a population sink in the past and where the population is now so depleted that it no longer results in a hot spot for collisions (Teixeira et al. 2017). Therefore, sites that require mitigation for rare species, even if these species have a large body size, may need to be primarily based on suitable habitat or corridors, instead of carcass and crash data, which are inherently rare. Addressing habitat connectivity for wildlife species requires yet other types of data, e.g., population viability analyses, wildlife movement data, and existing or planned habitat and corridors. In some cases, there may be overlap between road sections where direct road mortality occurs and road sections where habitat connectivity is needed most, but this is not necessarily the case.

Therefore, it is important to be clear about the "departure point" for the identification and prioritization process for road sections where mitigation measures may be required. If the "departure point" is human safety, the potential "destinations" can be very different compared to the potential "destinations" for a departure point rooted in biological conservation. In other words, depending on the objectives, different road sections may be identified and prioritized for potential mitigation measures (Huijser & Begley 2019).

9.2 Cost estimates associated with large wild mammal-vehicle collisions along US 89

A. MDT carcass data, supplemented with grizzly bear carcass data from the Interagency Grizzly Bear Study Team.

For this analysis we selected carcass data rather than crash data as carcass data are less susceptible to underreporting than crash data (see previous section). We selected carcass data collected by MDT road maintenance crews between 2012-2021 (10 full calendar years), between mile reference post 0.0 (near Gardiner) and 53.0 (near Livingston). While there is no standard, using 10 years' worth of data is aimed at striking a balance between: 1. Having sufficient data to correctly identify road sections where the number and associated costs of collisions with large wild mammals is relatively high, and 2. Still have the data be somewhat recent and reducing the probability of the number and associated costs of collisions has shifted spatially, e.g., as a result of changes in the landscape that may affect where animals are present, where they cross the road, and where they are hit by traffic. Carcass removal data collected by road maintenance crews are mostly suited to identify and prioritize road sections where common large mammals are hit, especially large ungulates. However, they are not suitable for small or rare animal species. Yet, some species, including grizzly bears, have a very high passive use value, an economic value that is lost when an animal dies (Huijser et al. 2022). Therefore, we supplemented the MDT carcass removal data with the grizzly bear road mortality data from the Interagency Grizzly Bear Study Team (IGBST).

The combined MDT and IGBST carcass data had 437 records of roadkilled animals (Table 32). White-tailed deer, mule deer, and elk were by far the most frequently recorded species, and there were six recorded grizzly bear road mortalities, all from the IGBST data set. Data on the costs associated with wildlife-vehicle collisions (WVCs) were only available for a few selected species, but the included costs related to vehicle repair, human injury, human fatality, and passive use values for the wildlife species concerned (Huijser et al. 2022). To estimate the costs associated with WVCs along US 89, the recorded species in the carcass database were assigned to "species categories" based on the size and weight of the species. All deer (i.e., white-tailed, mule, and unknown deer species), black bears and mountain lions were assigned to the "deer" category (Table 32). Elk were assigned to the "elk" category, bison were assigned to the "moose" category, and grizzly bear were assigned to the "grizzly bear" category. Domestic species, small wildlife species, and unspecified wildlife species were not included in the cost estimates.

Table 30. The species and their abundance in the combined MDT and IGBST carcass data. Color coding indicates what species fell into what species category for the cost calculations.

recorded species			"species" for economic analyses
10_ MOUNTAIN LION	2		Deer
11_ OTHER (WILD)	7		Elk
12_ DOMESTIC	2		Moose
13_ DEER UNKNOWN	15		Grizzly bear
14_ UNKNOWN	7		
16_ BISON	2		
2_ BLACK BEAR	1		
3_ GRIZZLY BEAR	6		
4_ ELK	78		
5_ WHITE-TAILED DEER	462		
6_ MULE DEER	437		

The costs associated with the wildlife-vehicle collisions for US 89 between mile reference posts 0.0 and 53.0 are shown in Figure 40 as the jagged line. The cost spikes for roadkilled animals around mile reference posts 3.6-4.8, 6.2-7.2, 9.5-10.5, 19.9-20.9, 28.5-29.5 are all associated with grizzly bear-vehicle collisions. The cost spike around mile reference post 51.5-52.5 is associated with numerous mule deer-vehicle collisions. The graph also includes threshold values based on a discount rate of 3% for the implementation of two different types of mitigation packages; one includes only underpasses once every 2 km, and the other also includes an overpass once every 24 km. See Huijser et al. (2022) for details of the threshold values for the mitigation measures and what the mitigation packages consist of. Wherever the costs associated with wildlife-vehicle collisions (jagged line) meets or exceeds the thresholds (horizontal lines), the implementation of the mitigation measure packages is less expensive than the costs of "no action" and having these collisions continue to occur. Based on the analyses, mitigation measures are attractive from an economical perspective alone along much of the length of US 89. Even though "only" 0.6 grizzly bears were hit per year on average, the total costs associated with hitting grizzly bears along US 89 was higher than the costs for hitting deer or elk (Table 33). The total estimated annual costs associated with large mammal-vehicle collisions along US 89 was $4,893,340.

