Potential Future Mitigation Measures for Wildlife and People Along I-90 and Other Major Highways in Western Montana, USA

Final Report

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16. Abstract

We explore the opportunities for potential future mitigation measures for wildlife and people along I-90 and other major highways across the Y2Y (the Yellowstone to Yukon Conservation Initiative) region in western Montana. We identified highway sections that had the highest concentration of collisions with large wild animals based on crash data and carcass removal data. We also conducted cost-benefit analyses for the implementation of wildlife fences in combination with wildlife crossing structures (underpasses and overpasses) along the highways in the study area. Then we compiled existing data on habitat and corridors for species of special conservation concern (grizzly bear, Canada lynx and wolverine) and obtained existing range distribution maps for other large wild mammals (white-tailed deer, mule deer elk, moose, pronghorn, bighorn sheep, bison, mountain lion and gray wolf). We conducted further analyses on grizzly bear road mortality and grizzly bear connectivity pathways. Our analysis of the barrier effect of the highways (based on hourly traffic volume counts) that cut through grizzly bear connectivity pathways centered around two conservation objectives. The first objective was to establish robust and functional connectivity between the Northern Continental Divide Ecosystem (NCDE) grizzly bear population and the Greater Yellowstone Ecosystem (GYE) grizzly bear population. The second objective was to facilitate recolonization by grizzly bears of the Bitterroot Ecosystem (BE). Depending on the objective, different highway sections were identified as barriers to grizzly bears. The road sections that were identified based on the two connectivity objectives were different from the road sections where most grizzly bears are killed by vehicles. The road sections that were identified based on the two connectivity objectives would need to be mitigated in a spatially coherent manner to reach the objectives, illustrating a strategic anticipatory approach to conservation rather than a reactionary approach to either conservation or human safety. An analysis of the 360-mile-long section of I-90 through the Y2Y area in Montana showed that 124 miles (34.4%) is important for grizzly bear connectivity and that 152 miles has major human safety concerns because of collisions with large wild mammals (mostly ungulates). While there is some overlap between the road sections that are important for grizzly bear connectivity and the road sections that have a relatively high concentration of collisions with large wild mammals, only 41.9% of the length of the road sections along I-90 that are important to grizzly bear connectivity are also important because of collisions, and only 34.2% of the length of the road sections along I-90 that are important because of collisions are also important to grizzly bear connectivity. This illustrates the need for a two-track system for the policy, funding and implementation of mitigation measures; one that is based on human safety, and one that is based on conservation. Furthermore, measures for human safety can relate to individual road sections, whereas measures for conservation must be spatially coherent at a landscape level.

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- Montana Fish, Wildlife & Parks (Cecile Costello, Justin Gude, James Jonkel)
- U.S. Fish and Wildlife Service (Rebecca Lyon, Wayne Kasworm).
- Jennifer Fortin-Noreus, formerly senior wildlife biologist with USFWS.
- Sarah Sells, U.S. Geological Survey, Montana Cooperative Wildlife Research Unit, University of Montana.

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1 Introduction

1.1 Background

This report explores the opportunities to address the impacts of roads and traffic along major highways across the Y2Y region of Western Montana. The project focuses on interstates (I-90 and I-15), US Highways, and numbered Montana Highways.

The objective is to not only identify road sections that bisect important habitat and corridors for select large mammal species, but also to identify where there is overlap and differences with the more traditional approach of transportation agencies to identify road sections where human safety is a concern because of hitting large mammals. Connectivity analyses tend to focus on endangered, threatened, or otherwise rare species that are of conservation concern, and also on migration corridors for large ungulates. More traditional human safety analyses by transportation agencies tend to be heavily influenced by common large ungulates (e.g. deer, elk and moose depending on the region in North America). The comparison of the two approaches will likely illustrate the need to develop policies and funding mechanisms to act where the connectivity concerns are greatest. These policies and funding mechanisms could then supplement the more traditional approaches of transportation agencies that are primarily rooted in human safety and reducing collisions with common large ungulates.

This project focuses on measures along the major highways that:

1. Reduce wildlife-vehicle collisions with terrestrial wild large mammals (i.e., large ungulates, grizzly bear, wolverine, and other species that are larger than a coyote/bobcat), which also improves human safety.
2. Reduce the barrier effect of roads and traffic and increase habitat connectivity for terrestrial wild large mammals (i.e., large ungulates, grizzly bear, Canada lynx, wolverine, and other species that are larger than a coyote/bobcat).

The project area includes the working area of Y2Y in the state of Montana (Figure 1, Figure 2Figure 2: The major highways in the Y2Y working area in the state of Montana.).

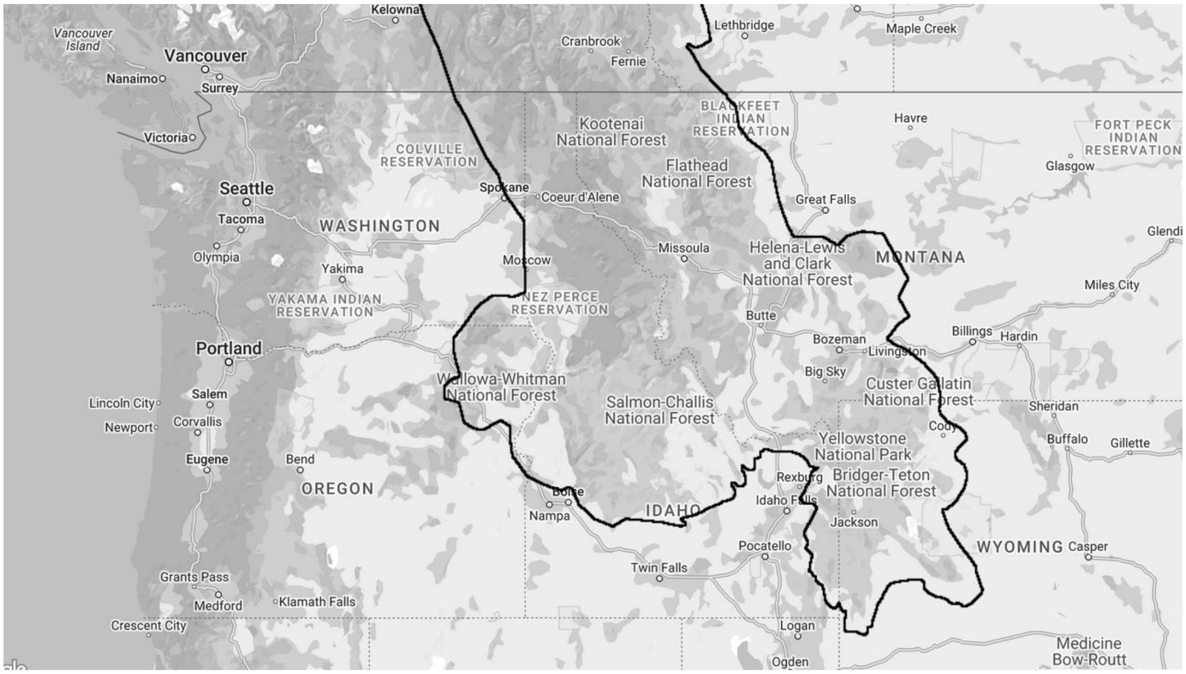


Figure 1: The US portion of the Y2Y Region. Note that for this project the study area is defined as the Y2Y working area in the state of Montana (excluding Canada, Washington, Oregon, Idaho and Wyoming).

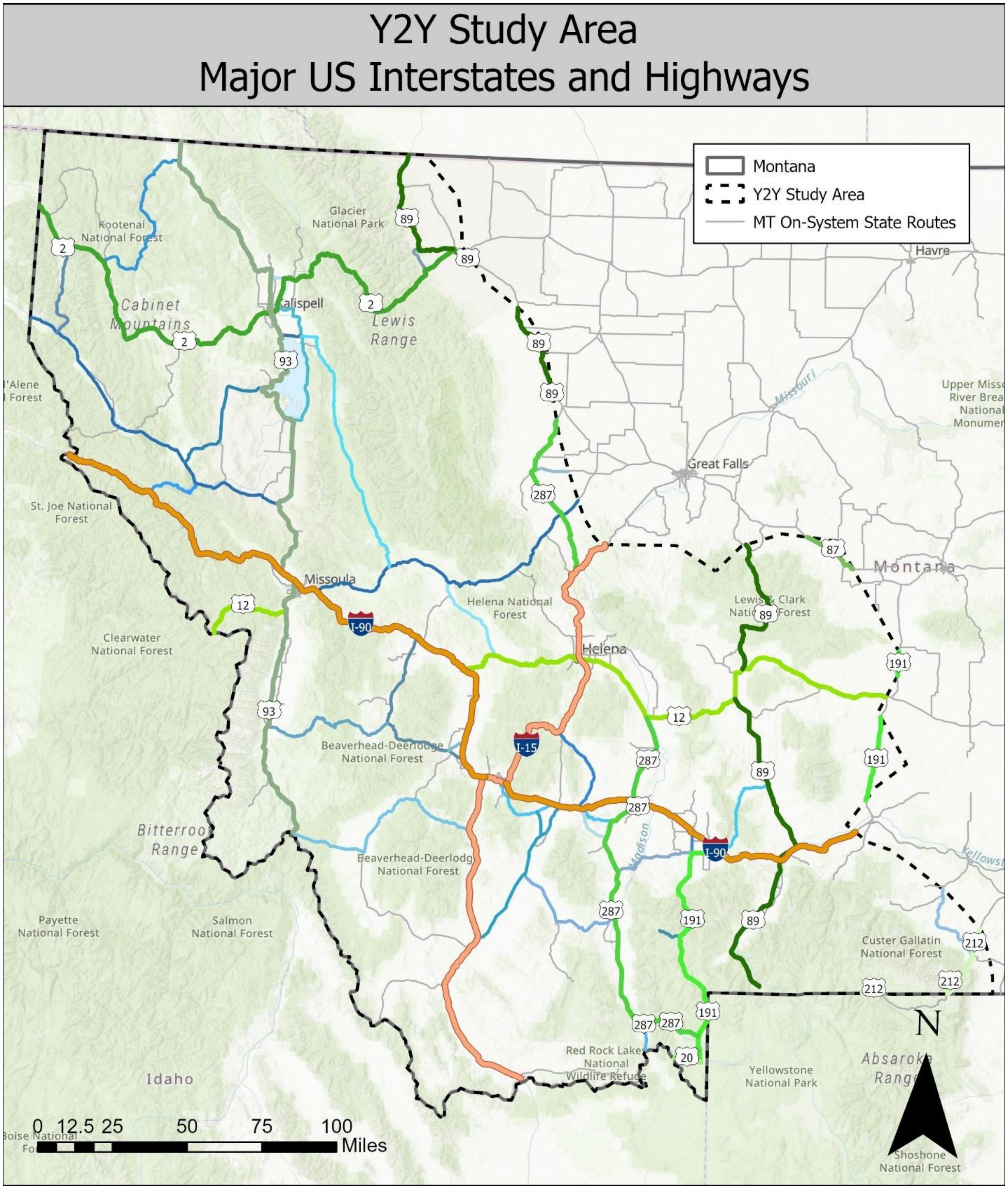


Figure 2: The major highways in the Y2Y working area in the state of Montana.

2 Collision data exploration

2.1 Data sources

We acquired the following data from the following sources related to large wild mammal-vehicle collisions in the Y2Y working area in Montana:

- **Wildlife-vehicle crash data collected by law enforcement personnel:** These data typically involve more severe crashes, as there are thresholds for the inclusion in a crash database (e.g., a minimum estimated vehicle repair cost of US $1,000 and/or human injuries or human fatalities) (Huijser et al., 2007). In practice, these crashes usually involve large mammal species such as white-tailed deer, mule deer, and elk, though the species name is not always recorded. The crash data were obtained from the Montana Department of Transportation (MDT).
- **Carcass removal data collected by road maintenance personnel:** MDT road maintenance crews collect this data when they remove carcasses of large mammals found on or near the road in the right-of-way. These carcasses may pose an immediate safety hazard or distraction to drivers (Huijser et al., 2007), but not all carcasses that are visible from the road or that are present in the right-of-way are removed or recorded. Typically, these carcasses involve large mammal species such as white-tailed deer, mule deer and elk. Wounded animals that leave the right-of-way before dying are usually not recorded, and carcasses of rare species may be removed by others (legally or illegally) before road maintenance crews arrive. Carcasses of small species are rarely recorded, as they are often not visible from a moving inspection vehicle and do not pose a safety hazard. Therefore, carcass removal data primarily relate to common large mammals. These data were obtained from MDT.
- **Grizzly bear road mortality data:** Considerable effort was made by the U.S. Geological Survey (USGS), Montana Fish, Wildlife and Parks (MTFWP) and United States Fish and Wildlife Service (USFWS) to compile all grizzly bear mortalities in comprehensive databases. The agencies concerned provided us with a subset of the data; the records that relate to grizzly bear road mortalities.
- **Salvage permit data:** In 2013, the Montana legislature passed a bill that allowed for the salvage of deer, elk, moose, and pronghorn killed by vehicles, which permits anyone (not just the driver involved) to take the animal, as long as a permit is obtained within 24 hours (Montana Fish, Wildlife & Parks, 2023; State of Montana, 2023).

Note that in this report the term “collisions” includes both wildlife-vehicle crash data and carcass removal data.

2.2 Data selection

- Area: The working area of Y2Y within the state of Montana.
- Roads included: All MDT on-system roads such as Interstates, US Highways, and numbered MT Highways. Note that we manually selected and included sections of numbered Interstates, US highways and State Highways that were not labeled as an MDT on-system route, including sections of I-90, US Highway 12, Montana Highway2, Montana Highway 21, Montana Highway 38, Montana Highway 49, Montana Highway 64, and S- 522. Other roads were not included.
- Period: The crash data, the carcass removal data, and the grizzly bear road mortality data covered the period from 1 January 2008 through 31 December 2022, totaling 15 full calendar years. The salvage permit records covered the period between 2013 (first record was 26 November 2013) and 31 December 2022 (9 full calendar years and just over 1 month). While the long period for crash and carcass removal data resulted in a robust dataset, it also meant that the spatial distribution of collision data may have been influenced by changes in land use, wildlife population size, wildlife movements, and the implementation of fences in combination with crossing structures. Major road sections that had mitigation implemented between 2008 and 2022 include Highway 93 North Evaro – Polson (construction 2004-2010, Highway 93 south Missoula – Hamilton (construction 2005-2012), and short sections along Montana Highway 206 (construction in 2008) and Montana Highway 200 near Lincoln (construction 2015). Therefore, care must be taken to evaluate the results for these road sections; the hotspot analyses may indicate past rather than current problems.
- Species: Only records of wild animal species were included. Records involving domesticated animal species were removed from both the crash and carcass removal data.
- Species size: For the MDT carcass database, only records that related to species larger than coyotes were included. Though Canada lynx and wolverine do not meet the size requirement, these species were regarded as species of special concern for the purpose of this report, and their records were retained, should they be present.
- Maximum distance from road: Collision records (i.e., crash and carcass data from MDT) within 25 meters (m) of on-system roads were included, while those beyond 25 m were excluded from the analysis because of lack of spatial precision. For salvage permit data we included records up to 50 m from an on-system road. In cases where locations could be projected onto more than one road, we verified the projections and removed duplicates. For species of special concern for this project (grizzly bears, Canada lynx, and wolverine) we followed a slightly different procedure to minimize the probability of incorrectly not including records. For observations that were not within 25 m of an on-system road, we evaluated the location in relation to other roads. If the observation did not appear to be associated with any other road, including off-system roads and dirt roads, we included the observation and projected it to the nearest location on the nearby on-system road. Other observations that were further than 25 m from the on-system roads were excluded.
- Carcass data: Carcass removal data, collected by MDT road maintenance personnel, were combined with grizzly bear road mortality data compiled by researchers from USGS, MTFWP and USFWS into one database. Salvage permit data were analyzed separately as they did not cover the same period, and because there was no basis to assume consistent search and reporting effort for the salvage permit data.

- Grizzly bear carcass data: There were 117 unique records for roadkilled grizzly bears in total in the combined database (19 from MDT carcass removal data, 16 from USGS from the Greater Yellowstone Ecosystem, 81 from MTFWP from the Northern Continental Divide Ecosystem, and 1 through USFWS from the Cabinet-Yaak Ecosystem). Of the 117 records, 103 were associated with MDT on-system roads. However, 19 of the 117 records were only reported through in the MDT carcass removal database, and not by USGS, MTFWP or USFWS. When MDT road maintenance crews think they have found a roadkilled grizzly bear, they are required to report it to MTFWP who will then share the observation with USFWS (Pers. Com. Jennifer Fortin-Noreus, formerly senior wildlife biologist with USFWS, through Kylie Paul, Center for Large Landscape Conservation). It appears that this procedure was not followed for the 19 animals, or that MTFWP corrected the species identification to black bear but that this did not result in a correction in the MDT carcass removal database. Combined with the location of these 19 records (mostly outside of permanently occupied grizzly bear habitat or along the edges of permanently occupied grizzly bear habitat (Figure 3), we changed the species name for the 19 records from grizzly bear to black bear, all associated with MDT on-system roads. In the end, 77 unique grizzly bear records were included in the spatial and economic analyses for this report. The other remaining 40 "grizzly bear" road mortalities were considered black bear instead of grizzly bear (N=19), grizzly bears outside the Y2Y area in Montana (N=8), or grizzly bears on other roads (i.e., not on an MDT on-system road) within the Y2Y area in Montana (N=13).

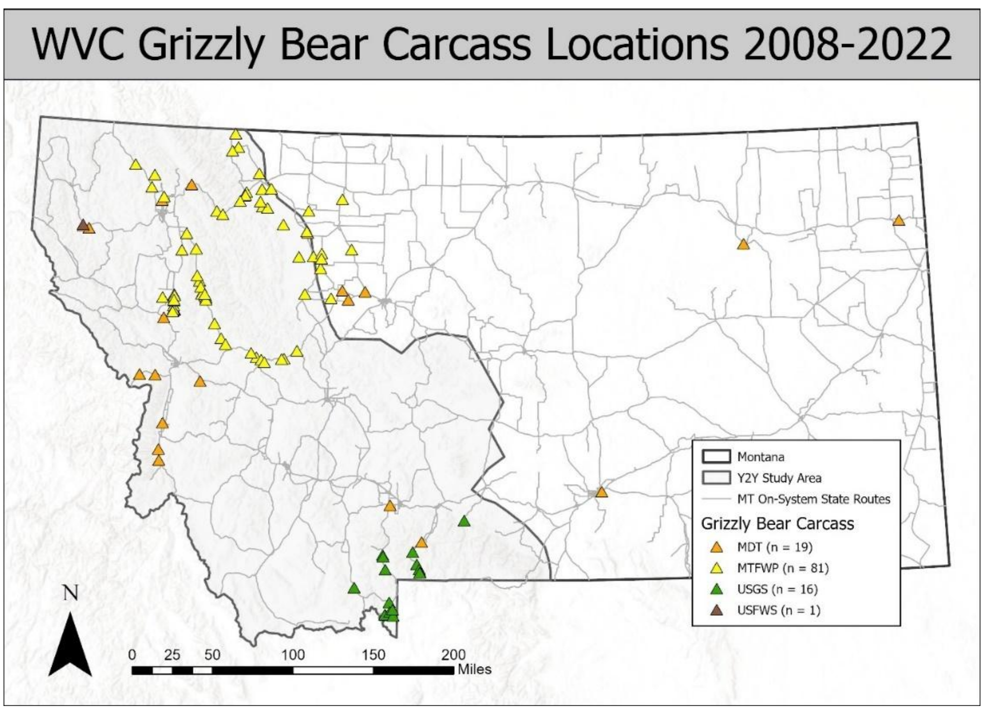


Figure 3: The location of the grizzly bear road mortalities recorded by the different state and federal agencies. The displayed data were not corrected by the authors of this report. Some observations displayed on this map are very likely incorrect. Note that we changed grizzly bear road mortality observations only reported by MDT (N=19) to black bear for subsequent analyses as they were most likely black bears rather than grizzly bears.

2.3 Number of records

The data selection resulted in 25,304 wild animal crash records and 67,130 wild animal carcass records on MDT on-system roads (Table 1). The number of selected salvage permit records on MDT on-system roads was 4,343 (Table 1). Interestingly, relatively many salvage permits were not on MDT on-system roads, despite increasing the maximum distance from 25 m (for MDT crash and carcass data) to 50 m (for salvage permit data).

Table 1: Number of records retained in the crash, carcass (combination of MDT carcass removal data and grizzly bear road mortality data from USGS, MTFWP and USFWS), and salvage permit databases.

Data selection	2008-2022		2013-2022
	Crash	Carcass	Salvage Permits
State of Montana (all species, incl. domestic)	41,970*1	93,863	10,092
Y2Y area in Montana, large wild mammals only	26,993*1	67,893	8,024
Y2Y area in Montana, large wild mammals only, MDT on-system roads	25,304*1,2	67,130*2	4,343*3

*1 Not identified to species level, only described as "wild animal".
*2 Up to 25 m from an MDT on-system road.
*3 Up to 50 m from an MDT on-system road.

2.4 Species retained in the carcass data

The most common species in the selected carcass removal data (a combination of MDT carcass data and USGS, MTFWP and USFWS grizzly bear road mortality records) was white-tailed deer (74.83% of all records) (Table 2). Mule deer (18.73%) and elk (3.81%) were the second and third most frequently recorded species. Other species include pronghorn, moose, mountain goat, bighorn sheep, bison, Canada lynx, mountain lion, gray wolf, black bear, and grizzly bear.

Table 2: Species retained in the carcass database (combination of MDT carcass removal data and grizzly bear road mortality data from USGS, MTFWP and USFWS) (1 January 2008 through 31 December 2022).

Species	**Total (N)**	**Total (%)**
Ungulates		
Pronghorn (*Antilocapra americana*)	417	0.62
White-tailed deer (*Odocoileus virginianus*)	50,234	74.83
Mule deer (*Odocoileus hemionus*)	12,574	18.73
Unknown deer species (*Odocoileus* spp.)	304	0.45
Elk (*Cervus canadensis*)	2,559	3.81
Moose (*Alces alces*)	354	0.53
Mountain goat (*Oreamnos americanus*)	7	0.01
Bighorn sheep (*Ovis canadensis*)	102	0.15
Bison (*Bison bison*)	62	0.09
Carnivores		
Canada lynx (*Lynx canadensis*)	2	0.00
Mountain lion (*Puma concolor*)	55	0.08
Gray wolf (*Canis lupus)*	18	0.03
Black bear (*Ursus americanus*)	365	0.54
Grizzly bear (*Ursus arctos horribilis*)	77	0.11
Total	67,130	100.00

2.5 Number of collisions per year

The number of reported crashes with wild mammals was somewhat stable between 2008 and 2014, then stabilized at a higher level through 2022 (Figure 4) In contrast, the number of reported large wild mammal carcasses declined, at first slowly, later more rapidly, through 2017 (Figure 4). Between 2018 and 2022 the number of reported large wild mammal carcasses was higher and relatively stable (Figure 2). In 2008, there were 4.1 reported large wild mammal carcasses for every reported wild mammal crash (Figure 5). This ratio declined strongly to 1.4 by 2017, followed by slightly higher ratios (approximately 1.9-2.5) between 2018 and 2022 (Figure 5).

A potential explanation for the decline in the number of reported carcasses, relative to crashes, could be the passing of a bill that allowed for the salvage of deer, elk, moose, and pronghorn killed by vehicles, which permits anyone (not just the driver involved) to take the animal, as long as a permit is obtained within 24 hours (Montana Fish, Wildlife & Parks, 2023; State of Montana, 2023). However, this bill only passed in 2013 and does not account for the already substantial drop in carcasses reported between 2008 and 2013. In addition, adding all the salvage permits (Figure 6) to the carcass data did not substantially change the ratios between 2018 and 2022 (range 2.1-2.7). Regardless, adding all the salvage permits to the carcass data is not realistic. Fairbank et al. (2024) found that along US Highway 89 between Gardiner and Livingston, Montana, weekly counts by research personnel resulted in nearly 8 times more deer and elk carcasses than reported through near daily carcass removal records by the Montana Department of Transportation.

Other studies have shown that crash data typically represent only a small portion (14-50%) of the carcass data, even if both datasets relate solely to large mammals (Tardif and Associates Inc., 2003; Riley & Marcoux, 2006; Donaldson & Lafon, 2008). It is important to note that carcass data records are also incomplete; animals that are not clearly visible from the road may not be removed or recorded. Studies have demonstrated that carcass counts often underestimate the number of large mammals hit by vehicles; correction factors of 2.8 (Lee et al., 2021) and nearly 8.0 (Fairbank et al., 2024) have been reported in other areas.

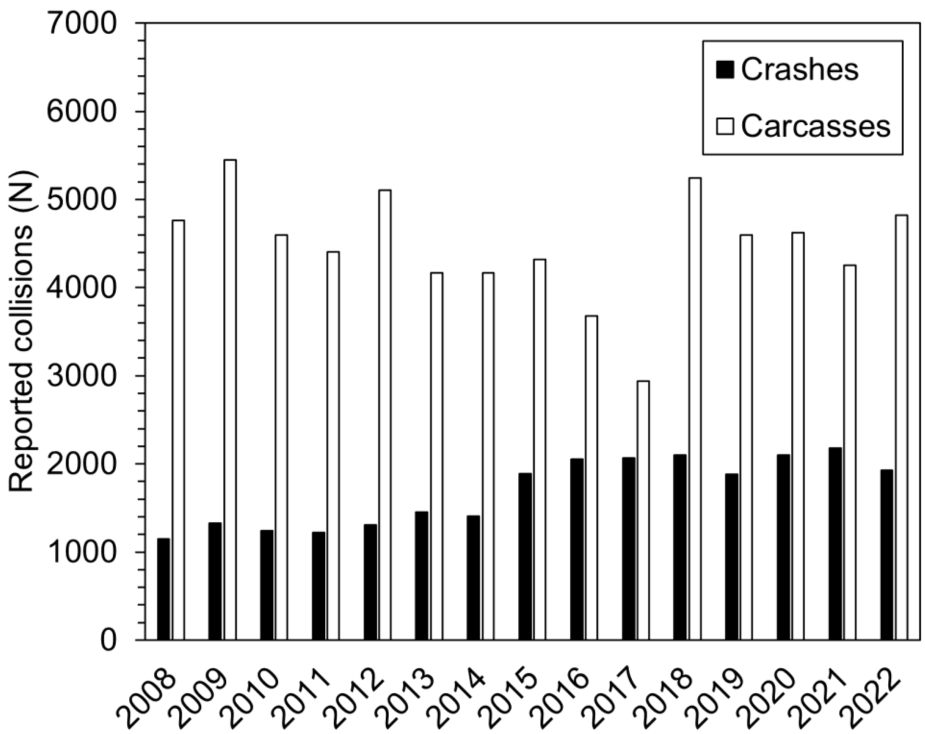


Figure 4: The number of reported crashes with wild animal species and large wild mammal carcasses by year.

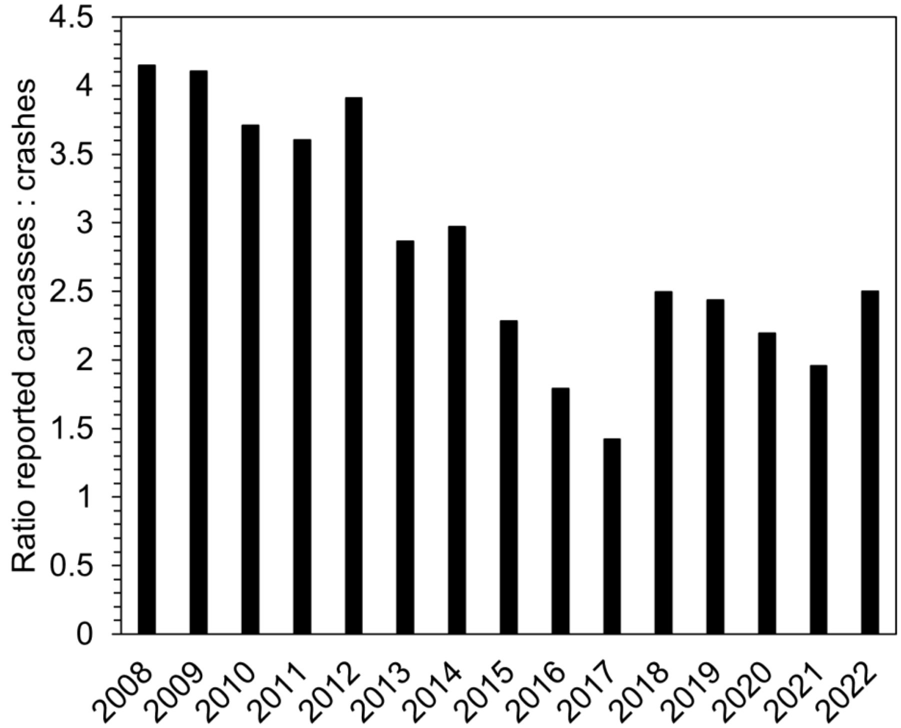


Figure 5: The ratio of the number of reported large wild mammal carcasses and crashes with wild animal species by year.

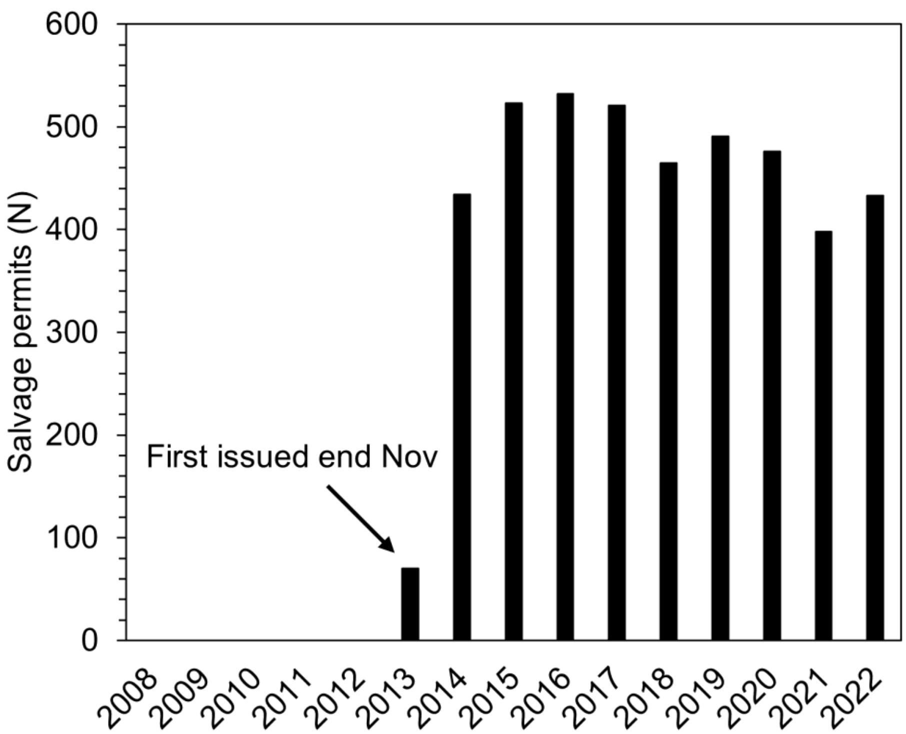


Figure 6: The number of large ungulate salvage permits issued by year (not issued 2008-2012, in 2013 first issued 26 November).

2.6 Number of collisions per month

Consistent with findings by Huijser et al. (2008), the number of reported crashes with wild animals was highest in the summer and fall, particularly in November, and lowest in late winter and early spring (February through April) (Figure 7). The number of reported carcasses with large wild animals was highest during the fall (October and November) and lowest in spring and summer (May through August) (Figure 7).

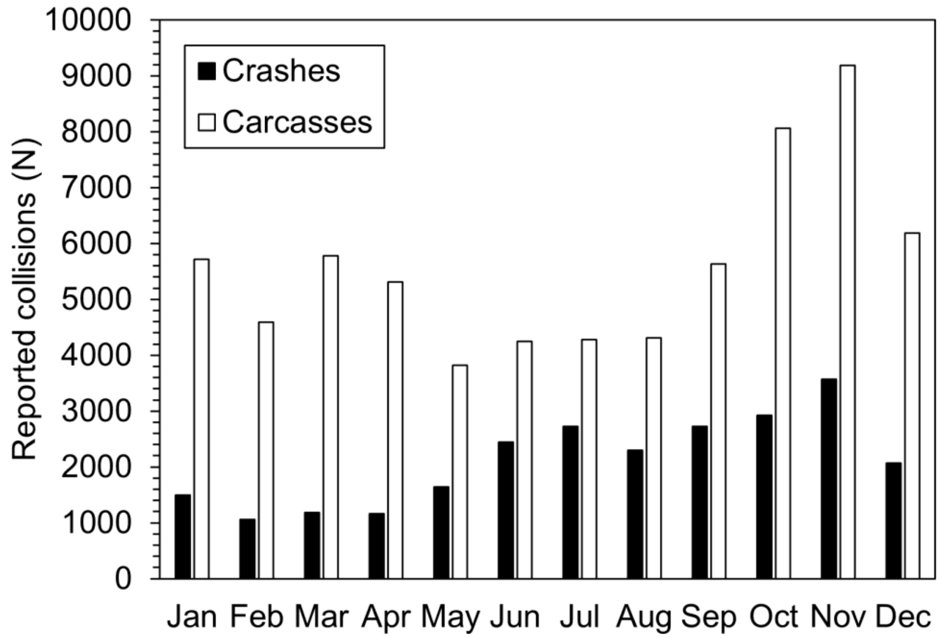


Figure 7: The number of reported crashes with wild animal species and large wild mammal carcasses by month.

2.7 Number of crashes by hour of day

Wild animal crashes occurred predominantly in the early morning (5-9 am) and in the evening and early night (5-11 pm) (Figure 8), which is consistent with Huijser et al. (2008). Fewer crashes were reported between 9 am and 5 pm. Note that the time-of-day data was only available for crash data, not for carcass removal data.

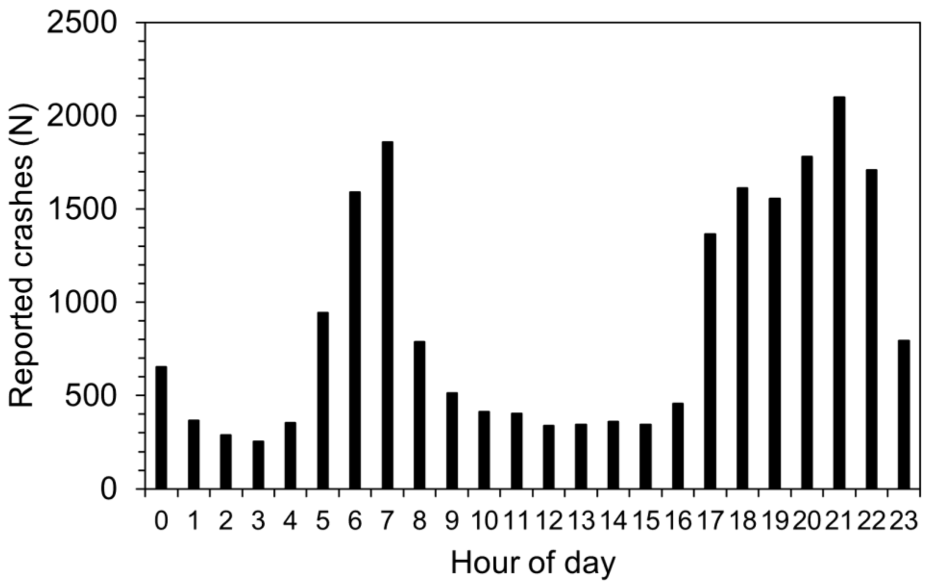


Figure 8: The number of reported crashes with wild animal species by hour of day (2008-2020 only (N=21,199), hour of day was not available for 2021 and 2022) (Note: "0"= between midnight and 1 am).

2.8 Severity of the crashes for humans

Most of the reported crashes involving wild animals resulted in property damage only (92.17%), consistent with Huijser et al. (2008) (Figure 9). Approximately 7.30% of the crashes resulted in a possible, minor, or serious human injury, and 0.15% resulted in human fatalities (Figure 9). Note that data on the severity of collisions for humans was only available for crash data, not for carcass removal data. While human fatalities can occur with large mammal collisions, the probability is generally low but increases with the size of the animal (Huijser et al., 2009).

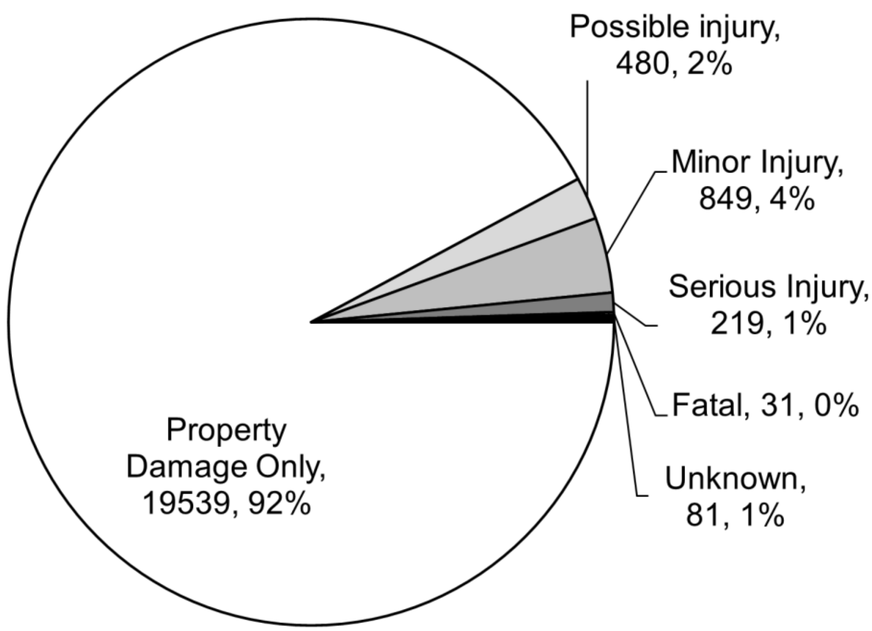


Figure 9: The severity for humans of the reported crashes with wild animal species (2008-2020 only (N=21,199), not available for 2021 and 2022).

3 Identification and prioritization of road sections based on collisions

3.1 Introduction

This chapter focuses on identifying and prioritizing road sections in the Y2Y working area in western Montana that have a relatively high concentration of wildlife-vehicle crashes, large mammal carcasses, and salvage permits. All spatial data were projected using the NAD 1983 StatePlane Montana FIPS 2500 coordinate system, with meters as the unit of measurement. All spatial analyses were conducted using ArcGIS Pro 3.3.2.

3.2 Methods

The road network was preprocessed by merging road segments based on their unique "ROUTE_ID" to create continuous, singular road sections. For analysis purposes, divided highways and parallel road segments were consolidated by removing duplicate routes, ensuring that each road was represented as a singular linear feature. These processed road sections were then systematically divided into road segments of 0.1 mile (160.9 meters) in length. Crash and carcass data within 25 m from an on-system road in the Y2Y working area were spatially joined to the nearest road analysis unit. This was conducted both as a total count per analysis unit and by individual species for carcass data to conduct the cost-benefit analysis (CBA). We conducted two different types of spatial analyses to identify and prioritize road sections with the highest number of wildlife-vehicle crashes and large wild mammal carcasses:

3.2.1 Kernel Density Estimation

The Kernel Density Estimation (KDE) analysis was used to assess point features of crash or carcass locations. A bandwidth of 0.5 miles (804.67 m) was applied, meaning that crashes and carcasses within 0.5 miles of each observation (i.e., a wildlife-vehicle crash or a carcass removal record) influenced the hotspot analysis. This is consistent with the spatial accuracy of the carcass removal data from MDT and the scale at which mitigation measures (e.g., wildlife fences and crossing structures) need to be implemented, typically over several miles of road (Huijser et al., 2016). The search radius is also aligned with similar studies (Gomes et al., 2009).

The analysis produces a density surface where each cell's size is 161 m by 161 m and its value represents the estimated density of collisions per square mile. The resulting heat map was divided into five percentage-based categories (<5%, 5–<25%, 25–<50%, 50–<75%, and 75–100%), identifying road sections with the highest densities (i.e., <5% = the 5 percent of the observations with the highest density) of collisions and carcasses to areas with the lowest densities (75–100%). This is a descriptive method that always indicates where the highest concentrations of incidents occur. The KDE analyses were conducted using the Spatial Analyst extension in ArcGIS Pro 3.3.2.