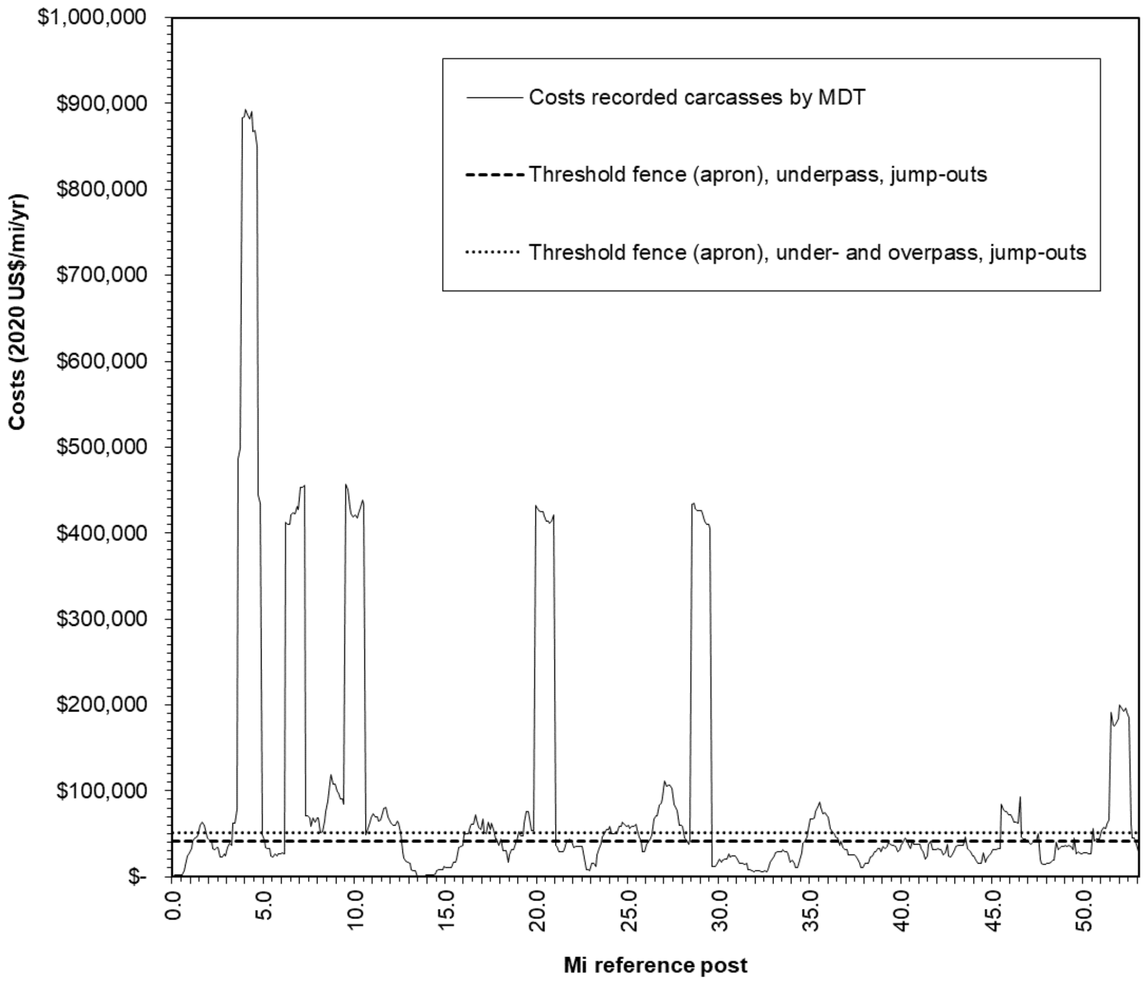


Figure 39. The costs (in 2020 US$) associated with large wild mammal-vehicle collisions (based on MDT carcass removal data, supplemented with grizzly bear carcass data from the Interagency Grizzly Bear Study Team) along US 89 (mile reference posts 0.0–53.0) per year (average 2012-2021), and the threshold values (at 3% discount rate) that need to be met in order to have the benefits of 2 different mitigation measure packages exceed the costs associated with the collisions over a 75-year time period. The costs for each 0.1 mile were based on the moving average of five adjacent 0.10-mile units on each side to estimate the costs per mile per year.

Table 31. The estimated costs associated with large wild mammal-vehicle collisions along US 89 (mile reference marker 0.0-53.0) based on MDT carcass removal counts supplemented with IGBST carcass data. Costs are based on Huijser et al. (2022).

	Total 2012-2021		Average per year	
Species	Roadkilled individuals (N)	Costs (2020 US$)	Roadkilled individuals (N)	Costs (2020 US$)
Deer	917	$17,504,613	91.7	$1,750,461
Elk	78	$5,709,288	7.8	$570,929
Moose	2	$220,794	0.2	$22,079
Grizzly bear	6	$25,498,704	0.6	$2,549,870
Total	1,003	$48,933,399	100	$4,893,340

We also calculated the total estimated costs associated with large wild mammal-vehicle collisions for the seven priority sites, as well as the costs per mile of road length in these priority sites (Table 34). From an economic perspective, Gardiner airport is the most attractive of the seven priority sites to mitigate, as the costs associated with large wild mammal collisions per mile is higher than for the other sites.

Table 32. The estimated annual costs (in 2020 US$) associated with large wild mammal-vehicle collisions for the seven priority sites along US 89 based on MDT carcass removal counts supplemented with IGBST carcass data. Costs are based on Huijser et al. (2022).

	Deer	Elk	Moose	Grizzly bear	Total	Total/mi
Gardiner Airport: RM 2.3 - 5.4	$131,714	$65,876	$0	$849,957	$1,047,547	$327,359
Corwin Springs: RM 7.6 - 10.5	$127,896	$43,918	$11,040	$424,978	$607,832	$202,611
Dome Mountain: RM 17.1 - 22.4	$40,087	$190,310	$0	$424,978	$655,375	$121,366
Merriman: RM 25.9 - 29.3	$183,254	$36,598	$0	$424,978	$644,831	$184,237
Mill Creek: RM 34.6 - 37.0	$125,987	$14,639	$0	$0	$140,627	$56,251
Pine Creek: 43.2 – 47.0	$169,892	$7,320	$0	$0	$177,212	$45,439
Livingston South (ext.): RM 48.0 - 52.4	$326,422	$0	$0	$0	$326,422	$72,538

A. Correction factors for MDT carcass data

While large mammal carcasses are typically more numerous than large mammal crashes, carcass data collected by road maintenance personnel are still an underestimate of the real number of animals that is killed by vehicles (e.g., Lee et al. 2021). For the year 2021 we had access to both MDT carcass data and additional carcass data sets collected by various other sources, including systematic, weekly survey data and opportunistic citizen science data collected by YSP through use of the ROaDS smartphone tool, IGBST grizzly bear road mortality data. We combined the MDT carcass data from 2021 with these other carcass data sources and removed any duplicates based on the following rule: 10 days in time and 0.1 miles in space. We then compared the MDT carcass data to all sources combined, including the same MDT carcass data, to calculate a "correction factor" for the MDT carcass data (Table 35). Note that for this comparison the 2021 MDT carcass data did not include IGBST grizzly bear road mortality data. Even though IGBST grizzly bear data were included in the "other sources," there was no reported road mortality of grizzly bears in 2021 along US 89.

White-tailed deer and mule deer were the most frequently reported species in the roadkill data from MDT as well as all sources combined (Table 35). Deer were followed by elk. Interestingly, when all carcass data were combined (all sources), there were 7.87 times more deer (white-tailed deer, mule deer, and unknown deer species combined) and 7.63 times more elk reported as roadkill compared to only using the MDT carcass data (Table 35). These correction factors for the MDT carcass removal data are very substantial, showing that there are many more deer and elk hit along US 89 than the MDT carcass removal data suggest. Moreover, these are still only carcasses that were reported, and there are likely additional carcasses that went unreported, both inside the right-of-way and outside of the right-of-way. Infrequently hit species such as moose, pronghorn, and mountain lion were only reported by other sources and never through MDT carcass removal counts (Table 35). This illustrates that carcass removal counts by road maintenance crews are not suited for infrequently hit species, including large mammal species. Note that rare species such as grizzly bear were never recorded through MDT carcass counts in any year, further illustrating that carcass-removal data recorded by road maintenance crews are not suited for rare species, even if they are large. This may be because MDT does not have the authority to remove grizzly bear carcasses because they are a listed species, and this may be true for other species as well. Furthermore, the comparison shows that MDT carcass counts do not include smaller mammal species, even if they are hit relatively frequently such as striped skunk or raccoon (Table 35).

Table 33. Comparison of the number of roadkilled individuals per species based on the MDT carcass counts, and for all sources combined (duplicates deleted) (all based on 2021 data). The correction factor is the multiplication factor for the MDT data to become a better representation of the actual number of animal carcasses.

2021			
Species	MDT	All sources	Correction factor
White-tailed deer	46	295	6.41
Mule deer	15	150	10.00
Unknown deer	0	35	Not recorded in MDT carcass data
All deer	61	480	7.87
Elk	8	61	7.63
Moose	0	2	Not recorded in MDT carcass data
Pronghorn	0	3	Not recorded in MDT carcass data
Red fox	0	5	Not recorded in MDT carcass data
Coyote	0	8	Not recorded in MDT carcass data
Mountain lion	0	1	Not recorded in MDT carcass data
Striped skunk	0	27	Not recorded in MDT carcass data
Raccoon	0	34	Not recorded in MDT carcass data
Cat	0	1	Not recorded in MDT carcass data
Dog	0	1	Not recorded in MDT carcass data
Livestock	0	1	Not recorded in MDT carcass data
Birds	0	6	Not recorded in MDT carcass data
Other	0	2	Not recorded in MDT carcass data
Other mammal	0	13	Not recorded in MDT carcass data

A. Corrected MDT carcass data, supplemented with grizzly bear carcass data from the Interagency Grizzly Bear Study Team.

Based on the correction factors for deer and elk (see previous section), we recalculated the number of roadkilled large animals at each 0.10-mile reference marker and calculated the estimated associated costs (Figure 41). We only corrected the number of deer (e.g., white-tailed deer, mule deer, and unknown deer species combined) and elk, and not any of the other species. Based on the analyses with the correction factors for deer and elk, mitigation measures are very attractive from an economical perspective alone along almost the entire length of US 89 (Figure 41).