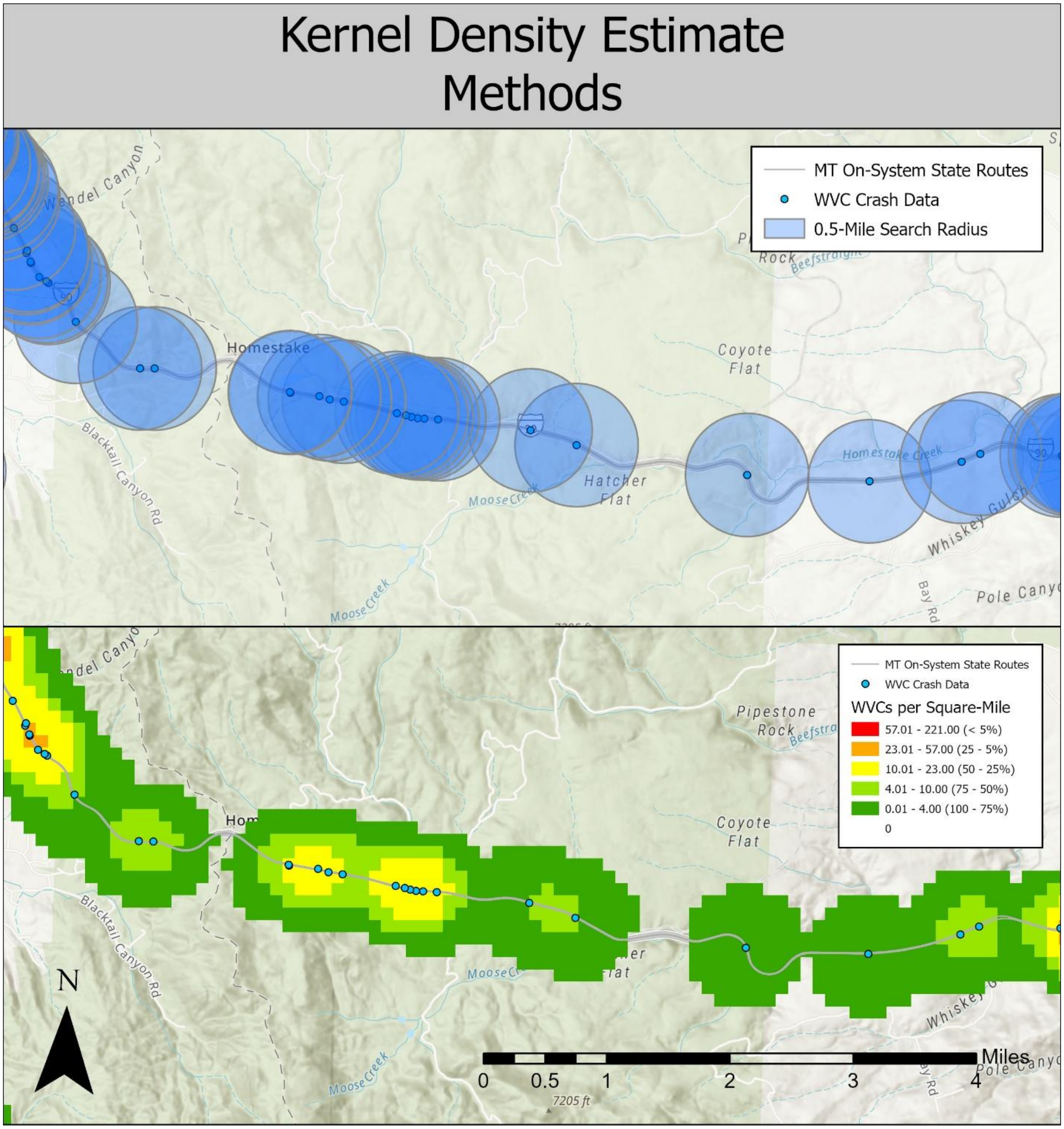


Figure 10: An example of a road section illustrating the search radius around each observation (i.e., a wildlife-vehicle crash or a carcass removal record, upper half of figure) and the KDE results (lower half of figure).

3.2.2 Getis-Ord Gi*

The Getis-Ord Gi* (GOG) analysis used the Getis-Ord Gi* statistic to identify statistically significant spatial clusters (hotspots and cold spots) of crashes and carcasses. Unlike the KDE, which is purely descriptive, this analysis identifies road segments where the concentration of crashes or carcasses significantly deviates from a random distribution. A fixed distance band of 0.5 miles was applied, consistent with the KDE analysis. No standardization of spatial weights was applied; all wildlife species were considered equal in contributing to the collision events. This analysis was conducted using the Hotspot Analysis (Getis-Ord Gi*) tool within the Spatial Statistics toolbox in ArcGIS Pro 3.3.2.

3.3 Results

The greatest concentrations of wildlife-vehicle crashes in western Montana were in the Flathead Valley (US Highway 93, Montana Highway 40 southeast of Whitefish, Montana Highway 35 and 82 around Big Fork, Montana Highway 35 around Creston and Evergreen), west of Flathead Lake (US Highway 93), on the Flathead Indian Reservation (including unmitigated sections of US Highway 93), in the Bitterroot Valley (US Highway 93 south of Missoula), around Missoula (I-90 west and east of Missoula), between Boulder and Helena (I-15), west of Helena (US Highway 12), south of Townsend (US Highway 287,) different sections of I-90 between Three Forks and Livingston, southeast of Bozeman (US Highway 191 south of Four Corners), south of Livingston (US Highway 89), north of Gardiner (US Highway 89), and south of Dillon (I-15) (Figure 11, Figure 12).

For carcass removal records, the same areas and road sections are of the greatest concern, but additional highway sections are of equal or greater concern (Figure 13, Figure 14). These additional highway sections include US Highway 2 between Kalispell and Libby, the Seeley-Swan (Montana Highway 83), Montana Highway 200 around Clearwater junction, different sections of I-90 (including Tarkio-St. Regis, around Clinton), around Hot Springs (Montana Highway 28), around Plains (Montana Highway 200), around Dillon (I-15), around Twin Bridges (Montana Highway 41 and Montana Highway 287), around Ennis (US Highway 287 and Montana Highway 287), near Augusta (US Highway 287) and west of Big Timber (I-90).

For salvage permit hotspots, there is an overlap with the crash and carcass records, but the highest concentration road sections are fewer and the tend to be partly associated with areas with a higher human population density (e.g., Bitterroot Valley, north-east of Kalispell (Figure 15, Figure 16). Additional high concentration areas include US Highway 2 south of Libby, the Ninemile area (I-90), around Helena (Green Meadow Driver), south of Bozeman, and between Gardiner and Corwin Springs (US Highway 89).

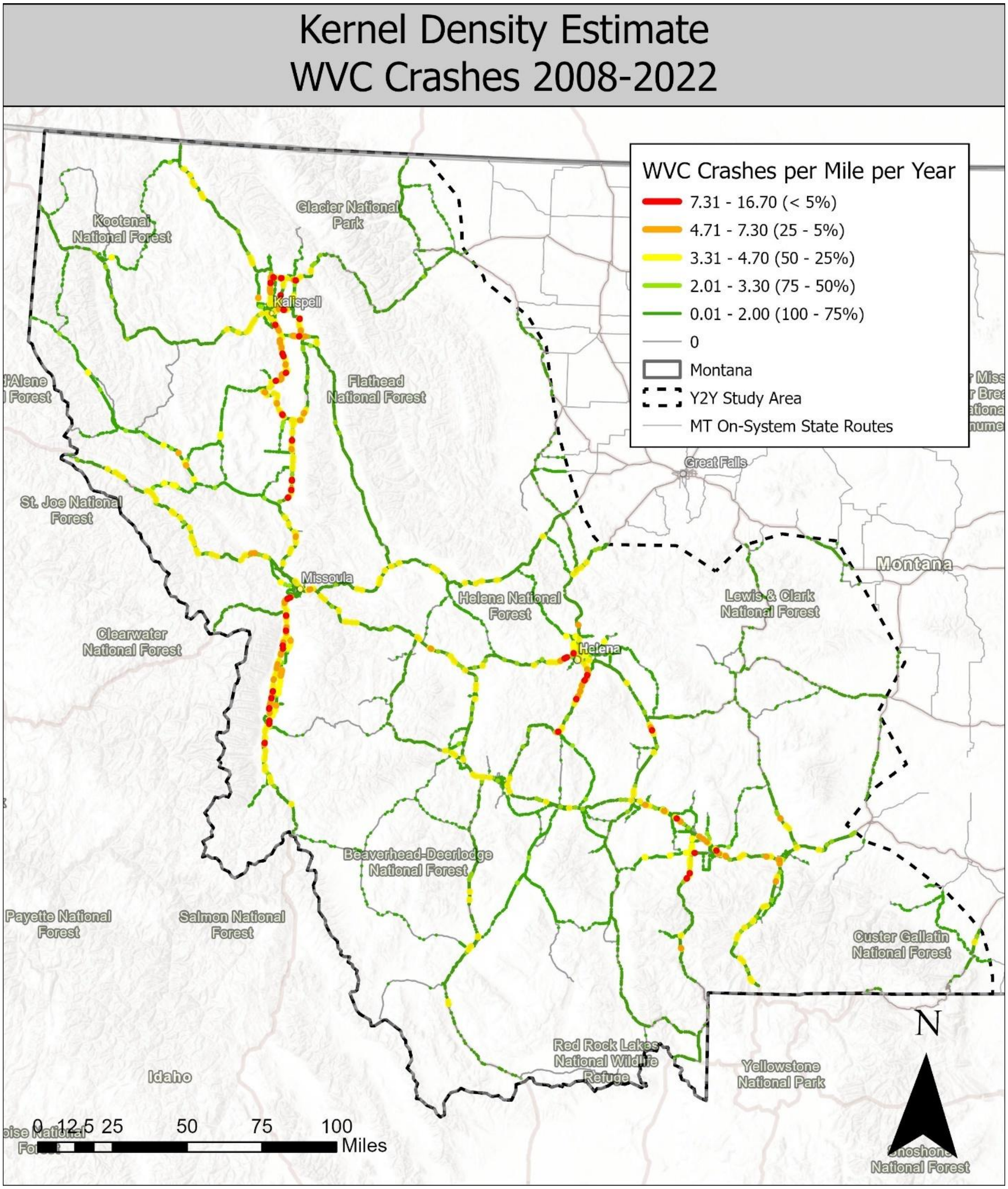


Figure 11: Kernel density hotspot map using percentiles for wildlife-vehicle crashes in western Montana (2008–2022). Areas with the highest densities are in red (<5%) and areas with the lowest densities are in green (75–100%).

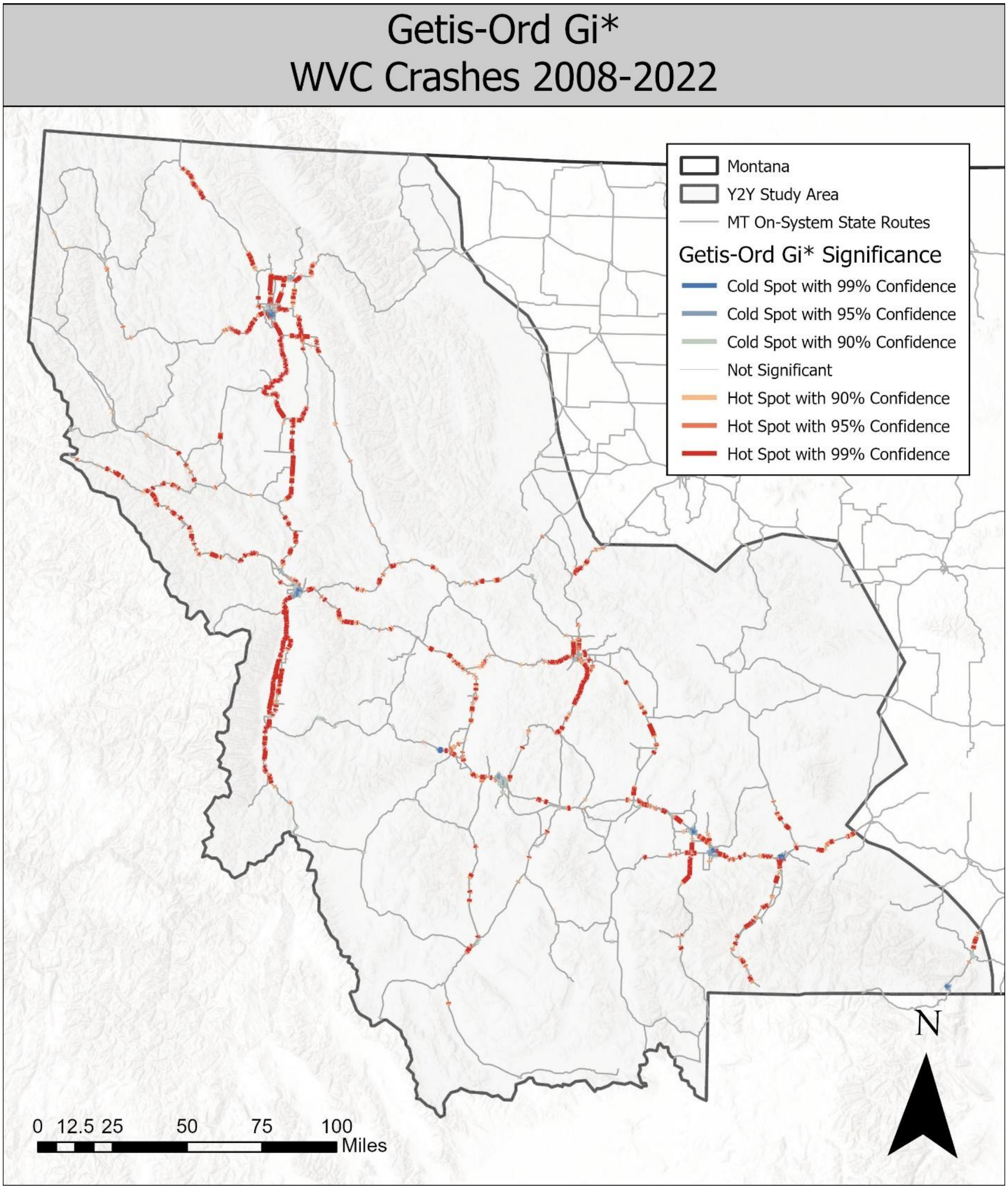


Figure 12: Getis-Ord Gi significant hotspot map for wildlife-vehicle crashes in western Montana (2008–2022).*

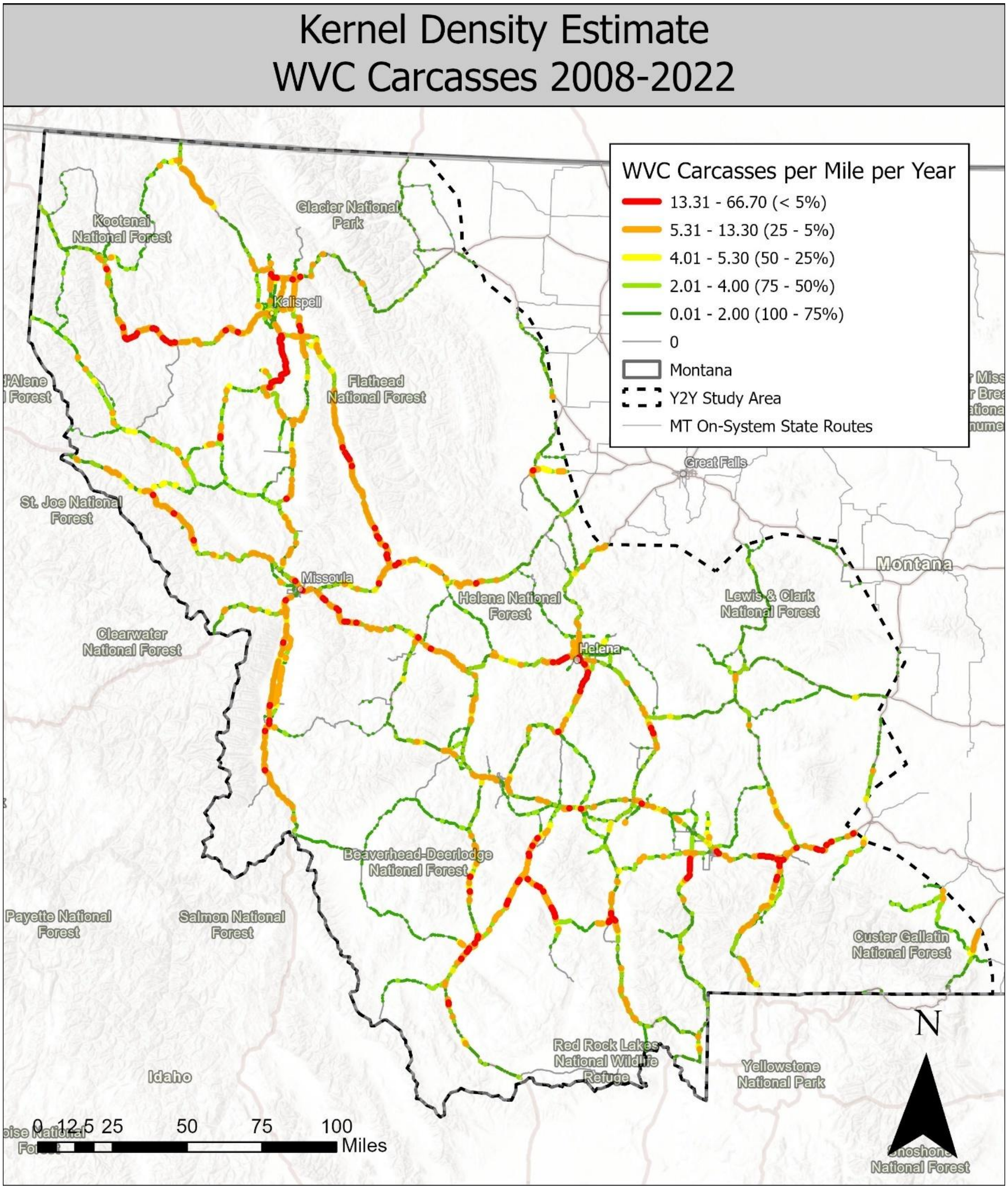


Figure 13: Kernel density hotspot map using percentiles for large wild mammal carcasses in western Montana (2008–2022). Areas with the highest densities are in red (<5%) and areas with the lowest densities are in green (75–100%).