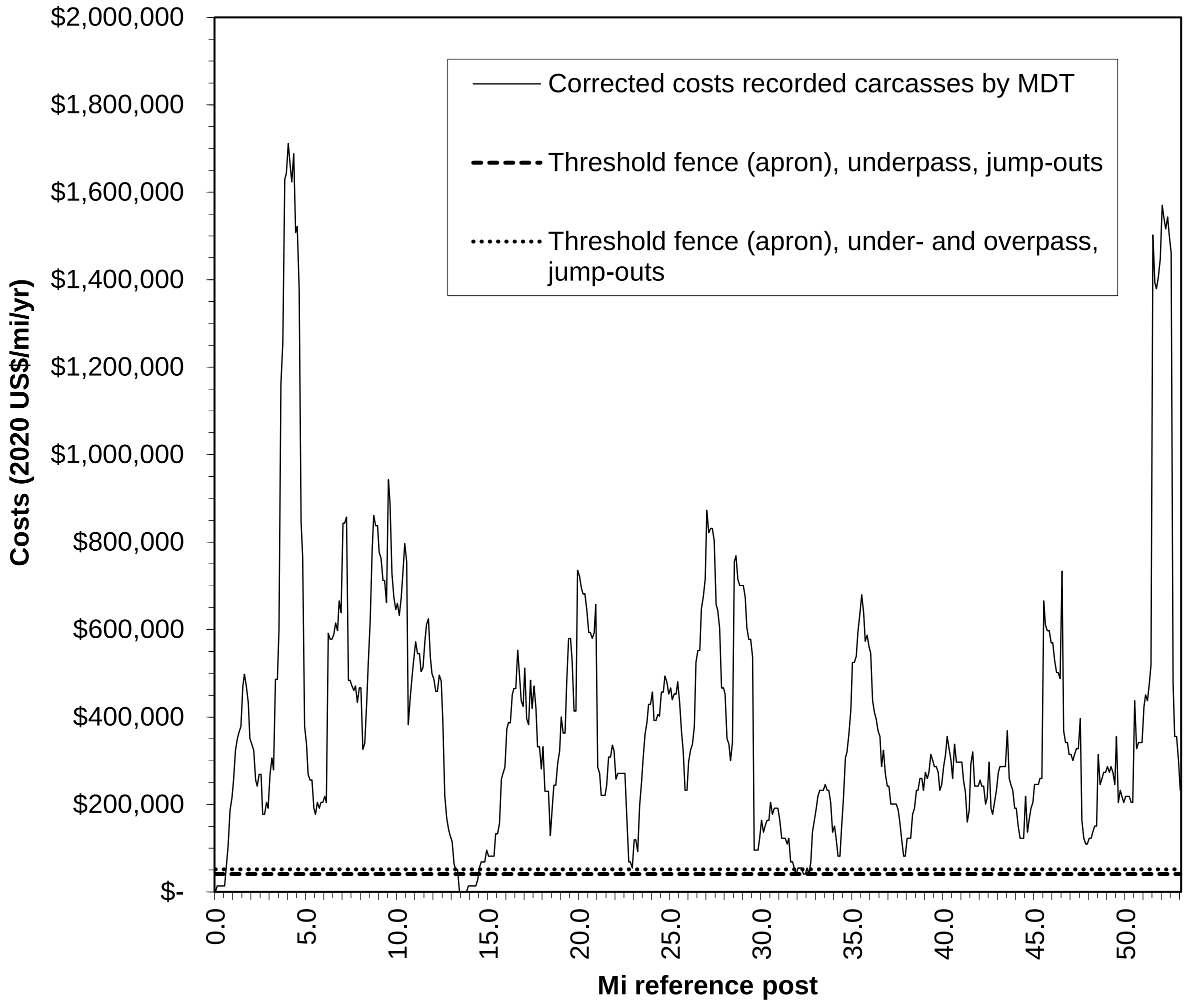


Figure 40. The costs (in 2020 US$) associated with large wild mammal-vehicle collisions (based on MDT carcass removal data with correction factors for deer and elk applied, supplemented with grizzly bear carcass data from the Interagency Grizzly Bear Study Team)

The total costs associated with hitting deer along US 89 were much higher than for elk, moose, or grizzly bears (Table 36). The total estimated annual costs associated with large mammal-vehicle collisions along US 89 was $20,704,267.

Table 34. The estimated costs associated with large wild mammal-vehicle collisions along US 89 (mile reference marker 0.0-53.0) based on MDT carcass removal counts supplemented with IGBST carcass data, and correction factor for deer and elk applied. Costs are based on Huijser et al. 2022.

	Total 2012-2021		Average per year	
Species	Roadkilled individuals (N)	Costs (2020 US$)	Roadkilled individuals (N)	Costs (2020 US$)
Deer	7,216.79	$137,761,304	721.679	$13,776,130
Elk	595.14	$43,561,867	59.514	$4,356,187
Moose	2	$220,794	0.2	$22,079
Grizzly bear	6	$25,498,704	0.6	$2,549,870
Total	7,820	$207,042,670	782	$20,704,267

We also calculated the total estimated costs associated with large wild mammal-vehicle collisions for the seven priority sites, as well as the costs per mile of road length in these priority sites (Table 37). From an economic perspective, Gardiner Airport is the most attractive of the seven priority sites to mitigate as the costs associated with large wild mammal collisions per mile is higher than for the other sites.

Table 35. The estimated annual costs (in 2020 US$) associated with large wild mammal-vehicle collisions for the seven priority sites along US 89 based on MDT carcass removal counts supplemented with IGBST carcass data, and a correction factor for deer and elk applied. Costs are based on Huijser et al. 2022.

	Deer	Elk	Moose	Grizzly bear	Total	Total/mi
Gardiner Airport: RM 2.3 - 5.4	$1,036,590	$502,637	$0	$849,957	$2,389,184	$746,620
Corwin Springs: RM 7.6 - 10.5	$1,006,544	$335,091	$11,040	$424,978	$1,777,653	$592,551
Dome Mountain: RM 17.1 - 22.4	$315,484	$1,452,062	$0	$424,978	$2,192,525	$406,023
Merriman: RM 25.9 - 29.3	$1,442,212	$279,243	$0	$424,978	$2,146,433	$613,267
Mill Creek: RM 34.6 - 37.0	$991,521	$111,697	$0	$0	$1,103,218	$441,287
Pine Creek: 43.2 – 47.0	$1,337,051	$55,849	$0	$0	$1,392,899	$357,154
Livingston South (ext.): RM 48.0 - 52.4	$2,568,940	$0	$0	$0	$2,568,940	$570,876

A. All species recorded by all sources

We tallied all roadkilled animals per species for 2021, 2022, and for part of 2023 (last observation that was included is from 12 May 2023) for all carcass sources combined (Table 38). Not all sources had data for all years; e.g., MDT carcass removal data were only available through 2021. Nonetheless, the combined data show the wide variety of species that are hit, including infrequently hit large wild mammal species (e.g., moose, pronghorn, bison, mountain lion, and black bear) and smaller species that are not typically reported by road maintenance crews (e.g., red fox, coyote, raccoon, and striped skunk)

Table 36. The total number of roadkilled individuals per species per year (2021, 2022, and 2023) for all available data sources combined.