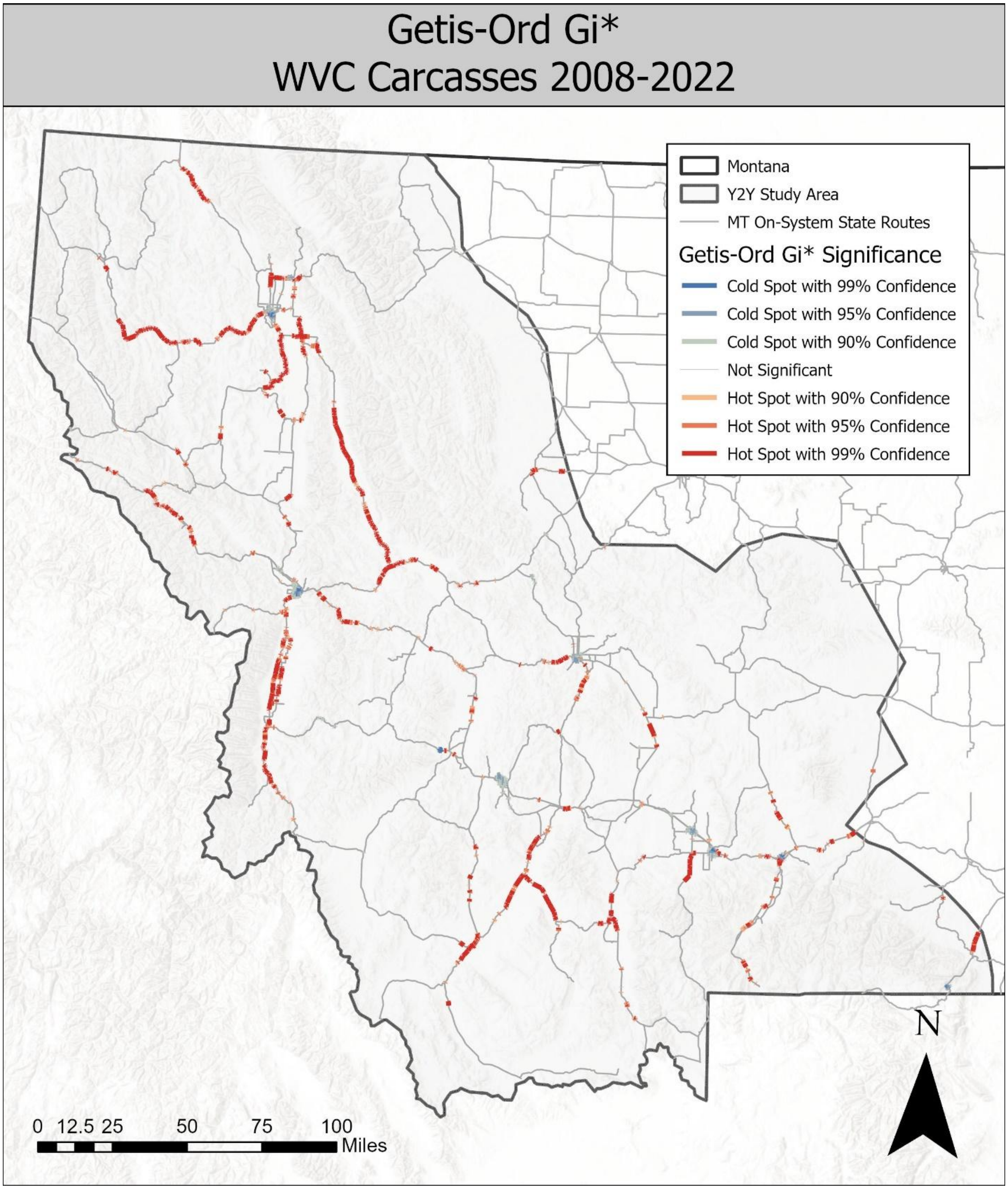


Figure 14: Getis-Ord Gi significant hotspot map for large wild mammal carcasses in western Montana (2008–2022).*

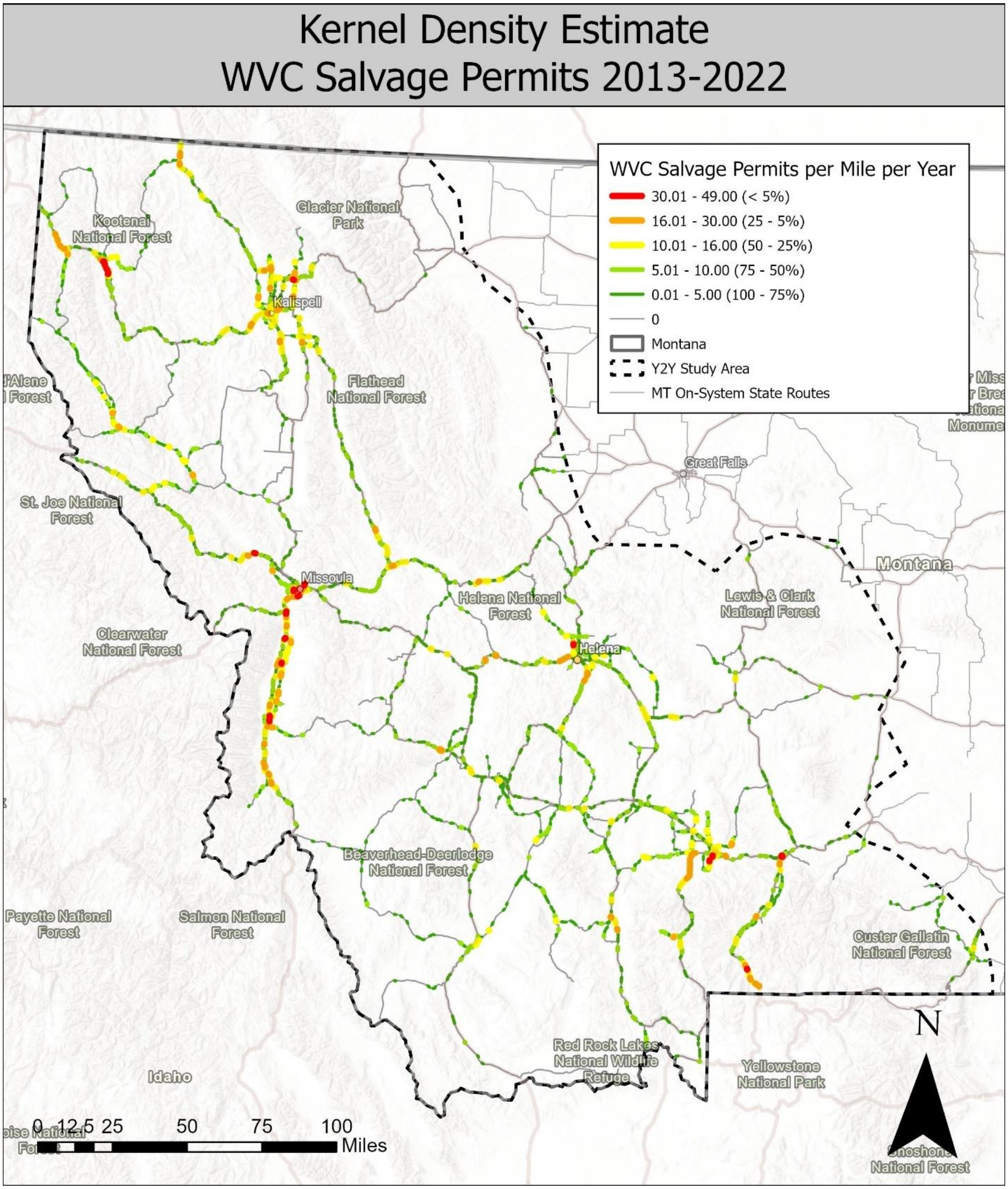


Figure 15: Kernel density hotspot map using percentiles for salvage permit records in western Montana (2013–2022). Areas with the highest densities are in red (<5%) and areas with the lowest densities are in green (75–100%).

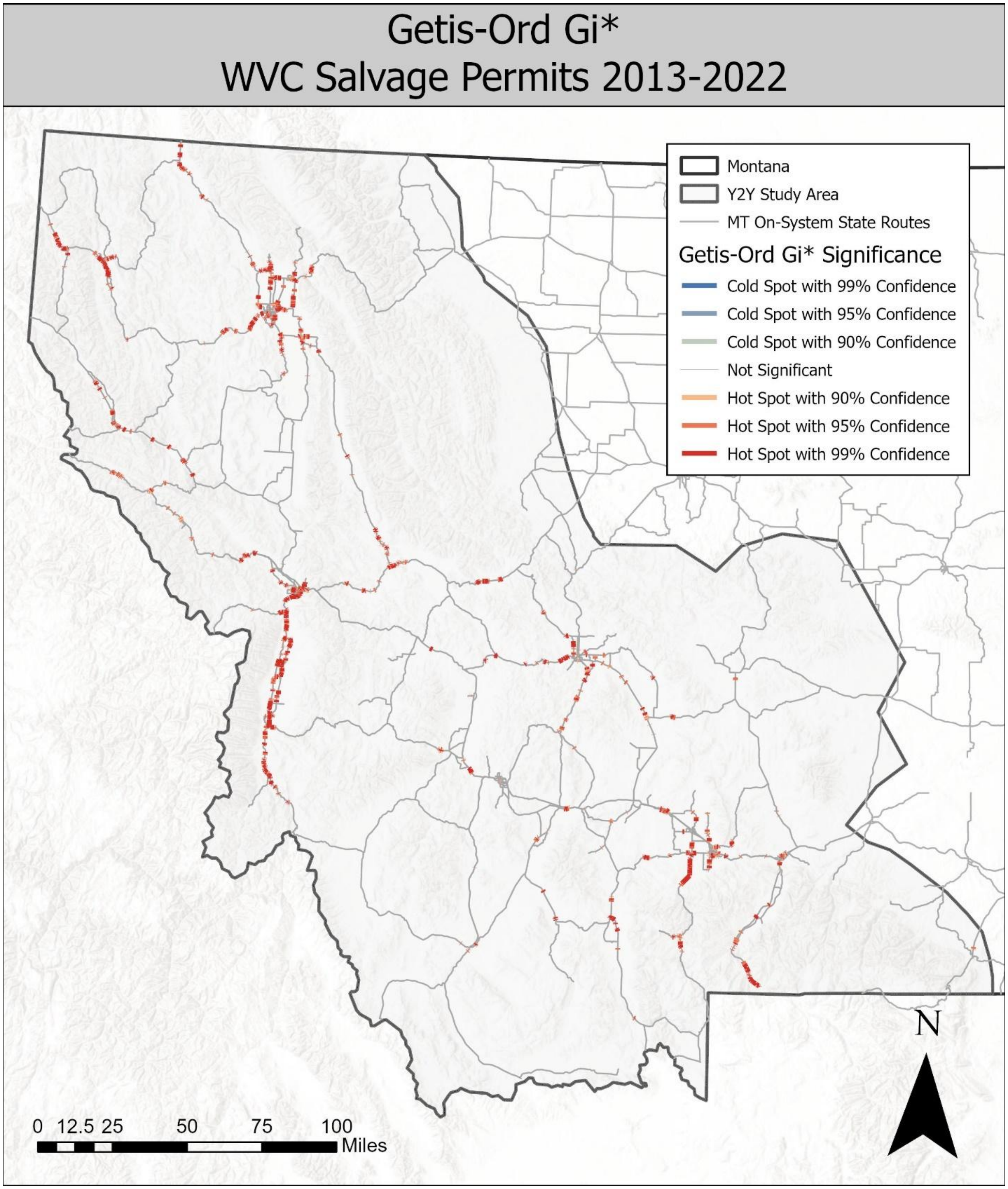


*Figure 16: Getis-Ord Gi*significant hotspot map for salvage permit records in western Montana (2013–2022).*

To allow for an easy visual comparison between the worst road sections based on crashes, carcasses and salvage permits, see Figure 17.

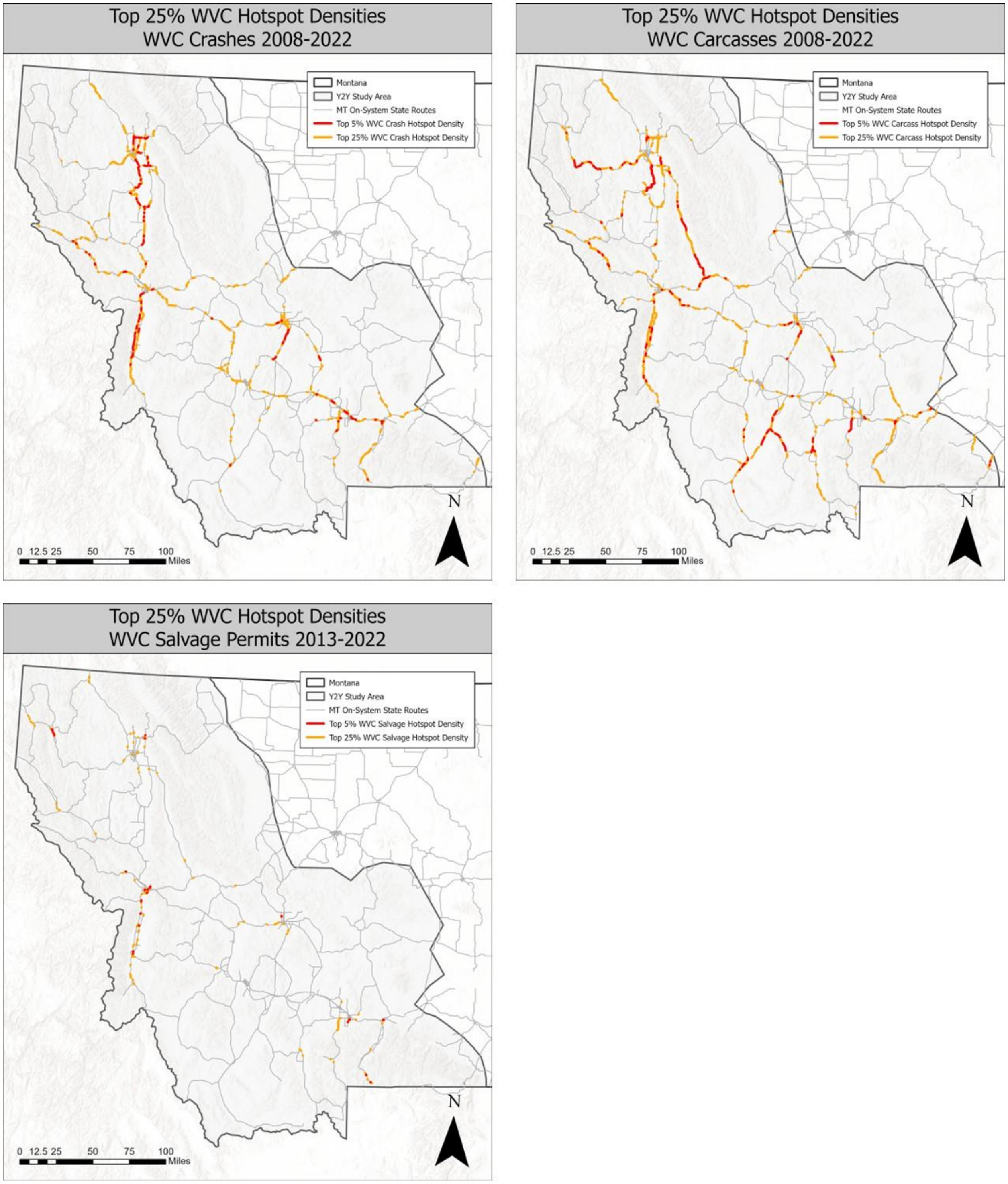


Figure 17: The top 5 and 25 percentile road sections for the wildlife-vehicle crashes, large wild mammal carcasses, and the salvage permit records in western Montana. The green stars refer to wildlife linkage areas identified by Y2Y.

3.4 Discussion

While wildlife-vehicle crash records and large wild mammal carcass removal records can both be expected to have a consistent search and reporting effort of MDT on-system highways, there are differences, based on both the Kernell Density Estimate and Getis-Ord Gi*analyses. This suggests that it is useful to evaluate the crash and carcass removal data separately during the decision process for wildlife mitigation measures. The hotspots based on crash data tend to be associated with higher traffic volume highways in the Flathead Valley, Mission Valley, and the Bitterroot Valley, areas with higher human population. The hotspots based on carcass removal data generally identify the same highway sections as the crash data but identify additional hotspots along highways in areas with lower human population. The salvage permit data do not have a comparable spatial distribution to either the crash or carcass data, but they seem to be at least somewhat associated with where many people live, and likely less associated with where most large mammals are hit by vehicles.

Note that the period included in the analyses (2008-2022) is long, and several road sections (e.g. US Highway 93 north and south of Missoula) have had fences and wildlife crossing structures implemented during this period. Therefore, some of the hotspots identified based on the 2008-2022 data are not necessarily still present. The analyses presented in this report do not allow for conclusions on the effectiveness of the mitigation measures in collision reduction, instead consult other reports (e.g., Cramer & Hamlin, 2016; Huijser et al., 2016).

4 Cost-benefit analyses for mitigation measures

4.1 Introduction

There are costs associated with the implementation of mitigation measures aimed at reducing collisions with large wild mammals. However, there are also costs associated with not implementing mitigation measures allowing collisions to continue to occur. If the benefits of mitigation measures are greater than their costs, implementation of mitigation measures is economically attractive. While the outcome of cost-benefit analyses can be a useful tool in the decision process, it should not be used as a litmus test for the implementation of mitigation measures; models are only partially capturing what should be considered (Huijser et al., 2009). For example, the model we apply for this project, is based on Huijser et al. (2009; 2022), and it is mostly based on parameters and values associated with vehicle repair costs, human safety, and the costs of material and labor for mitigation measures. Even though there is some representation of economic values based on conservation (Huijser et al., 2022a), the economic parameters and values associated with conservation are likely still underrepresented, and the costs associated with different parameters can change over time at different rates (Huijser et al., 2022a).

4.2 Species categories

We based the cost-benefit analysis for crash and carcass removal data on Huijser et al. (2009, 2022a). The costs associated with large wild mammal-vehicle collisions included the following types of parameters: vehicle repair costs, costs associated with human injuries and human fatalities, and passive use values. Passive use values, also known as non-use values, are the values individual people place on the existence of a given animal species or population as well as the bequest value of knowing that future generations will also benefit from preserving the species (Duffield & Neher, 2019). While species that are similar in body size and body weight pose a similar risk to human safety and vehicle damage, there are very substantial differences in passive use values between different species. For example, the passive use value for a white-tailed deer was estimated at $5,075 in 2020 US$ (26.59% of the $19,089 total cost) whereas the passive use value for a grizzly bear was estimated at $4,235,770 in 2020 US$ (99.67% of the $4,249,784 total cost) (Duffield & Neher, 2021; Huijser et al., 2022a, Table 3). In other words, economic parameters based on biological conservation can be a greater driver in cost-benefit analyses than human injuries, human fatalities and vehicle damage if rare and charismatic species such as grizzly bears are involved.

While there are differences in costs associated with different large wild animal species, the crash data did not include species names. Therefore, for the purpose of the cost-benefit analysis, all wild mammal-vehicle crashes were assumed to be "deer", which resulted in relatively conservative cost estimates associated with the crashes. In contrast, the carcass removal data did include species names. However, since we did not have cost estimates for every large wild mammal species, the carcass removal data were grouped into different species categories based on similarity in body size and body weight (Table 3).

Table 3: The species categories and costs of a collision used for the cost-benefit analysis and the species as noted in the carcass removal data.

Species categories for the purpose of the cost-benefit analysis	Species as noted in the carcass removal data	Costs (in 2020 US$) (Huijser et al., 2022a)
"Deer"	White-tailed deer, mule deer, unknown deer species, pronghorn, bighorn sheep, mountain goat, black bear, mountain lion	$19,089
"Elk"	Elk	$73,196
"Moose"	Moose, bison	$110,397
"Grizzly bear"	Grizzly bear	$4,249,784
"Wolf"	Wolf	$54,356

4.3 Cost estimates for collisions for every tenth of a mile

We summed the number of crashes and carcasses per species category for each 0.1-mile road segment for the 15-year study period. To account for spatial imprecision in the data (see Huijser & Bell, 2024), we aggregated values within a 0.5-mile radius from the center of each segment and calculated the number of crashes or carcasses per mile per year by dividing the 15-year totals by 15 for each 0.1-mile segment.

All analyses were conducted using the NAD 1983 StatePlane Montana FIPS 2500 coordinate system (units in meters) in ArcGIS Pro 3.3.2. These steps allowed us to estimate the cost of large wild mammal-vehicle collisions per mile per year for each 0.1-mile-long road segment:

1. The entire network of state-maintained roads in the study area was divided into 0.1-mile (161-meter) segments, with each segment containing the total number of reported crashes and carcasses from 2008 to 2022.
2. Using the *Generate Points Along Lines* tool, a point was placed at the center of each segment to serve as a reference location for spatial aggregation.
3. A 0.5-mile (805-meter) buffer was created around each center point using the *Buffer* tool, producing overlapping zones representing the local area around each segment.
4. A *Spatial Join* was performed between the buffers and the crash and carcass data to sum the total number of large wild mammal incidents within each buffer zone, standardized per mile for each segment.
5. The summed crash or carcass count from each buffer was joined back to its corresponding 0.1-mile segment, ensuring each segment reflected collision activity within its surrounding 0.5-mile area.

6. Total crash and carcass counts were divided by 15 (the number of study years) to calculate the average annual number of large wild mammal crashes or carcasses (per species category) per mile for each segment.
7. Average annual crash and carcass counts were multiplied by the estimated cost per collision for each species category (Huijser et al., 2022a; see also Table 3) to derive the cost per mile per year.
8. These values were then compared to economic thresholds or "break=even values" from Huijser et al. (2022a) (see also Table 4) to assess the cost-effectiveness of mitigation measures:
    - $40,857/mi/year: It is economically advantageous to implement wildlife fencing and underpasses on that road section, at least based on the parameters and values included in the cost-benefit model.
    - $51,547/mi/year: It is economically advantageous to implement wildlife fencing and underpasses and overpasses on that road section, at least based on the parameters and values included in the cost-benefit model.

We only included two different combinations of mitigation measures and both include wildlife fences in combination with wildlife crossing structures. We restricted the mitigation measures to those that included both fences and wildlife crossing structures because:

- Fences are the most effective and robust measure to reduce wildlife-vehicle collisions (almost always 80-100% reduction) (Huijser et al., 2016; 2021).
- Fences alone would result in an absolute or near-absolute barrier for the target species which is not ethical (Moore et al., 2021).
- Wildlife crossing structures provide safe crossing opportunities for wildlife and can increase permeability compared to an unmitigated road with a smaller footprint, allow for seasonal migration of large ungulates to continue, and can help improve population viability for select species (review in Huijser et al., 2021).

No other mitigation measures, other than fences in combination with wildlife crossing structures, can both substantially reduce wildlife-vehicle collisions and maintain or improve connectivity for wildlife (Huijser et al., 2021). Note that relatively recent technological approaches such as road- or car-based animal detection systems or light, sound or smell emitting devices along roads do not reduce the barrier effect of roads and traffic (Huijser et al., 2021). These technologies are aimed at the driver or an autonomous vehicle taking action to avoid a collision or they are aimed at scaring animals away from the road which increases rather than reduces the barrier effect of roads and traffic. Either way, these types of measures do not reduce the barrier effect of roads and traffic; they do not make it any easier for wildlife to reach the other side of the road. The thresholds associated with two different combinations of mitigation measures are listed in Table 4. There are many considerations for these cost estimates including a projected 25-year lifespan for fences, and a 75-year lifespan for crossing structures (see Huijser et al., 2009; 2022). The thresholds for the two different combinations of mitigation measures are based on the average costs per road length unit (both in kilometers and miles). However, the spatial scale of the mitigation measures affects their effectiveness:

- Mitigated road sections that are at least 3 miles long almost always reduce collisions with large wild mammals within the mitigated road section by 80-100% (Huijser et al., 2016). Shorter mitigated road sections are on average less effective (about 50%) and highly variable in their effectiveness depending on local circumstances (Huijser et al., 2016).
- For mitigated road sections to be effective on a larger spatial scale, we must avoid moving the collisions to adjacent road sections (Huijser & Begley, 2022). In this context, the mitigation measures may need to be implemented at road sections that are even longer than 3 miles in length. For example, it is considered good practice for the mitigation measures to cover the entire suitable habitat for the species, including an adjacent buffer zone based on the size of the home range of the target species (Huijser et al., 2022b). In practice this means that the length of the mitigated road sections should probably be many miles, potentially dozens of miles.

Table 4: The thresholds associated with two different combinations of mitigation measures (see Huijser et al. (2022a) for details).

Combination of mitigation measures	**Threshold in US$/km/yr (in 2020 US$ based on 3% discount rate)**	**Threshold in US$/mi/yr (in 2020 US$ based on 3% discount rate)**
Fence (apron), large mammal underpass once every 2 km (width 7.0-8.5 m, height 3.7-5.6 m), and 7 jump-outs per km road length	$25,388	$40,858
Fence with apron, large mammal underpasses once every 2 km (width 7.0-8.5 m, height 3.7-5.6 m), large mammal overpasses once every 24 km (50-60 m wide, replaces an underpass once every 24 km), and 7 jump-outs per km road length.	$32,030	$51,547

4.4 Results

Based on wild mammal-vehicle crashes, the economic thresholds for two different combinations of mitigation measures were especially met or exceeded for several sections of US Highway 93 (Ravalli – Whitefish and Missoula – Hamilton) (Figure 18). For large-wild mammal carcass removal data there were many more roads and road sections that exceeded the economic thresholds for one or both of the mitigation measure packages (Figure 19). These road sections include those around Flathead Lake, US

Highway 2 west and east of Kalispell, US Highway 83 through the Seeley-Swan, US Highway 200 from Missoula to Lincoln, I-90 from the Stateline with Idaho to Whitehall and also around Bozeman, Montana Highway 41 and 287 around Twin Bridges, US Highway 287 along the Madison River, US Highway 191 along the Gallatin River up to Four Corners, and US Highway 89 through the Paradise Valley.

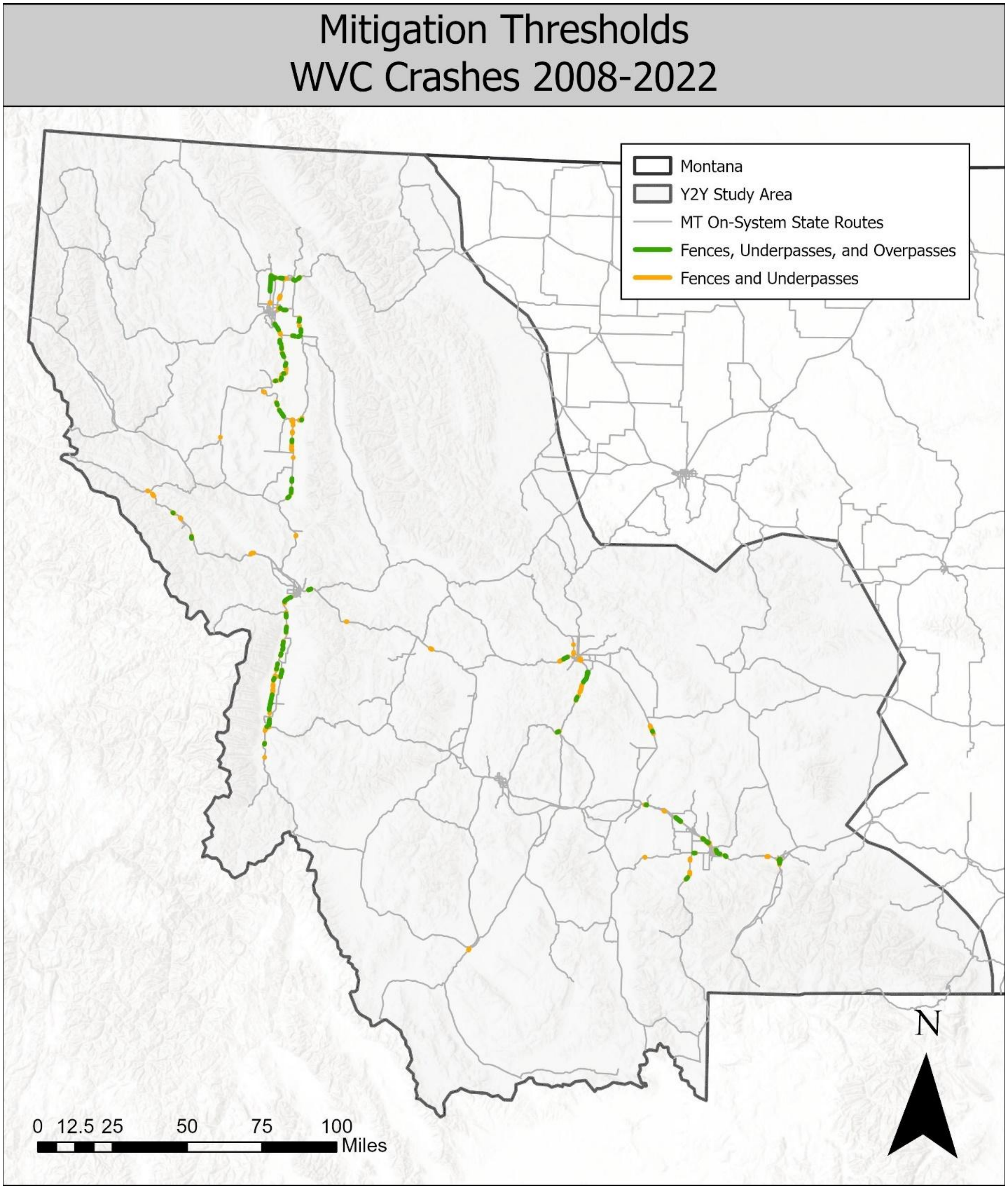


Figure 18: The road sections where the economic thresholds were met for the two different combinations of mitigation measures based on wild mammal-vehicle crash data (2008-2022).

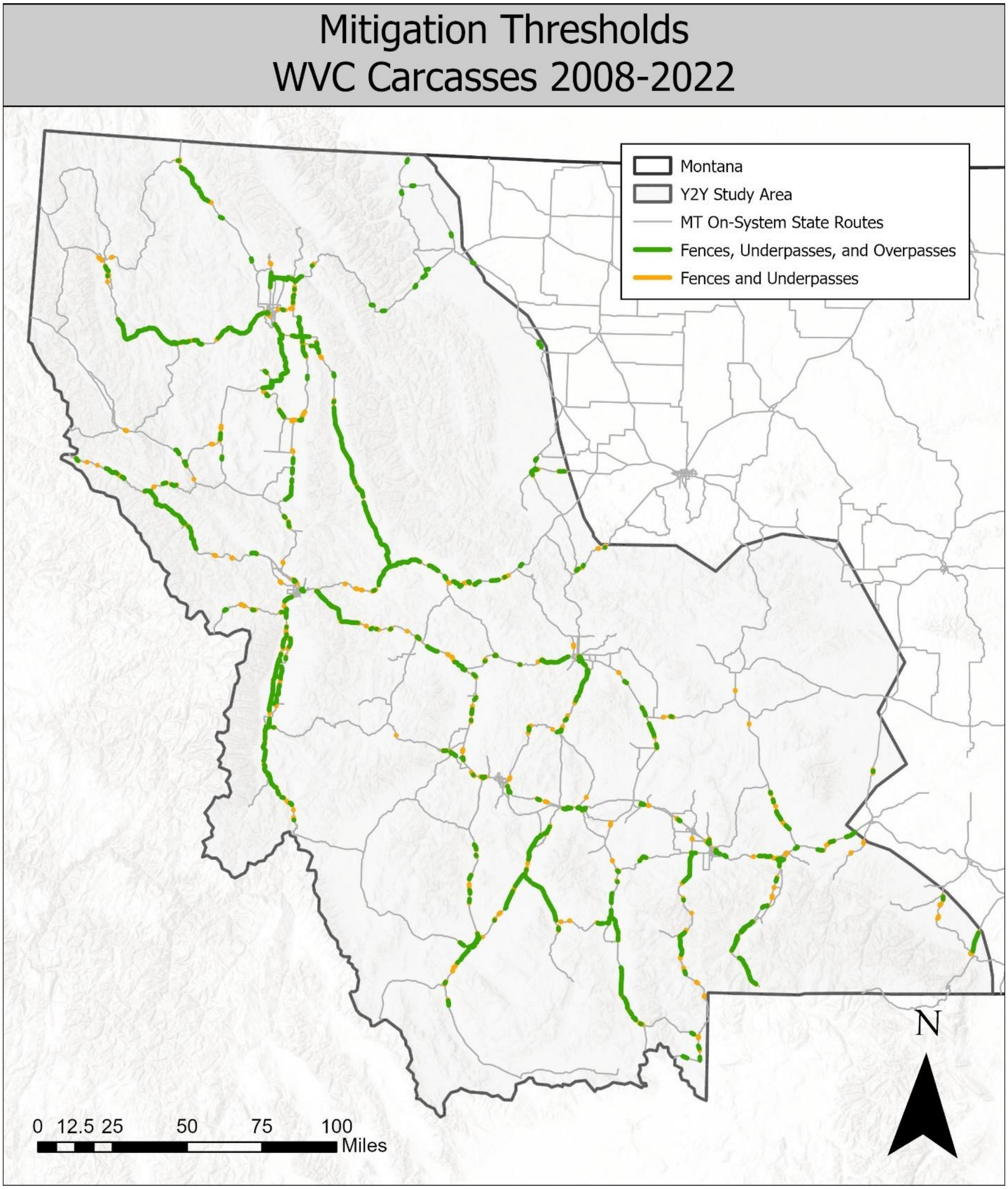


Figure 19: The road sections where the economic thresholds were met for the two different combinations of mitigation measures based on large wild mammal carcass removal data (2008-2022).

4.5 Discussion

The large wild mammal carcass removal data identified more road sections, including in different areas, that meet or exceed the economic thresholds for the two mitigation packages, than the wildlife crash data. This illustrates that the search and reporting effort for crash and/or carcass data is not consistent across the study area, and that it is prudent to evaluate both datasets separately when deciding on the potential implementation of mitigation measures. While the large wild mammal carcass records are generally more numerous than the wildlife crash records, the reporting effort of carcasses has been reducing over the years, at least compared to the crashes (see Chapter 2, Figure 4). This means that over time, especially in more recent years, the carcass data are increasingly underestimating the costs associated with large mammal-vehicle collisions, potentially by a factor 8 (Fairbank et al., 2024).

5 Road mortality for species of special conservation concern

5.1 Spatial distribution

For this report, species of special conservation concern include grizzly bear, Canada lynx, and wolverine. The locations of reported roadkilled individuals show that grizzly bears are killed by vehicles throughout most of the northern part of the Y2Y working area (i.e., the Cabinet-Yaak Ecosystem and the Northern Continental Divide Ecosystem), and around the Yellowstone (Greater Yellowstone Ecosystem) (Figure 20). No confirmed grizzly bear roadkills were present along I-90 or I-15 in the Y2Y area in Montana, or along the roads south of I-90 and west of I-15 between 1 January 2008 and 31 December 2022. This coincides with the NCDE population gradually expanding south towards I-90, the occupied range crossing I-90 in some areas in recent years (see later), However, grizzly bears still have low population density along I-90 and relatively few individuals attempt to cross I-90. A similar expansion of the NCDE population has been happening to the east towards I-15, the occupied range crossing I-15 in some areas in recent years (see later). Similar to I-90, grizzly bears still have low population density along I-15 and relatively few individuals attempt to cross I-15. In addition, both I-90 and I-15 have relatively high traffic volumes and are likely to be a substantial barrier to grizzly bears (see e.g., Pashby 2022).

There are only two records of roadkilled Canada lynx; one on Highway 83 near Condon in the Swan, and one on I-90 west of Bearmouth. Wolverine roadkills were not present in the database. While further analyses with grizzly bears are meaningful (sample size of 77 roadkilled individuals), further analyses were not useful or not possible for Canada lynx and wolverine.

The spatial analyses for grizzly bears only included observations of roadkilled animals between 1 January 2008 through 31 December 2022. However, grizzly bear road and railroad mortality around Missoula continued in 2023 and 2025 (Table 5) (Pers. Com. James Jonkel, Montana Fish, Wildlife & Parks). Around Missoula, no grizzly bear road or train mortality was reported in 2024 (Pers. Com. James Jonkel, Montana Fish, Wildlife & Parks).

Table 5: The Grizzly bear road and grizzly bear railroad mortality around Missoula observed in 2023-2025 (Pers. Com. James Jonkel, Montana Fish, Wildlife & Parks).

Date	Location	Description of roadkilled grizzly bears	Description of trainkilled grizzly bears
14 Aug 2023	Montana Highway 200 east of Lincoln.	Cub	
18/19 Oct 2023	Montana Highway 200, upstream from Bonner, Mile reference post 3.	Adult male	
2025	US Highway 93 North, just north of Missoula, Flathead Indian Reservation.	Cub	
11 Sep 2025	Along railroad, just off I-90 two miles SE of the Gold Creek Exit.		Young adult male
16 Sep 2025	Montana Highway 83, just north of Seeley Lake.	Two subadults (male and female)	
16 Dec 2025	I-90, just west of the Garrison Exit		Two unverified reports of a grizzly bear struck by a vehicle. Reporting parties were both insistent that it was a grizzly they observed. After being hit the bear was able to make its way off the interstate and into the Clark Fork River bottoms. FWP responded but no carcass was located.

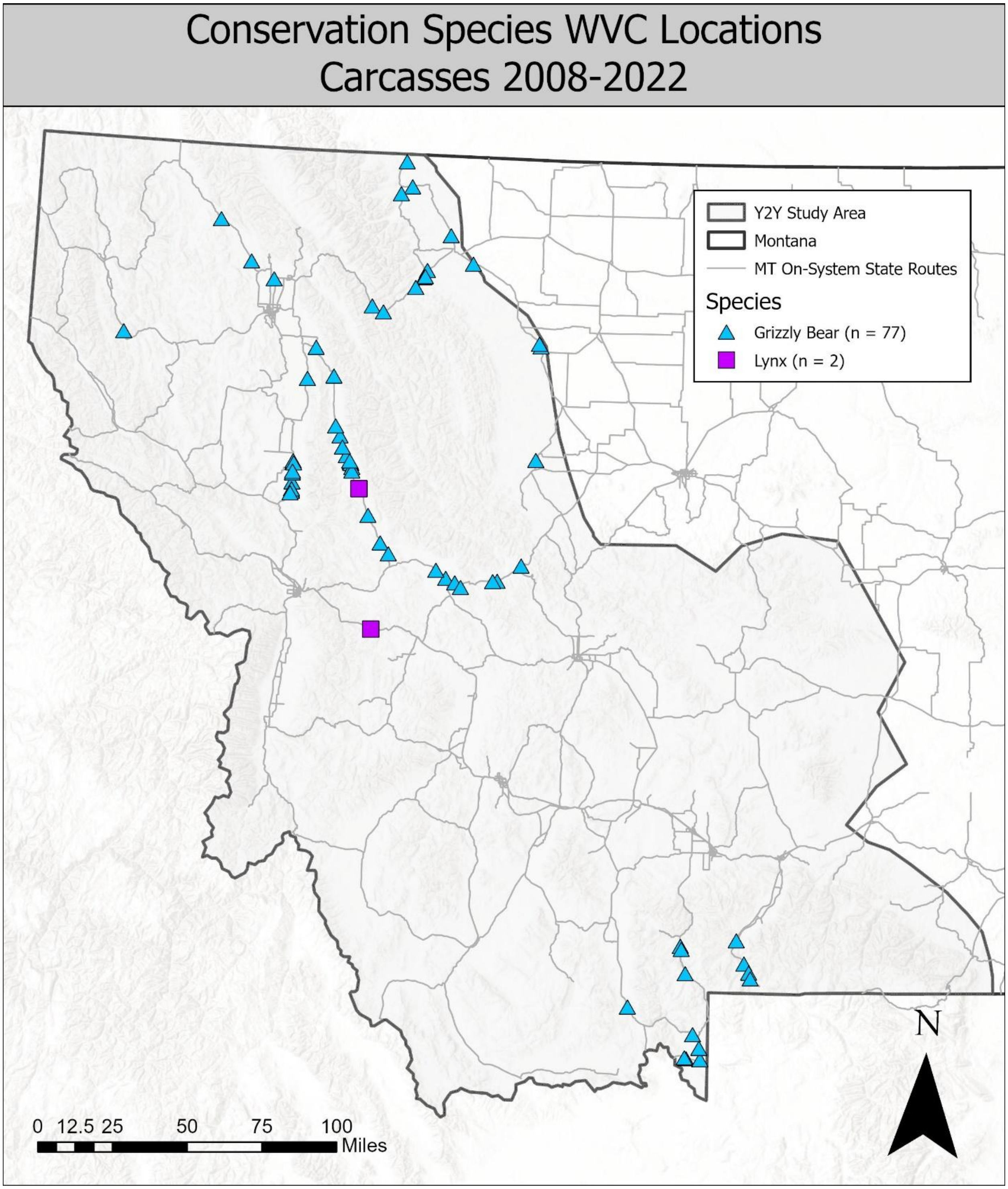


Figure 20: Wildlife-vehicle collisions with species of special concern in Y2Y area in Montana (2008–2022).

5.2 Grizzly bears

There were 98 records of roadkilled grizzly bears in Montana between 2008 and 2022 (90 inside and 8 outside of Y2Y area in Montana). Of the 90 roadkilled grizzly bears in the Y2Y area in Montana, 77 were along MDT on-system roads, and 13 were along off-system roads. The number of roadkilled grizzly bears was generally higher from 2018 onwards, with higher increasing proportions on off system roads in the Y2Y area and on both on- and off-system roads outside Y2Y area (Figure 21). This is consistent with increasing population size and range expansion of the NCDE and GYE populations.

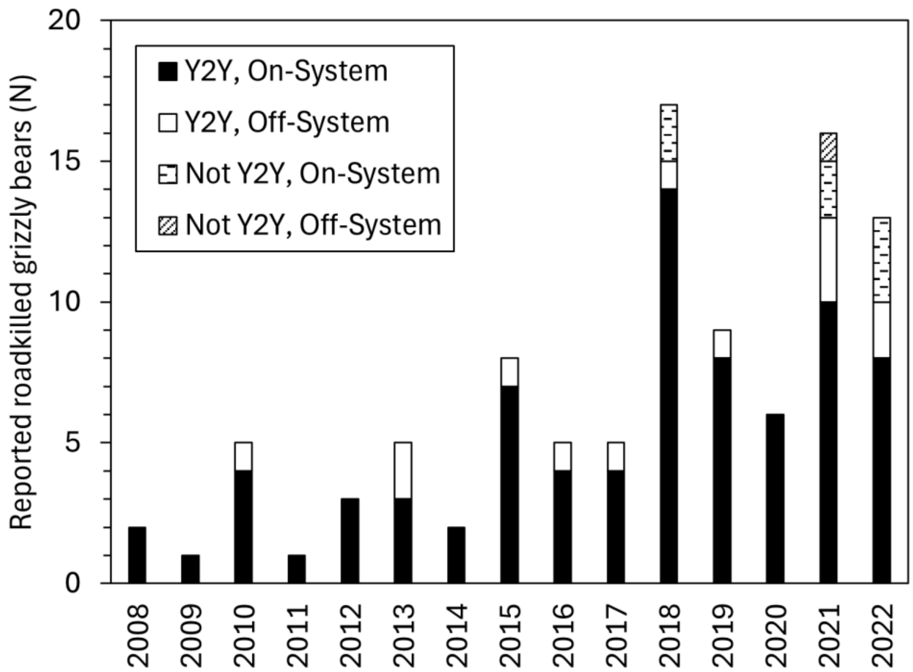


Figure 21: Reported grizzly bear road mortalities per year inside and outside the Y2Y area in Montana, and on- and off-MDT system roads between 2008–2022.

Grizzly bears were hit by vehicles from April through December (Figure 22). However, most of the collisions occurred May through October, corresponding with the active (i.e., non-denning) season.