Species	Total (N)	2021	2022	2023
White-tailed deer	360	295	50	15
Mule deer	225	149	53	23
Deer unknown species	61	35	15	11
Total deer	646	479	118	49
Elk	112	61	41	10
Moose	4	2	2	
Pronghorn	7	3	4	
Bighorn sheep	3	2		1
Bison	1			1
Mountain lion	1	1		
Red fox	6	5		1
Coyote	11	8	2	1
Black bear	3		2	1
Raccoon	65	35	27	3
Striped skunk	68	27	38	3
Opossum	4	4		
Other mammal	26	13	12	1
Bird	13	6	6	1
Cat	2	1		1
Dog	1	1		
Livestock	1	1		
Other	2	2		

10. Conceptual Renderings

10.1 Gardiner Airport

Figure 41. Existing roadway and conceptual rendering of an overpass in the Gardiner Airport Priority Site

10.2 Corwin Springs

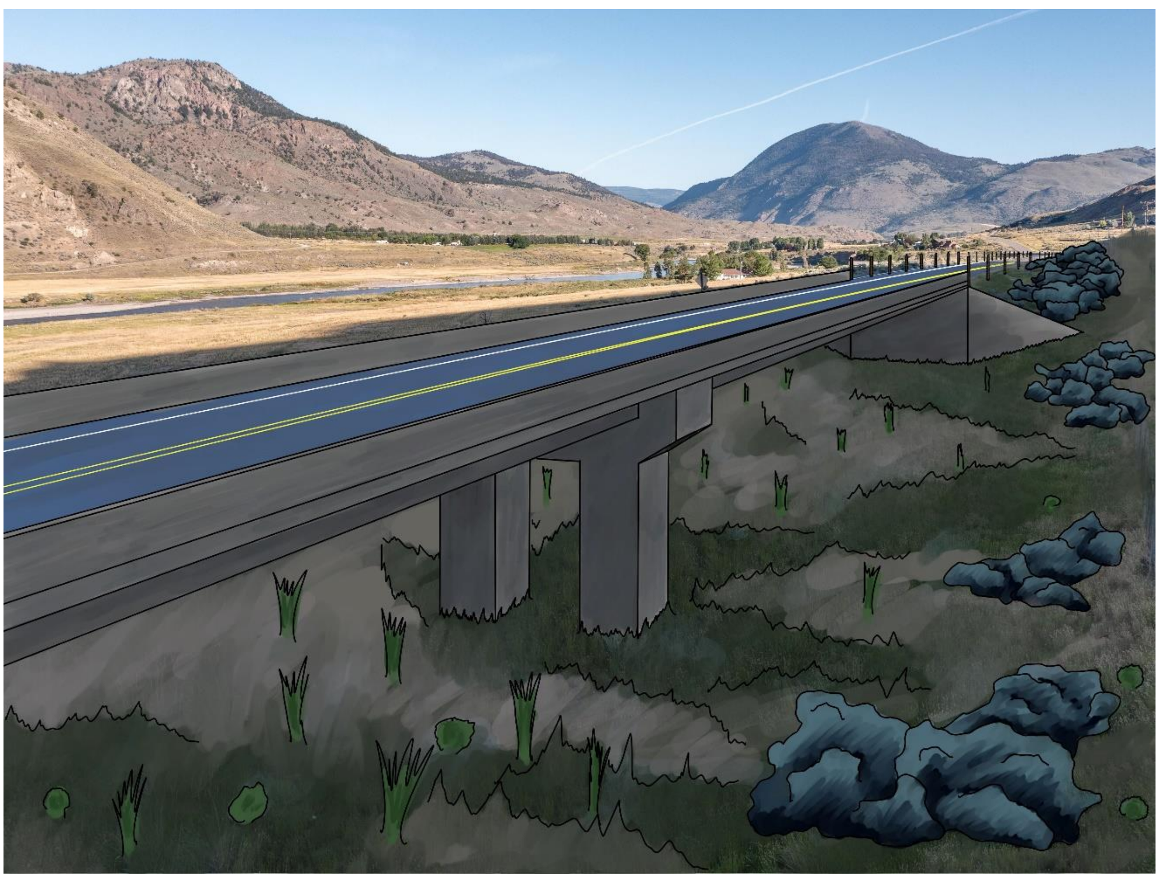


Figure 42. Existing roadway and conceptual rendering of an underpass in the Corwin Springs Priority Site

10.3 Dome Mountain

Figure 43. Existing roadway and conceptual rendering of an overpass at the Dome Mountain Priority Site

10.4 Eightmile Creek

Figure 44. Existing roadway and culvert and conceptual rendering of upsized underpass in the Mill Creek Priority Site

11. Potential Funding Sources

11.1 Introduction

According to Montana Department of Transportation (MDT) surveys, safety concerns and "wildlife crossings and barriers" are both in the top three or four priorities that stakeholders and the public would like to see the agency address in order to improve our state's transportation system. However, the number one obstacle to advancing more wildlife crossing projects in the U.S. is a lack of available funding, according to a recent survey of state department of transportation staff across the country (Cramer 2022). Fortunately, growing support for wildlife crossings nationwide, across all levels of governments, has established unprecedented new public funding opportunities for this work. Additionally, there is increasing interest from the philanthropic community in investing in projects that reduce wildlife-vehicle collisions while improving habitat connectivity. These wildlife accommodations can be "stand alone" projects or incorporated into a variety of transportation improvement projects, including new construction and reconstruction; resurfacing; restoration, rehabilitation, or replacement; "spot improvements" and safety projects; and preservation of roads and bridges. To learn more, see the definition of "construction" under 23 USC § 101(a)(4) and the improvement types listed on pages 8-9 of Montana's 2022-2026 Statewide Transportation Improvement Program.

This section begins with an overview of existing federal funding sources that could be used to advance the wildlife accommodation measures discussed in this Assessment. The majority of public funding available comes from these federal sources, given that 88.5% of Montana's roads and bridges are funded through federal dollars and the Montana Department of Transportation receives no funding from the state's general revenue fund (Montana Department of Transportation 2022). Most non-federal matching funds come from Montana's fuel tax and gross vehicle weight fees (Montana Department of Transportation 2022).

After reviewing federal funding sources, this section offers examples from across the country of innovative state and local funding mechanisms, as well as public-private partnerships. These examples could serve as models for establishing additional funding sources to implement the recommendations of the Assessment. Many wildlife accommodation projects throughout the U.S. are funded through a diverse array of funding sources, including local, state, and federal funding, as well as private contributions from individuals, foundations, and corporations. Leveraging all existing, eligible funding sources—in addition to establishing new funding streams and attracting private investments—is paramount for garnering sufficient funds to complete successful wildlife accommodation projects. A diversified portfolio approach is important for advancing both dedicated wildlife accommodations and wildlife accommodation measures as components of larger transportation projects.

11.2 Federal Infrastructure Funding Sources

In 2021, the federal government enacted the Infrastructure Investment and Jobs Act ("IIJA," Public Law 117-58), which established the first-ever *dedicated* federal funding for wildlife crossings. In addition to this dedicated funding, projects to reduce wildlife-vehicle collisions and/or improve habitat connectivity are eligible for funding from at least 14 other federal infrastructure programs. While there are billions of dollars available under the latter programs, they do not have funding set aside specifically for wildlife crossings. However, examples of wildlife crossing projects that have received federal funding under these broader transportation programs are provided in this section. Thus, wildlife components of larger capital improvement projects can receive funding from a variety of sources.

The funding amounts listed in the descriptions below are for fiscal years 2022-2026. Eligible entities for each of these programs are listed in Table 39. Additional information and resources on the programs described below can be found on the Center for Large Landscape Conservation's Wildlife and the Bipartisan Infrastructure Law webpage, Animal Road Crossings Solutions' webpage, the Federal Highway Administration's Bipartisan Infrastructure Law webpage, and the U.S. Department of Transportation's notice of funding opportunities webpage. For further information about wildlife crossing projects that have taken advantage of federal transportation dollars, including many of those described in this section, visit the Wonderful World of Wildlife Crossings Story Map.