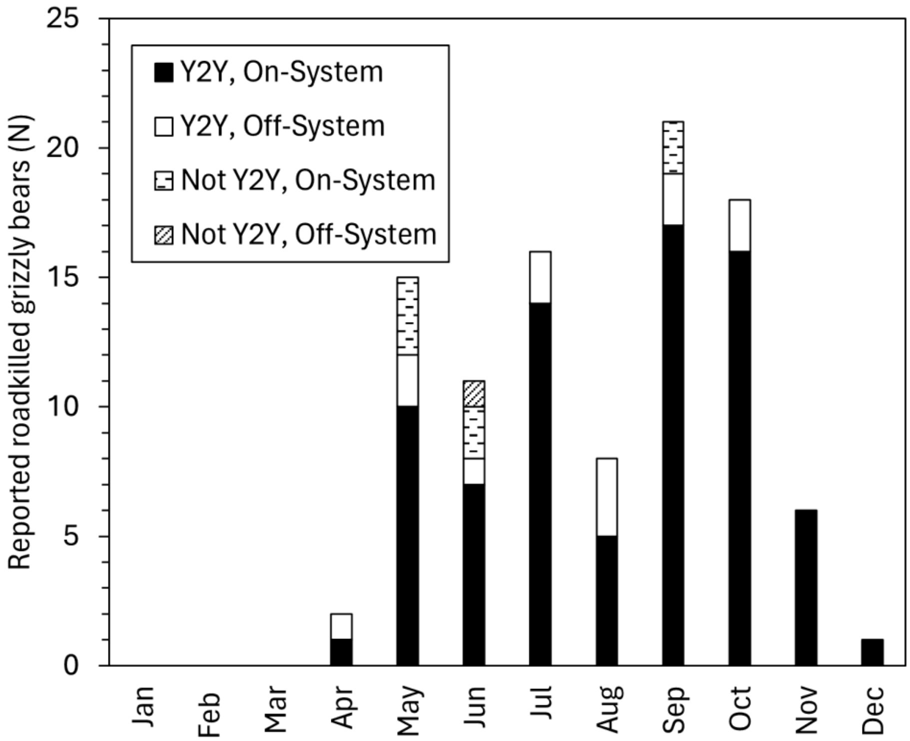


Figure 22: Reported grizzly bear road mortalities per month inside and outside the Y2Y area in Montana, and on- and off-MDT system roads between 2008–2022.

We conducted Kernell Density Estimate and Gettis-Ord Gi* analyses for the roadkilled grizzly bears (Figure 23, Figure 24, Figure 25). Areas with the highest concentrations were already described for Figure 20.

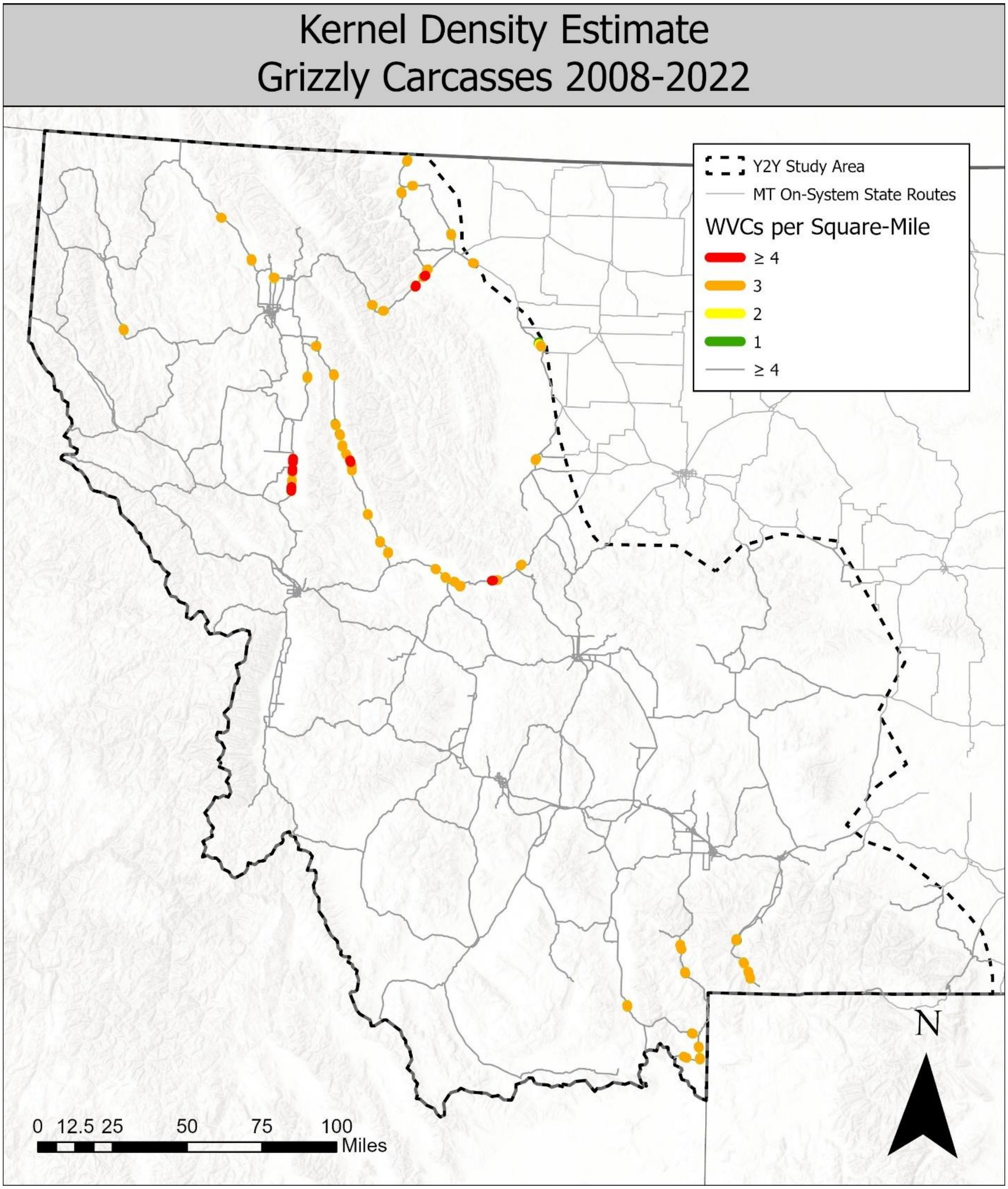


Figure 23: Kernel density hotspot map using percentiles for grizzly bear carcasses in western Montana (2008–2022).

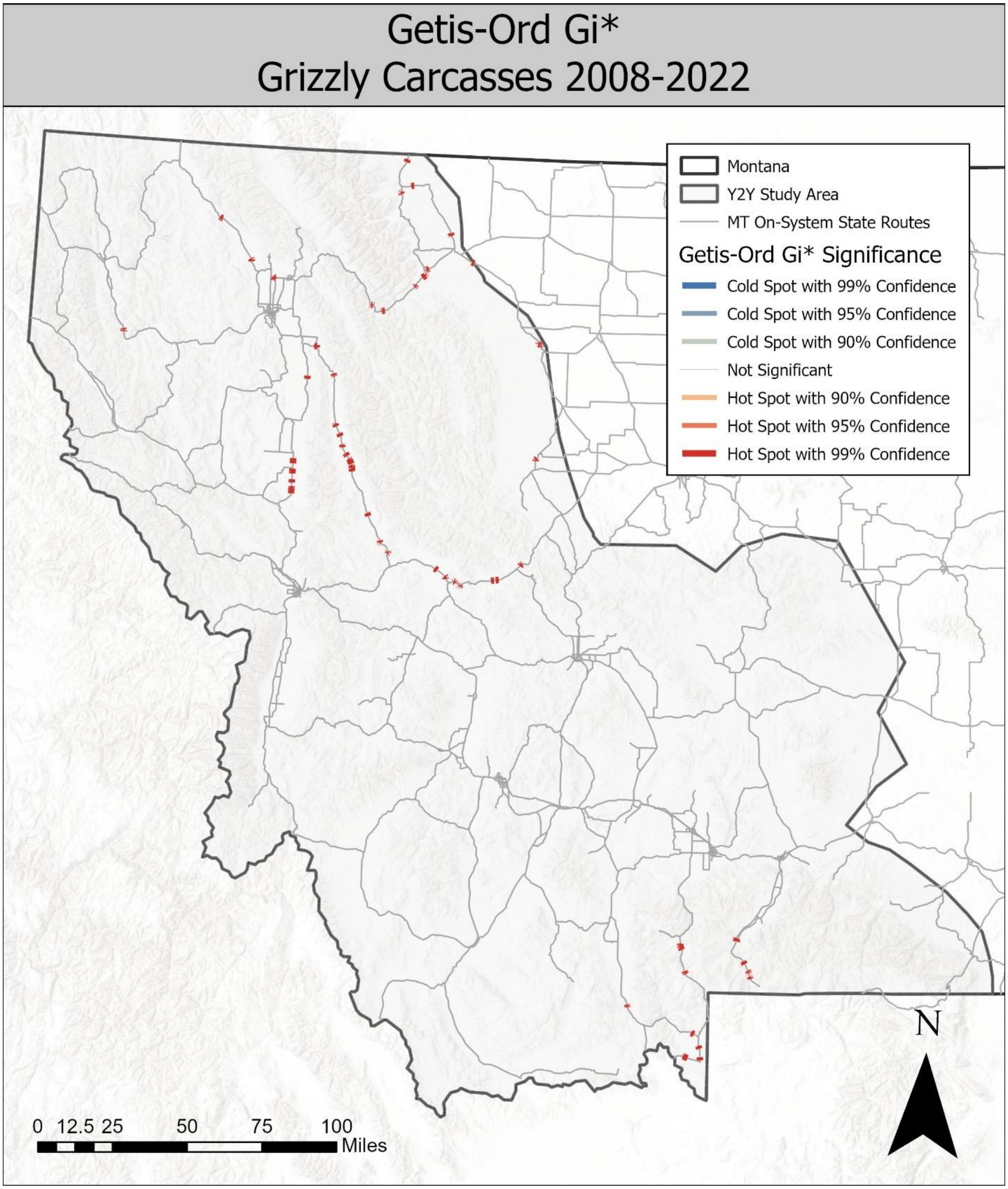


*Figure 24: Getis-Ord Gi*significant hotspot map for grizzly bear carcasses in western Montana (2008–2022).*

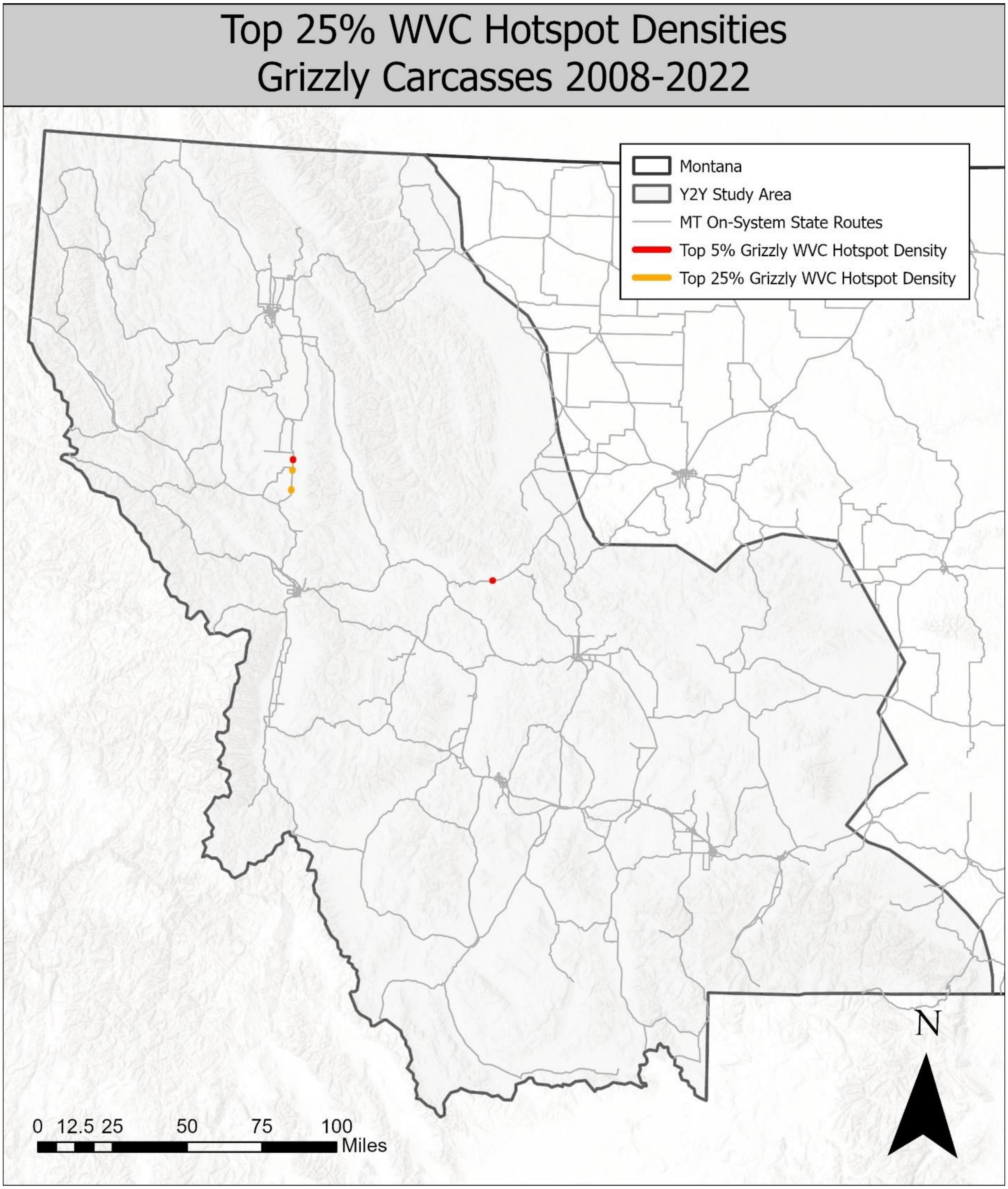


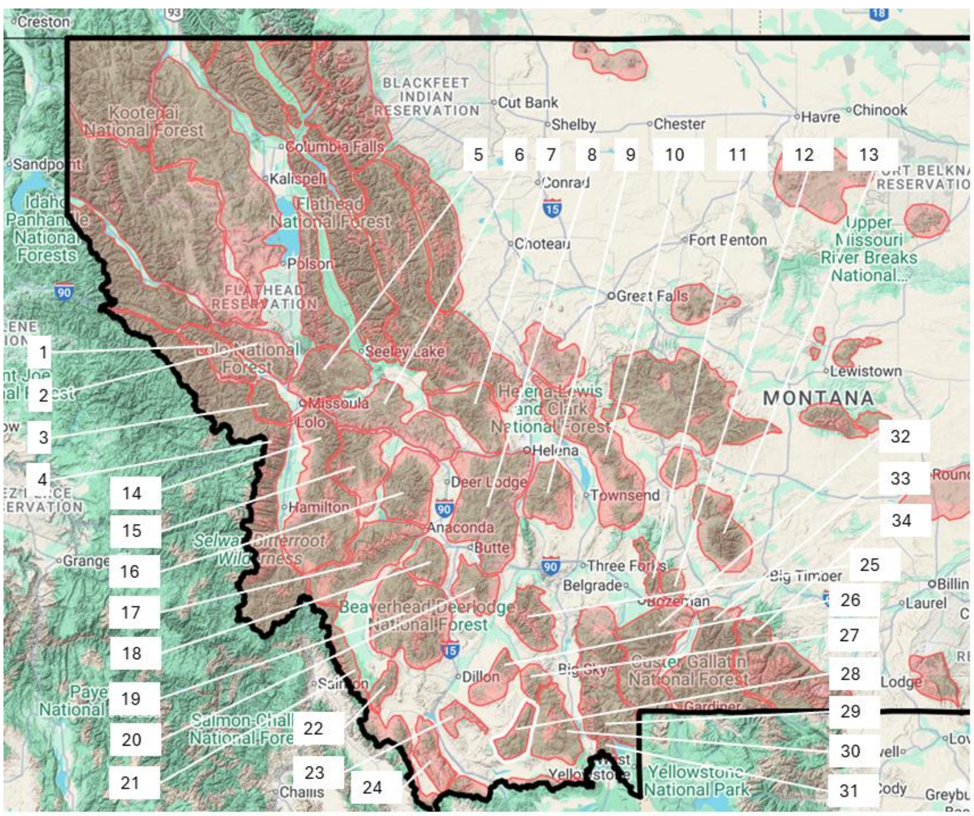
Figure 25: The top 5 and 25 percentile road sections for the grizzly bear carcasses in western Montana. The green stars refer to wildlife linkage areas identified by Y2Y.

6 Habitat and corridors for species of special conservation concern

6.1 Habitat and corridors

For this report, species of special conservation concern include grizzly bear, Canada lynx, and wolverine. We distinguish between areas with “good habitat” for these individual species, as well as corridors (or connectivity pathways) that connect between these areas with good habitat. These corridors are based on the shortest or most likely routes individuals could take if they are to move between large habitat patches. The habitat quality (or habitat security) and corridors for the three species were modelled by other researchers. We only applied their work in the context of the network of major highways in Montana.

In this report we refer to different mountain ranges. To clarify what mountain ranges are associated with the different names we indicated them on a map (Figure 26: The names of different mountain ranges in southwest Montana (based on Wally, 2024).Figure 26).



1 Ninemile Divide
2 Reservation Divide
3 Grave Creek Range
4 Bitterroot Mountains
5 Rattlesnake Mountains
6 Garnet Range
7 Nevada Mountains
8 Boulder Mountains
9 Elkhorn Mountains
10 Big Belt Mountains
11 Bridger Range
12 Bangtail Range
13 Crazy Mountains
14 Sapphire Range
15 John Long Mountains
16 Flint Creek Range
17 Anaconda Range
18 Fleecer Mountains
19 Pioneer Mountains
20 Highland Mountains
21 Beaverhead Mountains
22 Big Hole Divide
23 Blacktail Mountains
24 Tendoy Mountains
25 Tobacco Root Mountains
26 Ruby Range
27 Greenhorn Range
28 Snowcrest Range
29 Madison Range
30 Gravelly Range
31 Henrys Lake Mountains
32 Gallatin Range
33 Absaroka Range
34 Beartooth Mountains

Figure 26: The names of different mountain ranges in southwest Montana (based on Wally, 2024).

6.2 Grizzly bear

The USFWS has identified six recovery zones for grizzly bear in the lower-48 States (USFWS, 2018; 2024a). The recovery zones, their larger ecosystems, and their estimated population size are listed below (USFWS, 2024a). Note that a population of grizzly bears is defined as “two or more breeding females or one female with two consecutive litters” (USFWS, 2024b).

- Northern Continental Divide Ecosystem (NCDE): Estimated at 1,163 individuals.
- Greater Yellowstone Ecosystem (GYE): Estimated at 1,030 individuals.
- Cabinet-Yaak Ecosystem (CYE): Estimated at 70 individuals.
- Selkirk Ecosystem (SE) (northern Idaho, extreme north-east corner of Washington State and British Columbia): Estimated at <83 individuals in 2010, minimum estimate 51 individuals in the USA part of the SE.
- Bitterroot Ecosystem (BE): No known population. This area is in the (slow) process of being recolonized but has no known established population yet. However, individual grizzly bears have been dispersing through the BE with increasing regularity over the last years (USFWS, 2024b). The USFWS estimates that a grizzly bear population (i.e., “two or more breeding females or one female with two consecutive litters”) may become established in the BE through natural recolonization in the next 15 to 20 years (USFWS, 2024b).
- North Cascades Ecosystem (Northern Cascade Range in Washington State): No known population.

Four of these ecosystems (NCDE, GYE, CYE, and BE) and their smaller recovery zones are in Montana or at least partially in Montana (Figure 27). In 2023, there were an estimated 2,263 grizzly bears in the NCDE, GYE and CYE combined (this includes parts of Idaho and Wyoming). The Bitterroot Ecosystem and its smaller Bitterroot recovery zone was the only area that is at least partially in Montana that had no known established grizzly bear population. Grizzly bear populations have expanded their “occupied range” beyond the recovery zones in the NCDE, GYE and SE, and partially beyond the CYE recovery zone (Figure 24) (Costello et al., 2025; USFWS, 2026). Note that the occupied range can be influenced by a single grizzly bear with a GPS collar, and that breeding females are generally further behind than single grizzly bears, especially males, when recolonizing areas (Pers. Com. Jennifer Fortin-Noreus, formerly senior wildlife biologist with USFWS). This means that the grizzly bear density along the edges of the occupied range may be very low, highly variable, and potentially not have any breeding females nearby. Grizzly bear numbers and their recent range expansion in the lower-48 States is still a fraction (about 4.6%) of the estimated 50,000 grizzly bears that were present in “one large contiguous area throughout all or portions of 18 western States, including Washington, Oregon, California, Idaho, Montana, Wyoming, Nevada, Colorado, Utah, New Mexico, Arizona, North Dakota, South Dakota, Minnesota, Nebraska, Kansas, Oklahoma and Texas” (USFWS, 2025). Note that individuals (not populations) have been recorded beyond the occupied range (USFWS, 2021) (Figure 28).