Table 37. Eligible recipients for transportation funding programs under the Infrastructure Investment and Jobs Act of 2021

Program	State	Metro/Regional	Local	Tribal	Federal
Bridge Formula Program	x				
Bridge Investment Program	x	x	x	x	x
Federal Lands Access Program	x		x	x	x
Federal Lands Transportation Program	x				x
Forest Service Legacy Road and Trail Remediation Program					x
Highway Safety Improvement Program	x				
National Infrastructure Project Assistance (Mega) Program	x	x	x	x	
Local and Regional Project Assistance Grants (RAISE)	x	x	x	x	x
National Culvert Removal, Replacement, and Restoration Program	x		x	x	
Nationally Significant Federal Lands and Tribal Projects	x		x	x	x
Nationally Significant Freight and Highway Projects (INFRA)	x	x	x	x	x
PROTECT (competitive)	x	x	x	x	x
PROTECT (formula)	x				
Rural Surface Transportation Grant	x	x	x	x	
Surface Transportation Block Grant	x				
Wildlife Crossings Pilot Program	x	x	x	x	x

Categories of eligible entities listed in the header include state departments of transportation ("State"), metropolitan planning organizations or regional transportation authorities ("Metro/Regional"), local transportation authorities ("Local"), tribal departments of transportation ("Tribal"), and federal natural resource management agencies ("Federal"). Programs are listed in alphabetical order.

Montana's funding flow for federal-aid funding, MDT's non-federal matching funds, state-funded programs, and other federal allocations and transfers is illustrated in Figure 46.

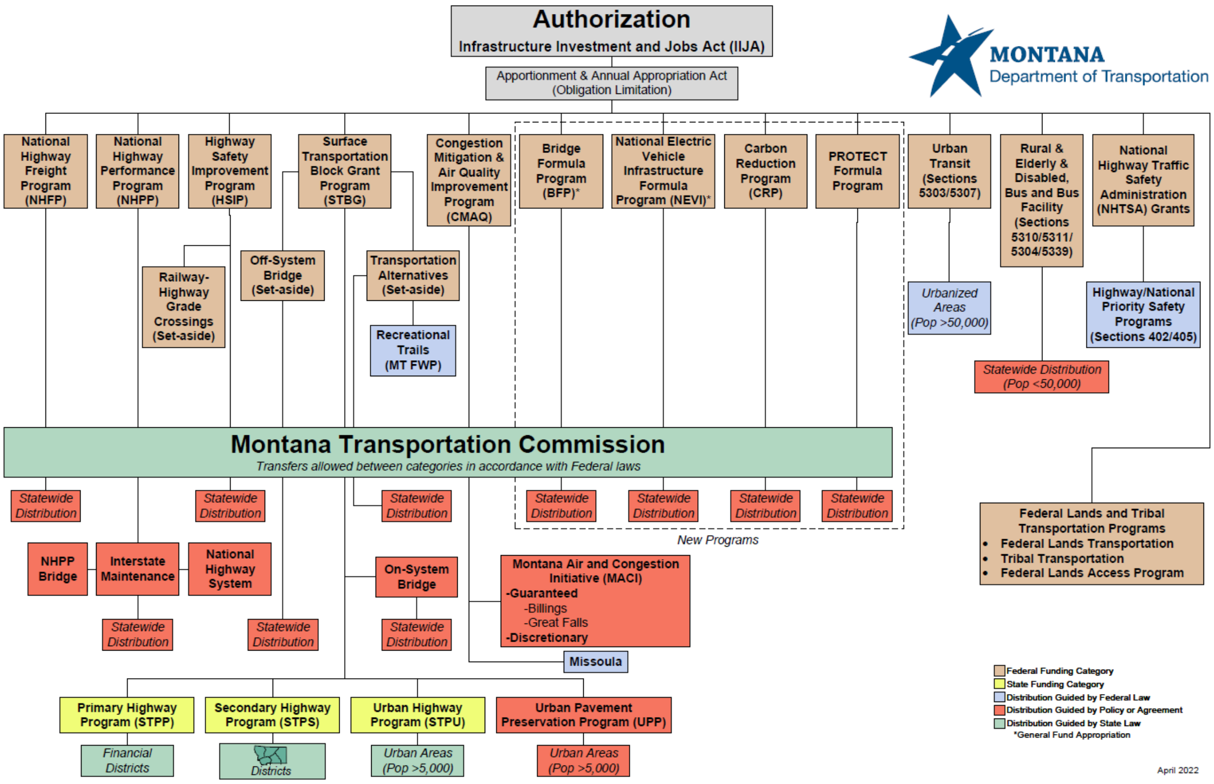


Figure 45 Funding Flow for Federal Reauthorization Funds (Montana Department of Transportation, 2022-2026 Statewide Transportation Improvement Program)

11.2.1 Discretionary Grant Programs

The following Infrastructure Investment and Jobs Act (IIJA) programs provide discretionary grants distributed through competitive application processes at the national level.

Wildlife Crossings Pilot Program

This $350-million pilot grant program establishes dedicated funding for projects to reduce wildlife-vehicle collisions and improve habitat connectivity (23 USC § 17). Proposals for funding under this program will also be evaluated based upon the extent to which the project leverages non-federal funding; supports local economies and tourism; integrates innovative technology and design techniques; provides educational and outreach opportunities; and evaluates the efficacy of the project. Eligible entities include state departments of transportation, tribes, federal land management agencies, metropolitan planning organizations, local governments, regional transportation authorities, and special districts. Eligible partners include foundations, non-governmental organizations, universities, and other government agencies. Additionally, 60% of funds will go to projects in rural areas (Federal Highway Administration 2022).

Rural Surface Transportation Grant Program

This $2-billion program is for highway, bridge, or tunnel projects to improve and expand the surface transportation infrastructure in rural areas (those with a population of fewer than 200,000 residents) to increase connectivity, improve safety, enhance reliability, generate regional economic growth, and improve quality of life (23 USC § 173).

Wildlife infrastructure projects, including tunnels and detection systems, are eligible for funding. Projects must have completed preliminary engineering studies and begin construction within 18 months. The federal cost share is generally 80% and other sources of federal assistance can be used for match (U.S. Department of Transportation 2023).

Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation (PROTECT)

This program includes $7.3 billion in formula allocation funding and $1.4 billion in discretionary grant funding for states and communities to make transportation resilience improvements to mitigate the risk of recurring damage from extreme weather events, flooding, or other natural disasters (23 USC § 176). Eligible projects include natural infrastructure and "protective features" that increase the size or number of drainage structures, replace culverts with bridges, lengthen or raise bridges, or upsize culverts for climate resilience and ecosystem benefits (Federal Highway Administration 2022). The federal cost share for projects under this program in Montana is 86.58% (Montana Department of Transportation 2022).

Bridge Investment Program

This $12.5-billion program is for projects to replace, rehabilitate, preserve or protect one or more bridges on the National Bridge Inventory; replace or rehabilitate culverts for purposes of improving flood control; and improve habitat connectivity for aquatic species (23 USC § 124). The program includes $100 million in grants for planning, feasibility analysis, and revenue forecasting. This set-aside is for measures to improve bridge and culvert condition, safety, efficiency, and reliability; and to replace, rehabilitate, preserve, or protect one or more bridges on the National Bridge Inventory. More specifically, projects that replace or rehabilitate culverts to improve flood control and habitat connectivity for aquatic species are eligible for funding. The federal cost share is 50% for large bridge projects, 80% for other bridge projects, and up to 90% for "off-system" bridges.

Example: In 2022, Flathead County (Montana) secured $240,000 in Bridge Investment Program funding for bridge improvements, including wildlife connectivity improvements (*Federal Highway Administration 2022*).

National Culvert Removal, Replacement and Restoration Program

This $1-billion program is for states, local governments, and tribes to facilitate fish passage through removing, replacing, or repairing culverts or weirs (23 USC § 6703). The federal cost share is up to 80% (Federal Highway Administration 2023).

Local and Regional Project Assistance Grants: Rebuilding American Infrastructure Sustainably and Equitably (RAISE)

This $7.5-billion program is for road, rail, transit, and other surface transportation of local and/or regional significance (49 USC § 6702). Selection criteria include safety, sustainability, equity, economic competitiveness, mobility, and community connectivity. Eligible projects include those that replace or rehabilitate a culvert or prevent stormwater runoff for the purpose of improving habitat for aquatic species. The maximum award is $25 million per project. The federal cost share is generally 80%, but could be higher for projects located in rural, disadvantaged, or impoverished areas (U.S. Department of Transportation 2022).

Example: In 2019, the Wyoming Department of Transportation received $14.5 million under a previous iteration of this program (Better Utilizing Investments to Leverage Development, or "BUILD") to construct wildlife crossings (including underpasses, fencing, and jump-outs) along U.S. Route 189 (*Wyoming Department of Transportation 2019*).

Nationally Significant Multimodal Freight and Highway Projects Program (INFRA)

This $8-billion program is for multimodal freight and highway projects of national or regional significance that improve the safety, efficiency, and reliability of the movement of freight and people (23 USC § 117). Projects that increase safety on freight corridors where wildlife frequently cross the road are now eligible for funding. At least 30% of funding for small projects ($5 million minimum) goes towards rural areas and 25% of funding for large projects ($25 million) goes towards rural areas. Large projects must have completed preliminary engineering studies, begin construction within 18 months, demonstrate a need for federal funding, and demonstrate available non-federal funding. The federal cost share is generally 60% but could be up to 80% for small projects (U.S. Department of Transportation 2022).

Example: In 2022, the Colorado Department of Transportation (CDOT) received a $100-million INFRA grant for highway improvements on Interstate-70 (*U.S. Department of Transportation 2022*). The project includes construction of a wildlife underpass and directional fencing, "the first major wildlife crossing to be constructed along the I-70 Mountain Corridor, and it will allow wildlife to safely cross underneath the interstate at a location which has historically been a hotspot for wildlife related crashes," according to CDOT (*Colorado Department of Transportation 2022*)

Nationally Significant Federal Lands and Tribal Projects

This $275-million program is for the construction, reconstruction, and rehabilitation of nationally significant federal lands and tribal transportation projects (23 USC § § 203). Federal entities and state, county, or local governments may apply if sponsored by an eligible federal land management agency or tribe. Eligible projects include measures to mitigate wildlife-vehicle collisions and mitigate damage to habitat connectivity and aquatic organism passage, including constructing, maintaining, replacing, or removing culverts and bridges. The federal cost share is up to 90% for projects on non-tribal transportation facilities (Federal Highway Administration 2022).

National Infrastructure Project Assistance ("Mega")

This $5-billion program is for large and complex transportation projects (including highway, bridge, freight, railway, and certain public transportation projects) with national or regional economic, mobility, or safety benefits. Half of the funds are allocated to projects greater than $500 million and the other 50% are allocated to projects between $100-500 million. The federal cost share is 60% but total federal assistance for a project receiving a grant under this program could be up to 80% (U.S. Department of Transportation 2023).

Example: In 2023, the North Carolina Department of Transportation was awarded $110 million to replace the Alligator River Bridge on U.S. Highway 64. The project includes wildlife crossing structures and directional fencing to improve habitat connectivity between the north and south areas of the roadway and reduce wildlife-vehicle collisions (*U.S. Department of Transportation 2022*).

11.2.2 Formula Funding Programs

The following IIJA programs distribute funding directly to states via formula allocations or formula grants.

Bridge Formula Program

This $27.5-billion program is for states to complete bridge replacement, rehabilitation, preservation, protection, or construction projects on public roads (23 USC § 124). Funds can be used to plan, design, engineer, or construct bridges; to replace and rehabilitate bridges; and to improve bridges in poor condition. Given that "improvements that reduce the number of wildlife-vehicle collisions, such as wildlife crossing structures" are included in the definition of "construction" under IIJA (23 USC § 101(a)(4)(H)), wildlife crossings are presumably an eligible component of construction projects funded under this program (Federal Highway Administration 2022). The federal cost share for projects under this program in Montana is 86.58% (Montana Department of Transportation, 2022-2026 Statewide Transportation Improvement Program).

Surface Transportation Block Grant Program

This $72-billion program is for state and local government projects on federal-aid highways and bridges on any public road, as well as transit capital projects (23 USC § 133). It includes design, construction, monitoring, maintenance of wildlife crossing structures, or other measures designed to reduce wildlife-vehicle collisions. The $7.2 billion for the Transportation Alternatives (TA) set-aside has funding available for local transportation projects, including environmental mitigation activities, such as reducing wildlife mortality caused by roads or improving terrestrial or aquatic connectivity. Local governments and other eligible entities (such as metropolitan planning organizations and non-profits) can apply for this funding through a competitive grant process developed by the state (Federal Highway Administration 2022). The federal cost share in Montana for projects under this program is 86.58% (Montana Department of Transportation, 2022-2026 Statewide Transportation Improvement Program).

Example: In 2010, a public-private partnership secured a Transportation Alternatives grant that—when matched with a State Wildlife Grant and from the U.S. Fish and Wildlife Service and private dollars—funded construction of underpasses and fencing to provide safe passage for amphibians during their seasonal migration across the Monkton-Vergennes Road in Vermont.

Highway Safety Improvement Program

This $15.6-billion program provides states with funding to save lives and prevent serious injuries on public roads, in accordance with their highway safety plans (23 USC § 148). Projects that improve safety by reducing wildlife-vehicle collisions are eligible. The federal cost share is 90% (Federal Highway Administration 2022).

Example: In 2015, the Colorado Department of Transportation used Highway Safety Improvement Program dollars to construct a series of wildlife underpasses along State Highway 160 (Colorado Department of Transportation 2015).

Federal Lands Transportation Program

This $2.2-billion program is for projects that improve multimodal transportation on roads, bridges, trails, transit systems, and other transportation facilities (23 USC § 204). It includes $130 million in direct federal spending for the U.S. Forest Service, $180 million for the U.S. Fish & Wildlife Service, $1.7 billion for the National Park Service, and $154 million in competitive grant funding for other federal land management agencies. IIJA doubles the previous cap of $10 million to a current cap of $20 million per year for funds under this program that can be used for projects that reduce wildlife mortality due to roads while maintaining habitat connectivity (Federal Highway Administration 2022).

Example: In recent years, the Texas Department of Transportation, in coordination with the U.S. Fish & Wildlife Service, constructed a series of wildlife underpasses, primarily for ocelots, around the Laguna Atascosa National Wildlife Refuge using Federal Lands Transportation Program funds *(Federal Highway Administration 2023*).

Federal Lands Access Program

This $1.5-billion program is for improving multimodal transportation on roads, bridges, trails, transit systems, and other transportation facilities that access the federal estate on infrastructure owned or maintained by states and local governments (23 USC § 204). It places an emphasis on high-use federal recreation sites and federal economic generators. It includes environmental mitigation during planning, engineering, and construction phases on or adjacent to federal lands to reduce wildlife mortality due to roads and maintain habitat connectivity (Federal Highway Administration 2023).