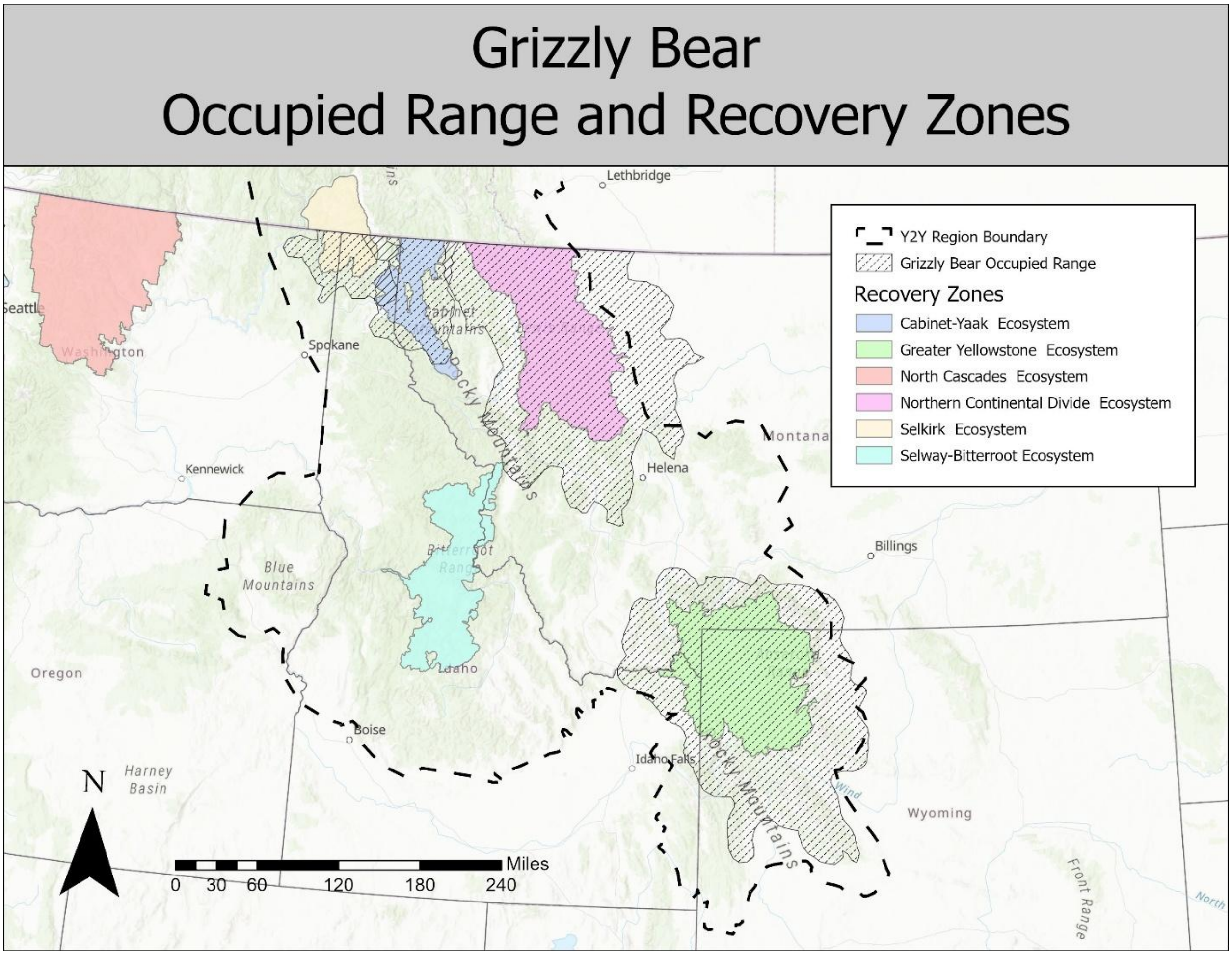


Figure 27: The grizzly bear recovery zones in the lower-48 States, the range currently occupied by grizzly bear populations in the lower-48 States (situation 2024), and the Y2Y area in the lower-48 States (USFWS, 1993; 2026; Costello et al., 2025).

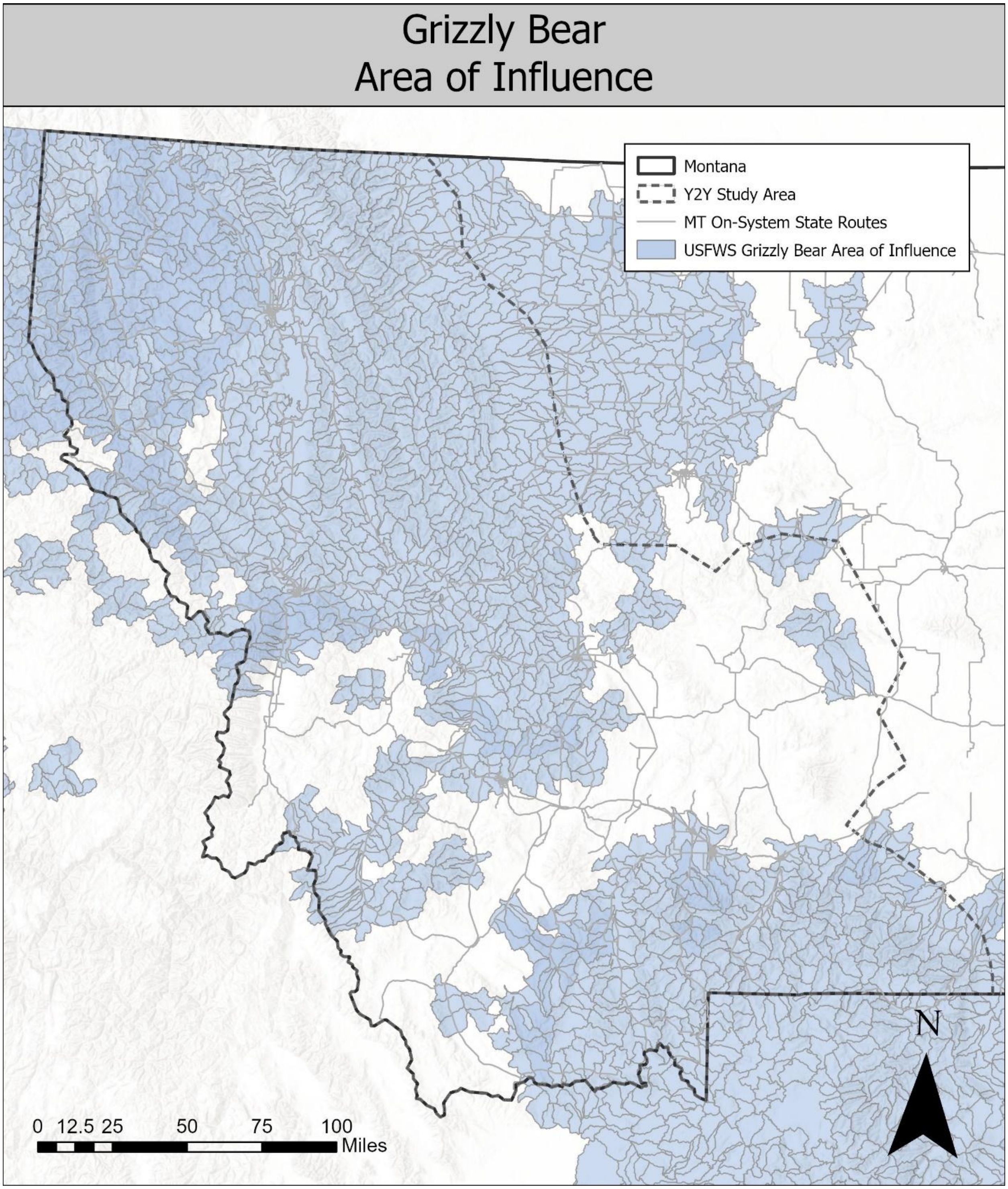


Figure 28: Watersheds where grizzly bears have been recorded (2011 through 2020) in the Y2Y area in Montana. Note that one wandering grizzly bear can "paint a trail" of many adjacent watersheds, and that this map does not reflect permanent or current presence, it only reflects where grizzly bears have been at least once in the previous decade (USFWS, 2021; Pers. Com. Jennifer Fortin-Noreus, formerly senior wildlife biologist with USFWS).

Grizzly bears can live in a wide variety of habitat types and, until a few hundred years ago, lived throughout the Y2Y area in Montana. However, their occupied range was severely reduced beginning in the 1800s, mostly because of direct killing by humans. Therefore, current predicted grizzly bear habitat security is now highest in areas with low human presence. Based on the habitat use of GPS-collared grizzly bears in the Northern Continental Divide Ecosystem, Sells et al. (2023a; 2023b) and Sells and Costello (2024) generated predicted habitat use maps for the different recovery zones in Montana, including adjacent areas (Figure 29, Figure 30). These maps show the relative probability of grizzly bear use in and around the recovery zones, provided that grizzly bears are present to begin with. Each recovery zone and adjacent area is mapped independently. For example, within the Bitterroot Ecosystem relatively high probability of habitat use is predicted for the areas in the northern parts of the recovery zone and north to I-90 and east to I-15. However, the relatively high probability of habitat use for the areas in and around the Bitterroot Ecosystem does not indicate higher probability of habitat use than adjacent areas north of I-90 which were evaluated in the context of the NCDE and adjacent areas. Nonetheless, the northern Sapphire Mountains, the John Long Mountains, the Flint Creek Range, the Anaconda Range, and the Beaverhead Mountains show relatively high predicted habitat use that is outside any of the recovery zones. This area is now also, at least partially, occupied range (Figure 27) and dispersing grizzly bears, including a few females, have been recorded in the northern Sapphire Mountains (Figure 28) (Pers. Com. James Jonkel, Montana Fish, Wildlife & Parks). In 2018 the first female with a juvenile was recorded south of I-90 in the northern Sapphire Mountains (Pers. Com. James Jonkel, Montana Fish, Wildlife & Parks).

Grizzly bears may not only move through areas with high habitat security. Natural and unnatural attractants can also influence their movements. For example, *"the presence of riparian berry crops (hawthorn, service berry and choke cherry) adjacent to highways and interstates, situated alongside river and stream corridors, act as a catalyst for ensuring grizzly bear and black bear highway crossing occurrences over time"* (Pers. Com. James Jonkel, Montana Fish, Wildlife & Parks). *"Riparian berry lode and other abundant natural foods or human-related attractants (e.g., uncontained garbage) can tempt grizzly bears to cross busy highways"* (Pers. Com. James Jonkel, Montana Fish, Wildlife & Parks). This can include I-90 as well as lower volume highways such as Montana Highway 200 between the junction with Montana Highway 141 and Lincoln. *"Eight grizzly bear road-killed mortalities have been documented in the Blackfoot Canyon (also referred to as Lincoln Canyon) and the Lincoln Basin. It is the only area where I have consistently observed lots of grizzly bear scat on highway black top. During certain years, especially when the berry load is on, grizzlies walk up and down the highway under the cover of darkness and feed on roadside berries and road-killed ungulates. We also have a ton of grizzly bear radio-collar data showing that bears cross this section of Montana Highway 200 on a regular basis in the spring, summer and fall"* (Pers. Com. James Jonkel, Montana Fish, Wildlife & Parks).

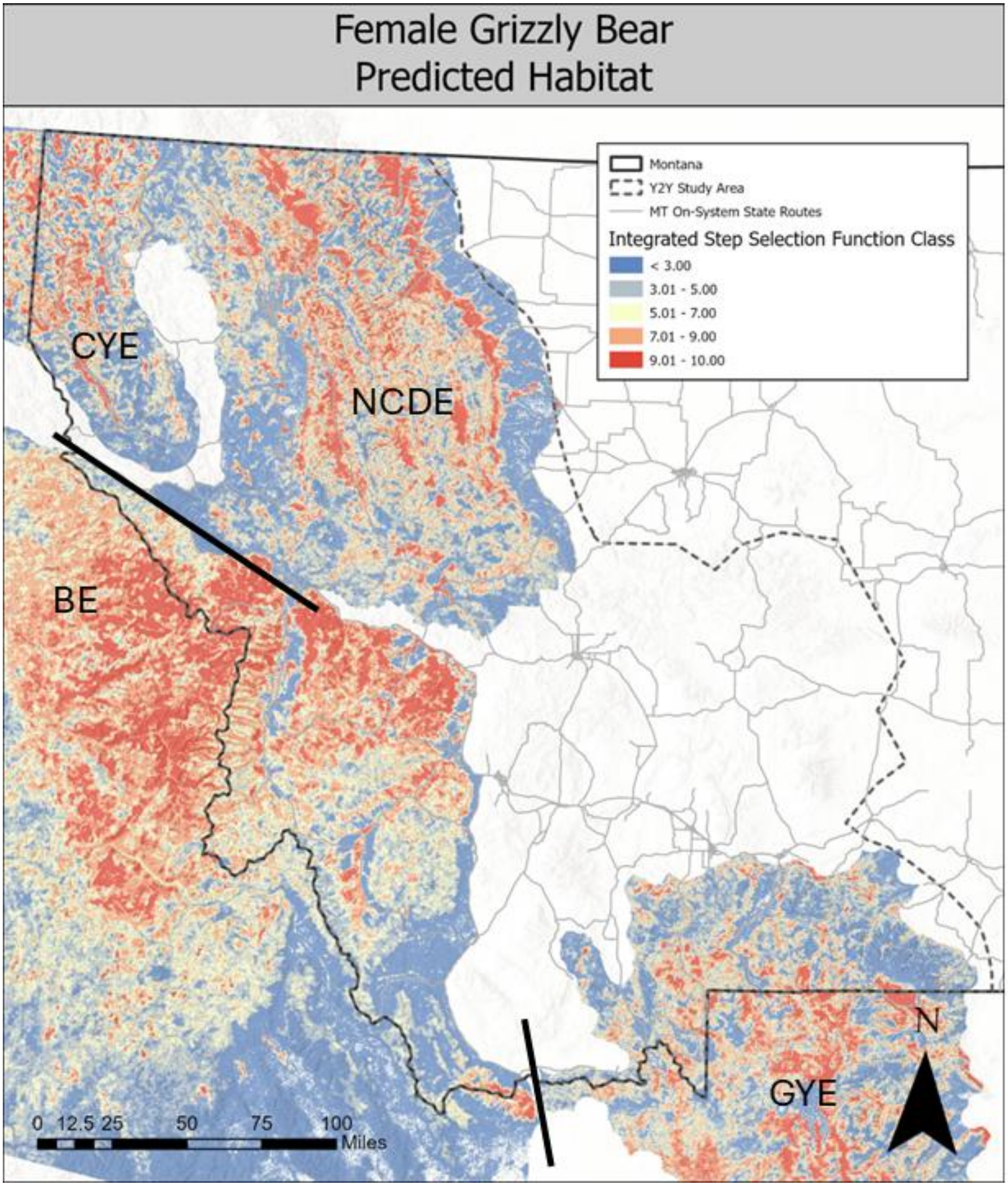


Figure 29: Predicted habitat use for the NCDE-CYE, GYE and BE (combined recolonization and reintroduction scenario) of female grizzly bears (Sells et al., 2023b; Sells & Costello (2024). Red areas represent relatively high predicted use within each recovery zone and adjacent landscape, blue areas represent relatively low predicted use within each recovery zone and adjacent landscape.

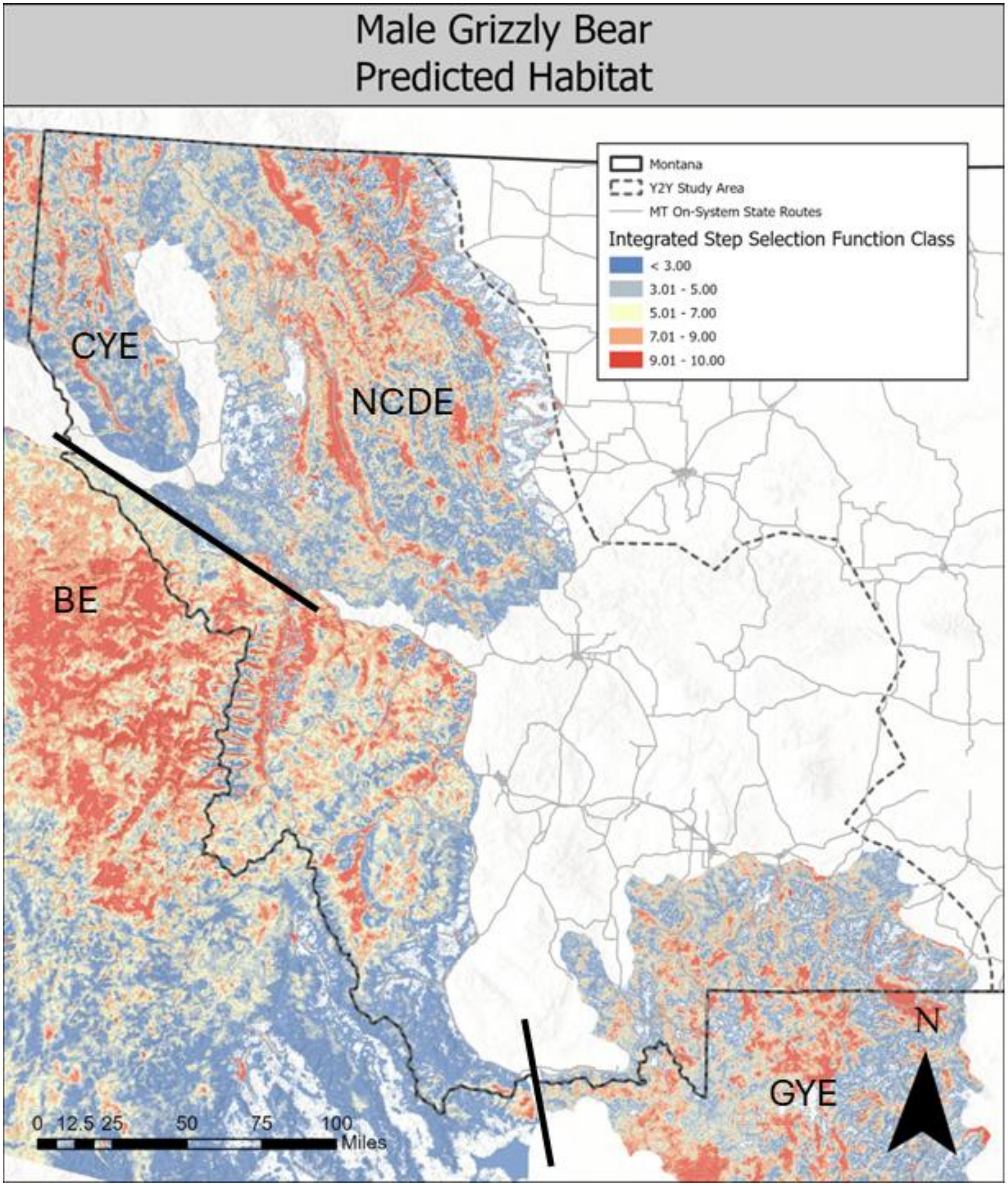


Figure 30: Predicted habitat use for the NCDE-CYE, GYE and BE (combined recolonization and reintroduction scenario) of male grizzly bears (Sells et al., 2023b; Sells & Costello (2024). Red areas represent relatively high predicted use within each recovery zone and adjacent landscape, blue areas represent relatively low predicted use within each recovery zone and adjacent landscape.

Sells et al. (2023b) modeled grizzly bear movements between the NCDE, CYE, BE and GYE areas (Figure 31, Figure 32, Figure 33, Figure 34). Sells et al. (2023b) simulated directed and undirected movements. Directed movements had start and end points in the different populations centered around the individual recovery zones). Undirected movements had start points in the NCDE, CYE, or GYE, but they did not have predetermined end points for their simulated movements. In general, “connectivity pathways were primarily associated with mountainous areas and secondarily with river and stream courses in open valleys” with great similarity between males and females (Selles et al., 2023). Directed pathways can help identify where grizzly bears may move through areas that are less hospitable to them. Undirected movements are better at predicting habitat use, and potential recolonization, in areas close to the start point in the individual recovery zones. Both directed and undirected pathways can help identify and prioritize areas where human-grizzly bear interactions can or should be managed most. This includes reducing direct road mortality of grizzly bears, and improving connectivity across roads, especially relatively busy roads (Waller & Servheen, 2005; Waller & Miller, 2015).