Example: In 2017, the Idaho Department of Transportation received $2.8 million in Federal Lands Access Program funds to build a wildlife overpass on State Highway 21, with $220,000 in matching funds from a public-private partnership including Idaho Department of Fish and Game, the U.S. Forest Service, Army Corps of Engineers, the Western Federal Lands Highway Division, non-governmental organizations, and local cities and counties (*Idaho Department of Transportation*).

11.3 Federal Conservation Funding Sources

11.3.1 Collaborative-based, Aquatic Focused, Landscape Scale Restoration Program

IIJA established this $80-million competitive funding program for projects to restore water quality or fish passage on federal and non-federal lands (23 USC § 204). Priority is given to a proposal resulting in the most miles of streams being restored for the lowest amount of federal funding. Projects should contain proposed non-federal funding and request no more than $5 million (U.S. Forest Service 2023).

11.3.2 Forest Service Legacy Road and Trail Remediation Program

IIJA provided $250 million for direct federal spending on capital improvement and maintenance under this existing program (established under 16 USC 532). Eligible projects include decommissioning and repairing roads and trails to mitigate detrimental impacts to sensitive ecosystems and watersheds. Additionally, funding can be used to replace or install bridges and culverts (or low-water trail crossings), address public safety of roads and trails, restore unneeded roads and trails to a more natural state, address storm-damaged areas, and remove or replace pipes and other structures that impede aquatic habitat connectivity (U.S. Forest Service 2023).

11.3.3 America the Beautiful Challenge

The America the Beautiful Challenge combines funding from federal agencies and the private sector for a total of $1 billion over the next five years to support the implementation of large-scale ecosystem conservation and restoration across public and private lands. It provides funding for projects to address five objectives, one of which is "connecting and reconnecting wildlife corridors, large landscapes, watersheds, and seascapes" (National Fish and Wildlife Foundation 2022). The first funding cycle was completed in November 2022 and awarded $91 million. The 2023 Request for Proposals was issued and closed April 20, 2023. Implementation grants are $1 million to $5 million in size over four years (with landscape-scale restoration projects potentially eligible to receive more) and planning grants are $200,000 to $2 million in size over two or three years. State government agencies, U.S. territories, Indian Tribes, non-profit 501(c) organizations, local governments, municipal governments, and educational institutions are eligible to apply for the grants.

11.3.4 Proposed Recovering America's Wildlife Act

Recovering America's Wildlife Act is a proposed bipartisan, popular piece of federal legislation (S. 1149) that would provide significant financial and technical assistance to states and tribes to recover listed species, including implementation of State Wildlife Action Plans. This funding could be used to conserve or restore wildlife and plant species of greatest conservation need, support state wildlife conservation strategies, or enable wildlife conservation education and recreation. Montana's State Wildlife Action Plan identifies habitat fragmentation as a specific threat to the state's wildlife and habitat, and further identifies highways as a major source of fragmentation (Montana Fish, Wildlife & Parks 2015).

11.3.5 U.S. Fish and Wildlife Service Funding for Imperiled Species

Wildlife accommodation projects that conserve species that are listed as threatened or endangered under the Endangered Species Act, and/or conserve the habitat of those species, could potentially receive funding from existing U.S. Fish and Wildlife Service (USFWS) grant programs such as the Cooperative Endangered Species Conservation Fund and the Partners for Fish and Wildlife Program. Additional USFWS financial assistance opportunities can be found here.

11.3.6 Western Big Game Seasonal Habitat and Migration Corridors Fund

The National Fish and Wildlife Foundation administers the Western Big Game Seasonal Habitat and Migration Corridors Fund, which provides grants for projects to conserve the winter range and migration routes of pronghorn, elk, and mule deer in 11 western states, including Montana (National Fish and Wildlife Foundation 2022(a)). The fund has around $3 million available annually, awards approximately six to ten grants per cycle, and requires a 1:1 non-federal match of in-kind or cash contributions. One of the four strategies of the program is to work **"**cooperatively with tribal nations, private landowners and *state highway departments to improve fencing,* including modifying, removing, installing if serving to direct big game movement out of harm's way, or seasonally adapting fencing if proven to impede movement of big game through priority migration corridors" (emphasis added, National Fish and Wildlife Foundation 2022(b)). The program has funded a number of projects to reduce wildlife-vehicle collisions and improve habitat connectivity across highways. For instance, in 2022, the program funded the following initiatives:

- A project in Montana to "address habitat connectivity on the Blackfeet Nation through removal and upgrade of fences, [and] reduction of animal-vehicle collisions along key sections of highway."
- A project in Idaho to "improve big game passage success rates across US-95 ... and reduce wildlife-vehicle collisions by repairing and extending 2.8 miles of wildlife funnel fencing along wildlife crossing infrastructure."

- A project in Oregon to install 10 miles of fencing that will "direct mule deer and elk to a newly constructed wildlife underpass along U.S. Highway 97," thereby reducing wildlife-vehicle collisions and reconnecting 75 miles of a wildlife migration corridor.

11.4 Innovative State Funding Mechanisms

11.4.1 Montana Wildlife and Transportation Partnership Project Program

In 2018, the Montana Department of Transportation (MDT), Montana Fish, Wildlife & Parks, and Montanans for Safe Wildlife Passage formed the Montana Wildlife and Transportation Partnership (MWTP) to address wildlife-vehicle conflicts. In 2023, MWTP launched a new planning tool and program to identify areas in greatest need of wildlife accommodations on highways throughout the state and strategically pursue effective solutions. This includes a MWTP Project Program to solicit, evaluate, and advance public-private partnership proposals for transportation projects specifically aimed at addressing wildlife-vehicle conflicts and improving habitat connectivity. Under this program, MDT funding may be available for feasibility studies of selected projects. However, applicants should identify additional sources of funding to design and build the proposed project, if it is determined feasible by the preliminary analyses (Montana Department of Transportation 2023).

11.4.2 Other State Funding Models

Additionally, other states are establishing innovative funding mechanisms for wildlife crossing projects, rather than drawing resources from existing state transportation budgets. The following examples could serve as potential models for a new, state-level funding mechanism for wildlife crossings:

- In 2005, the Wyoming Legislature created the Wyoming Wildlife & Natural Resource Trust to fund habitat and natural resource conservation across the state. Eligible projects include those that mitigate adverse consequences to wildlife habitat or mitigate wildlife conflicts, including wildlife crossings (Wyoming Wildlife & Natural Resource Trust 2023). The fund allows individuals and organizations to donate to these projects.

- Both Wyoming and Oregon have created specialty wildlife conservation license plates. Money from the sale of these license plates and the renewal fees go towards established state funds that support habitat connectivity and wildlife crossing projects (Wyoming Game & Fish Department 2023, Oregon Wildlife Foundation 2022).

- Wildlife connectivity legislation enacted in California in 2021 sets up a compensatory mitigation credit scheme that allows California Department of Fish and Wildlife to grant the California Department of Transportation credits for wildlife crossings that can be used for future transportation projects requiring environmental mitigation (California Legislative Information 2021).

11.5 Innovative Local Funding Mechanisms

One tool that local governments have employed to fund wildlife crossing projects is the establishment of special purpose taxes. For instance, in 2019, Teton County, Wyoming, passed a $10-million Special Purpose Exercise Tax to support construction of priority wildlife crossing structures identified in the county-wide Wildlife Crossing Master Plan (Jackson Hole Conservation Alliance 2020). Similarly, Pima County, Arizona, dedicated $45 million of its local sales tax revenues to conserve and restore "critical wildlife linkages" through measures such as building wildlife crossings, including underpasses on State Route 86 (Regional Transportation Authority, Pima County 2022).

11.6 Public-Private Partnerships

Fully covering all the costs associated with designing, building, monitoring, and maintaining wildlife crossing infrastructure is more feasible when partnerships are able to secure private contributions to match public funding available for a project. Indeed, one of the criteria against which the Federal Highway Administration will evaluate proposals under the Wildlife Crossings Pilot Program is the extent to which the proposed project leverages other funding sources, including from public-private partnerships (as stated explicitly in the statute, 23 USC § 171(e)(2)(A)). Identifying or establishing a nonprofit organization that can receive tax-deductible donations for the project is an important consideration. Private contributions often come from individuals, charitable foundations, or corporations. Additionally, land trusts across the country are contributing to wildlife crossing projects by ensuring land on both sides of the road remains protected as viable habitat for the species attempting to cross (Center for Large Landscape Conservation 2022).

Below are some examples of public-private partnerships that have funded wildlife crossing projects:

- The Western Big Game Seasonal Habitat and Migration Corridors Fund is a public-private partnership between the National Fish and Wildlife Foundation, the U.S. Department of the Interior, the U.S. Department of Agriculture, Bezos Earth Fund, and several corporations: Burlington North Santa Fe Railway, ConocoPhillips, Altria Group, and Microsoft. The program has awarded $11.7 million across 52 projects, leveraging $57.5 million in matching contributions (National Fish and Wildlife Foundation 2022(c)).
- A large portion of the Liberty Canyon wildlife crossing on US Highway 101 in California has been funded through private contributions. The project has received donations from thousands of private, philanthropic, and corporate institutions globally, including $26 million from the Annenberg Foundation and Wallis Annenberg, who is now the namesake of the overpass (Annenberg Foundation 2022).
- The Land Trust of Santa Cruz County protected three properties on both sides of Highway 17, collected data, raised funds, and is partnering with the California Department of Transportation, Santa Cruz County Regional Transportation Commission, and others to construct a wildlife underpass (Land Trust of Santa Cruz County 2022).
- In 2017, the Adirondack Chapter of The Nature Conservancy (TNC), Adirondack Land Trust, and New York State Department of Transportation partnered to install the state's first "critter shelf" inside a large culvert to help wildlife safely cross underneath the road (Civil & Structural Engineer Media 2017). The culvert is located between private lands protected by conservation easements and TNC monitored the culvert with wildlife cameras (The Nature Conservancy 2019).
- The WYldlife Fund, a partner foundation of the Wyoming Game and Fish Department, has prioritized funding wildlife crossing projects, such as building 15 miles of exclusionary fencing to direct wildlife to underpasses on Interstate 25 (WYldlife Fund 2022).

In Montana, public-private partnerships have long been a critical source of support for conserving the state's natural heritage. For instance, Montana's Outdoor Legacy Foundation (MOLF) is the primary nonprofit partner of Montana Fish, Wildlife & Parks and the two entities have partnered on funding proposals to reconnect habitat and facilitate wildlife movement. MOLF leverages private funding for conservation (including "wildlife/wildlands management and care") and manages the Montana Fish and Wildlife Conservation Trust (Montana Outdoor Legacy Foundation 2023). Thus, Montana has an existing entity that could potentially play a similar role to the WYldlife Fund and the Oregon Wildlife Foundation in funneling private funding towards wildlife accommodation projects to leverage public dollars.

11.7 Conclusion

In summary, there are various public and private transportation and conservation funding sources currently available to support implementation of the recommendations of the Assessment. In addition, a number of state and local funding programs could be established to provide financial support. Ultimately, cultivating public-private partnerships will be important for securing robust and reliable funding streams for all the phases and elements of successful wildlife crossing projects. The strongest project partnerships include diverse stakeholders—such as wildlife and transportation agencies, academic researchers, non-governmental organizations, and local landowners and business owners—working together to advance the common cause of making roads safer for drivers and wildlife.

12. Conclusions

The information included in this report should inform and support area communities and agency decision-makers to select and pursue wildlife accommodation options. With the passage of the Infrastructure Investment and Jobs Act of 2021, significant funds for wildlife accommodation measures are available nationwide on a competitive basis. The US 89 Wildlife & Transportation Assessment better equips Montana's Paradise Valley and Gardiner Basin communities to take advantage of new funding opportunities to protect people and wildlife in the Greater Yellowstone Ecosystem.

The Assessment compiled, overlaid, and evaluated wildlife-vehicle collision and wildlife carcass data, wildlife movement and habitat data, and live wildlife observations from aerial surveys. It also incorporated wildlife sightings and roadkill information gathered via citizen science. The Assessment further drew upon local and expert knowledge gathered through in-person outreach and an interactive map. Road areas identified through an in-depth spatial data analysis were evaluated in a field review conducted by an interdisciplinary Technical Advisory Committee of state, and federal planners, along with biologists, engineers, transportation experts, and the Research Team from the Center for Large Landscape Conservation (CLLC), Montana State University's Western Transportation Institute (WTI), Montana Freshwater Partners, and the representatives from the Yellowstone Safe Passages Partnership.

The report describes seven Priority Sites located in important areas for wildlife movement and/or that pose elevated risks to human and wildlife safety and provides recommendations for potential wildlife accommodation measures. Mitigation along other areas of the study roads may also be warranted based on the documentation and analysis in this report, especially when highway projects are planned.

In addition to the terrestrial Priority Sites, the report summarizes the potential "barrier effect" of culverts passing under US 89 based on an assessment of factors in the field, and opportunities to improve culverts for both aquatic and terrestrial wildlife passage. While retaining a barrier to passage may be desirable in some cases to protect the integrity of native species, further evaluation and consultation with fisheries biologists is suggested to assess the status of these culverts more fully.

The report's recommendations describe appropriate locations for prospective wildlife accommodation measures such as culverts, bridges, underpasses and overpasses, and/or animal detection systems—each in combination with fencing—that consider terrestrial and/or aquatic wildlife passage. Many sites include major drainages from surrounding public lands that intersect with US 89 and the Yellowstone River and feature existing infrastructure that has the potential to facilitate animal movements, such as a bridge spanning a riparian corridor. During the field evaluation, the Research Team and Technical Advisory Committee considered means to incorporate existing infrastructure, new structures, and additional alternatives to reduce collisions with wildlife (e.g., variable message signs for areas that have spatially discreet or seasonal conflicts). A range of accommodation strategies have a role to play in helping to reduce collisions and maintain wildlife movement in the study area.

In the case of terrestrial species, despite crossing structures with fencing requiring high initial investment, research shows they are cost effective over the course of their lifetime (generally 75 years or more) due to greater efficacy in reducing wildlife-vehicle collisions and lower maintenance costs than other options (Brennan, Chow, and Lamb 2022; Huijser et al. 2009). Further, given that bridges and culverts that are upscaled and designed to allow for wildlife passage are usually better able to accommodate stream and floodplain function due to larger size and capacity, they may also make infrastructure more resilient to “extreme” weather events like flooding. Applying the findings of this Assessment to bridges or other priority locations when replacement is scheduled offers a best-case scenario for cost-effective implementation.

The analysis within this report is based on available data. Not all data sets are comprehensive; some are collected opportunistically (including both Montana Department of Transportation and citizen science carcass data), and the data sets are skewed towards large mammals and charismatic species such as elk and grizzly bears. Some data gaps and limitations that could be aided by further research are mentioned in the discussion of Priority Sites.

The options for prospective wildlife accommodation measures along key road segments described in this report are intended as a guide to inform decision-making processes rather than serve as a prescription for specific actions. Implementation of any prospective measure depends on factors such as public support, design, engineering feasibility, potential agreements with land management agencies and/or private landowners, and funding availability.

The Research Team suggests that making US 89 safer for travelers and wildlife is a multi-year, multi-site, multi-stakeholder proposition that will take collective action to bring about. The Assessment provides a foundation to allow for discussion about how to reach these goals based on robust information and understanding.

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