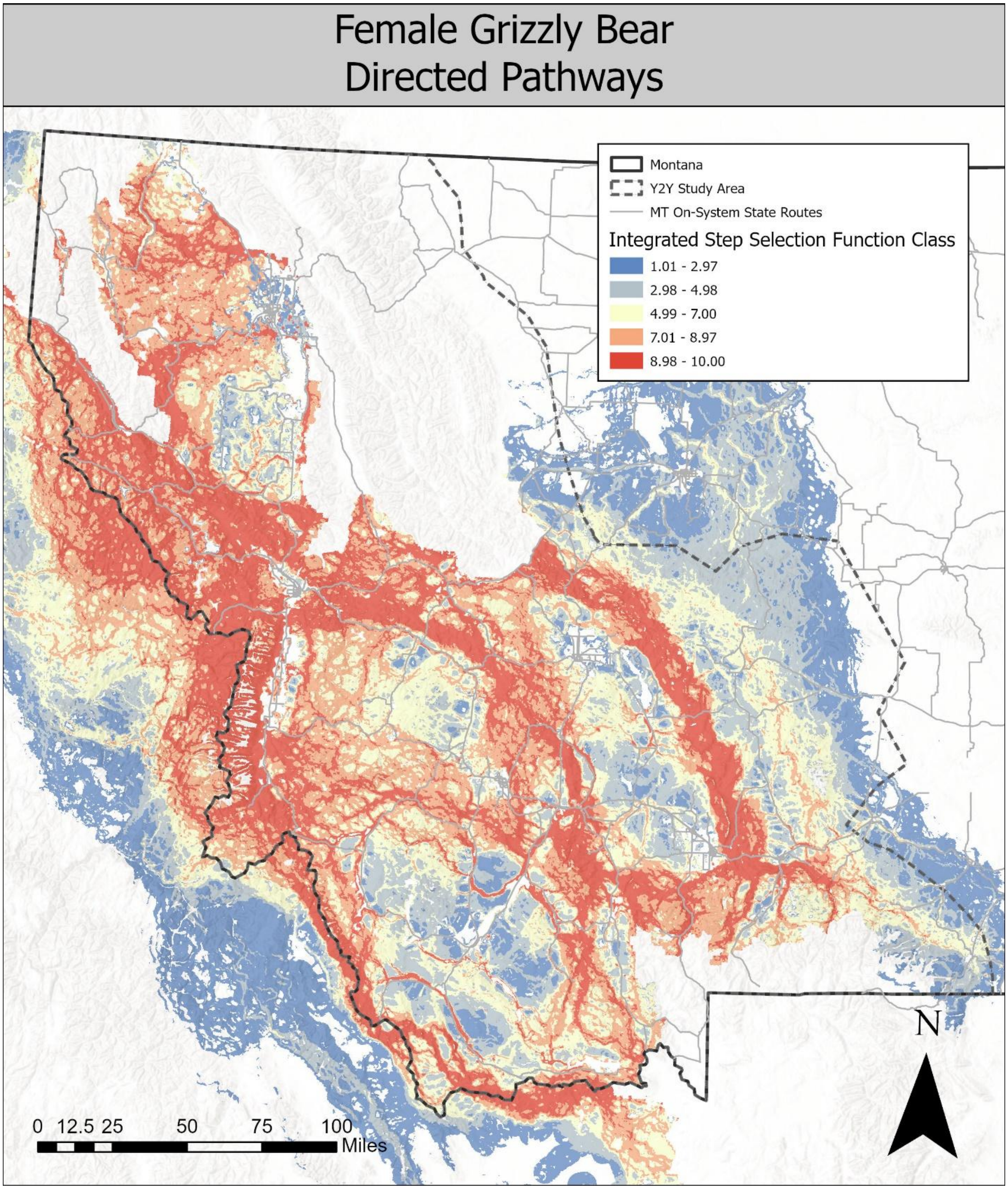


Figure 31: Predicted directed pathways for female grizzly bears between recovery zones in the Y2Y area in Montana (Sells et al., 2023b). Red areas represent relatively high predicted use, blue areas represent relatively low predicted use.

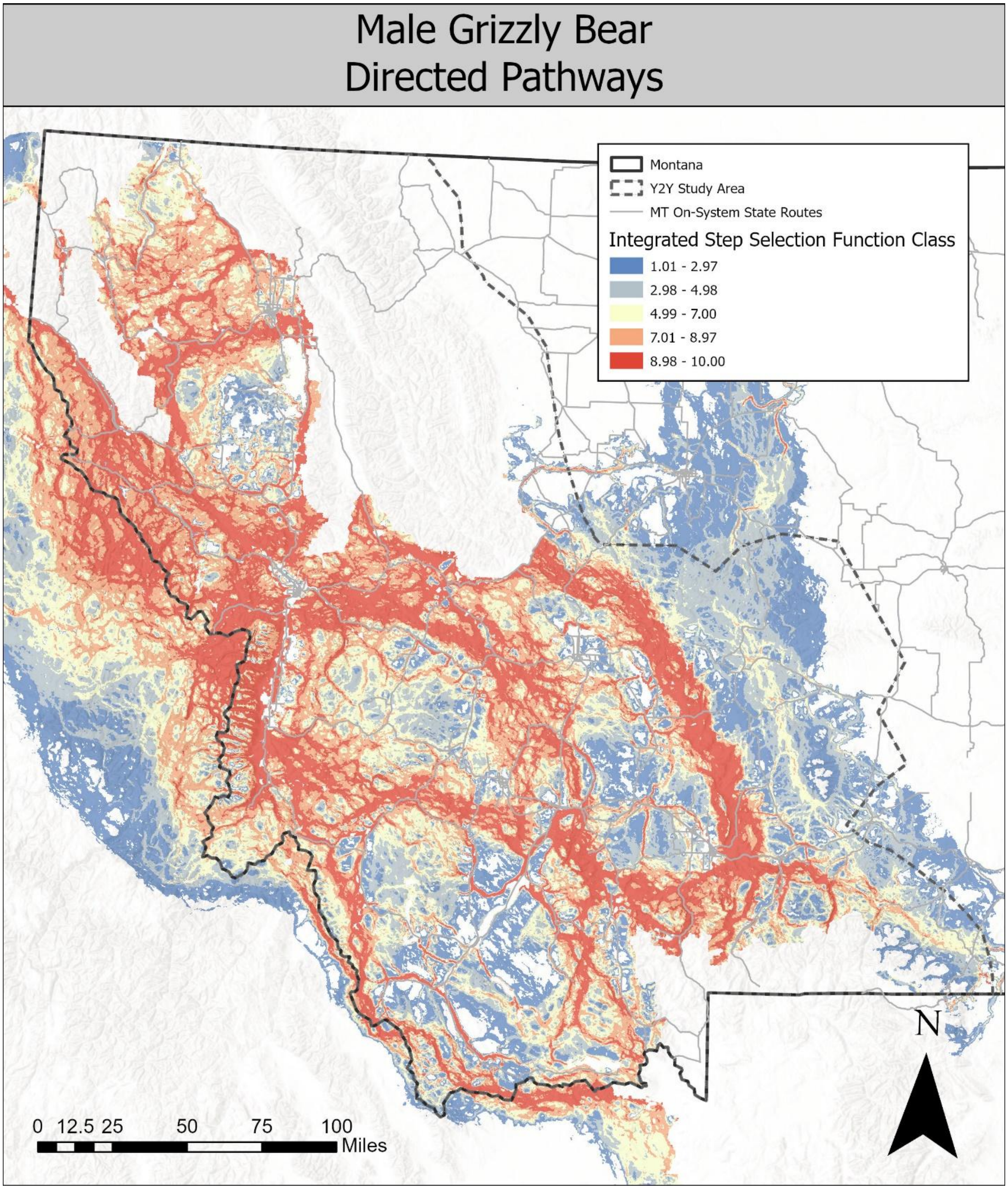


Figure 32: Predicted directed pathways for male grizzly bears between recovery zones in the Y2Y area in Montana (Sells et al., 2023b). Red areas represent relatively high predicted use, blue areas represent relatively low predicted use.

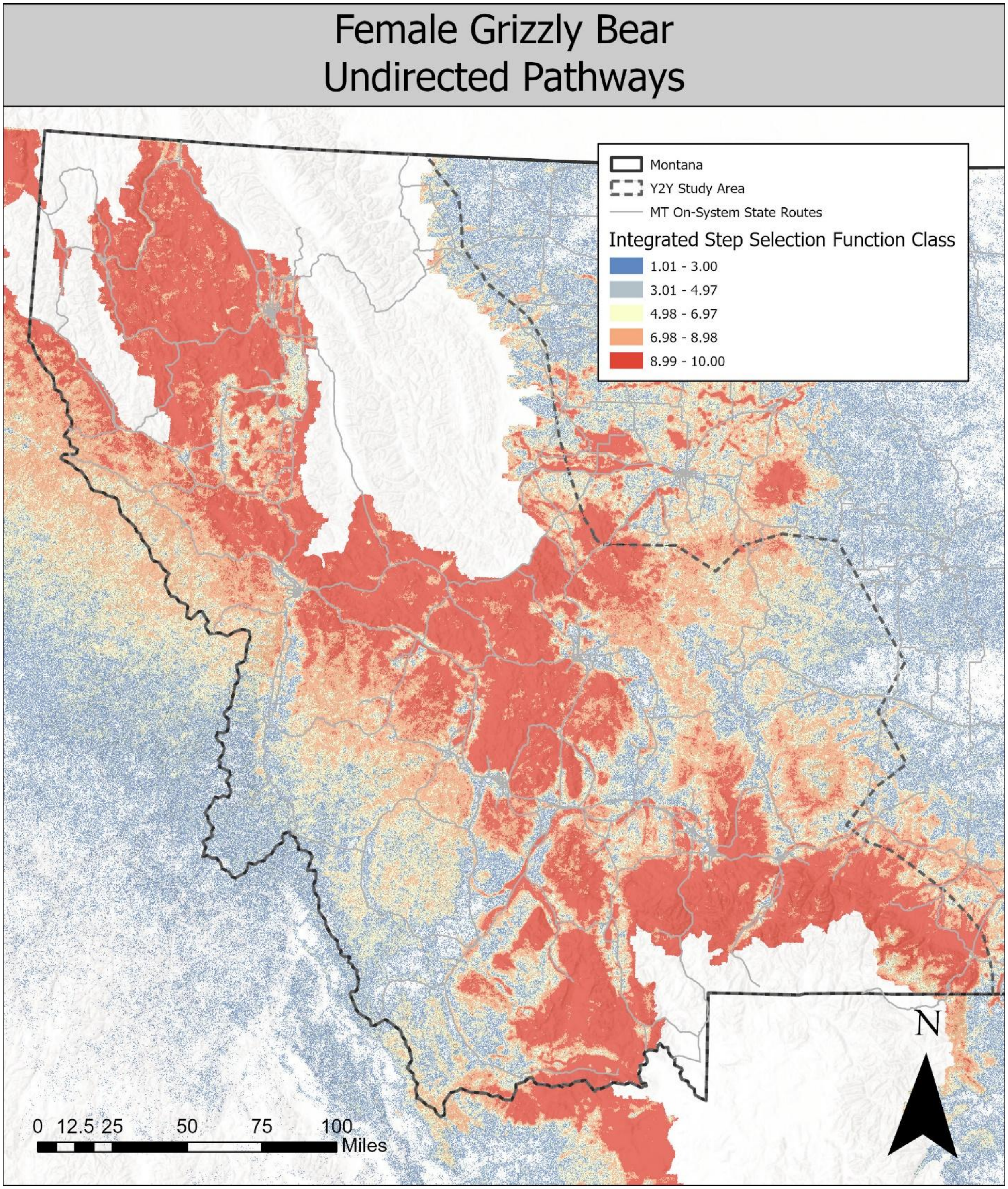


Figure 33: Predicted undirected pathways for female grizzly bears near the occupied recovery zones in the Y2Y area in Montana (Sells et al., 2023b). Red areas represent relatively high predicted use, blue areas represent relatively low predicted use.

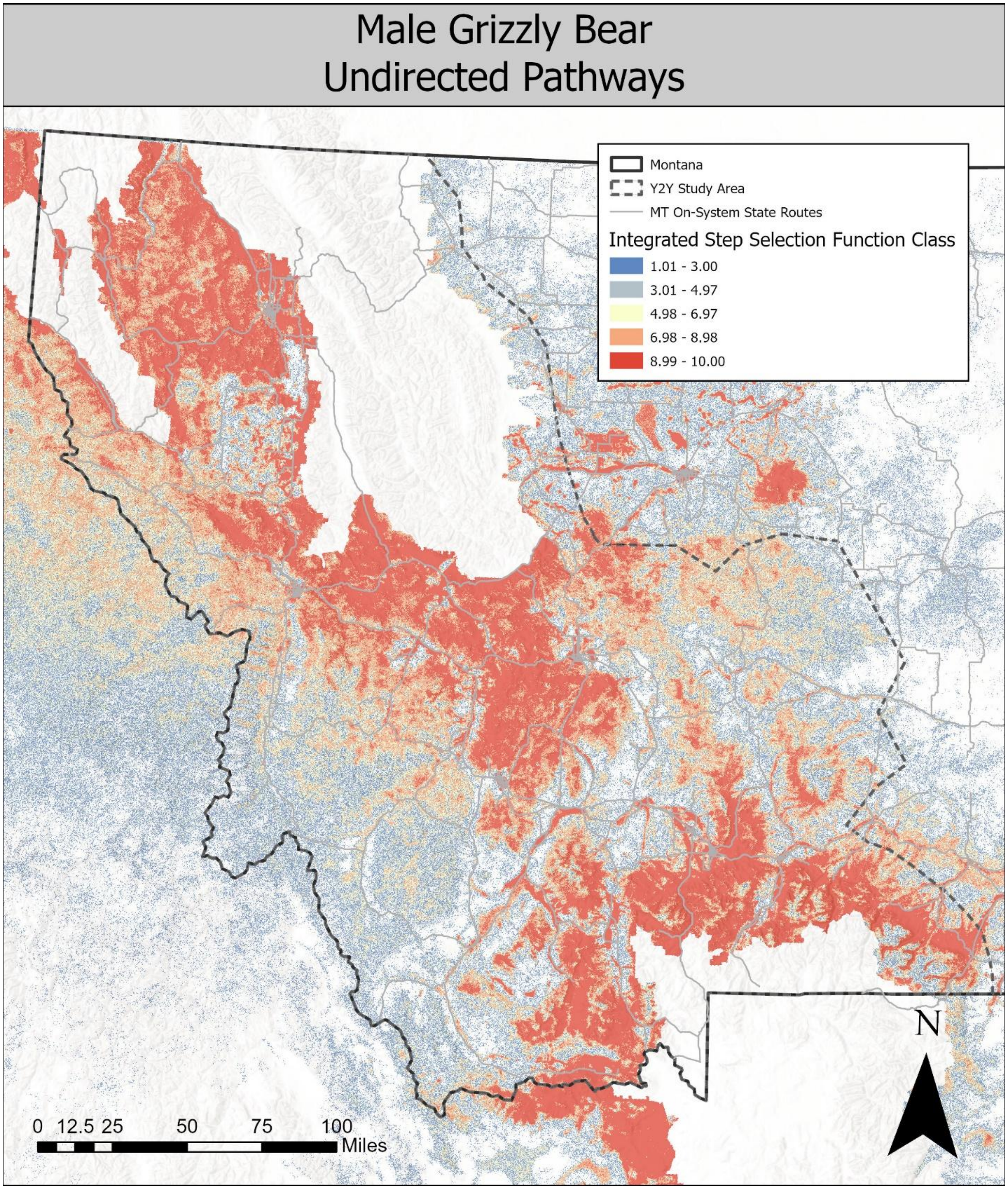


Figure 34: Predicted undirected pathways for male grizzly bears near the occupied recovery zones in the Y2Y area in Montana (Sells et al., 2023b). Red areas represent relatively high predicted use, blue areas represent relatively low predicted use.

The work by Sells et al. (2022; 2023a; 2023b) and Sells and Costello (2024) allows for a strategic approach for grizzly bear conservation. However, different conservation objectives result in different recommended actions. For example:

1. Objective: Achieve functional connectivity for grizzly bears between the NCDE and GYE. The combination of occupied range (Costello et al., 2025; USFWS, 2025a; 2026), watersheds where grizzly bears have been present in the previous decade (USFWS, 2021) and the modeling of both directed and undirected movements for both females and males (Sells et al., 2023b) suggest that mitigating the following road sections would need to be prioritized:
   - I-90 at Homestake Pass and the section between Whitehall-Cardwell and Cardwell Hill in combination with:
     - I-15 between Butte and Helena

     In 2024, in this area, the distance between occupied ranges from the NCDE and GYE was about 45 mi (72 km) (Costello et al., 2025; USFWS, 2026).

   - I-90 at Bozeman Pass in combination with:
     - I-15 between Helena and Cascade

     Here, in 2024 the distance was about 99 mi (159 km) between occupied ranges from the NCDE and GYE (Costello et al., 2025; USFWS, 2026).

   Additional major directed and undirected pathways (Sells et al., 2023b), occupied range (Costello et al., 2025; USFWS, 2025a), and watersheds where grizzly bears have been present in the previous decade (USFWS, 2021) suggest also mitigating the following road sections:

   - I-90 between Missoula and Deer Lodge in combination with
     - I-15 south of Butte
     - I-15 south of Dillon

     Here, in 2024 the minimum distance, following directed pathways for females, was about 85 miles (137 km) (Flint Creek Range – Madison Range), 125 mi (201 km) (Sapphire Range – Pioneer Mountains – Madison Range) or 175 mi (282 km) (Sapphire Range – Beaverhead Mountains – I-15 at Monida Pass) between occupied ranges from the NCDE and GYE (Costello et al., 2025; USFWS, 2026).

   Note that these road sections are, or are likely to be, the road sections that represent the greatest barriers to grizzly bears. However, other US Highways and Montana Highways may also represent a substantial barrier to grizzly bears and may also need to be mitigated to allow for a meaningful number of individual grizzly bears to move between the NCDE and GYE.

2. Objective: Facilitate recolonization of the BE by grizzly bears. The BE recovery zone has been estimated to potentially host a population of 200-400 grizzly bears by Servheen et al. (1991) or 321 grizzly bears by Boyce and Waller (2003). The estimated occupied range of the NCDE population slightly overlaps the northern portion of the BE (Costello et al., 2025). The combination of occupied range (Costello et al., 2025), watersheds where grizzly bears have been present in the previous decade (USFWS, 2021), and the modeling of both directed and

undirected movements for both females and males (Sells et al., 2023b) suggest that mitigating the following road sections would need to be prioritized:

- I-90 between Missoula and Drummond in combination with:
    - US Highway 93 between Lolo and Florence, potentially also just north of Lolo
    - US Highway 93 between north of Stevensville and south of Hamilton

  Here, in 2024 the distance between occupied range of the NCDE population and the BE recovery zone is 0 mi (0 km) (Costello et al., 2025; USFWS, 2026).

  Note that grizzly bears (both males and females) have crossed to south of I-90 in recent years. Here, the first female with cub was observed south of I-90 in 2018, and females with cubs are present in this area just north of I-90 (Pers. Com. Jennifer Fortin-Noreus, formerly senior wildlife biologist with USFWS, Pers. Com. James Jonkel, Montana Fish, Wildlife & Parks). This means that this section of I-90 is the most likely section to have females (potentially with cubs) continue to cross I-90, currently and in the immediate future.

- I-90 between Missoula and Cyr (includes the Sixmile and Ninemile areas) in combination with:
    - US Highway 12 between Lolo and Lolo Pass (though this section of US Highway 12 is not a substantial barrier to grizzly bears based on traffic volume, see later).

  Here, the distance between occupied range of the NCDE population and the BE recovery zone is or 0 mi (0 km) (USFWS, 2024a; Costello et al., 2025; USFWS, 2026).

  Note that grizzly bears have crossed I-90 west of Missoula in recent years. However, the nearest females with cubs from the CY recovery zone are north of Montana Highway 200 (at least 16 mi (26 km) from I-90) (Pers. Com. Jennifer Fortin-Noreus, formerly senior wildlife biologist with USFWS). Nonetheless, there are females south of Montana Highway 200 further west between Trout Creek and the border with Idaho (Pers. Com. Jennifer Fortin-Noreus, formerly senior wildlife biologist with USFWS). Females with cubs from the NCDE population north of I-90 may be closer, likely just east of US Highway 93 in the Evaro area (9 mi (14 km) from I-90). This means that this section of I-90, at least compared to the section between Missoula and Deer Lodge, is less likely to have females (potentially with cubs) cross I-90, currently and in the immediate future.

6.3 Canada lynx

Areas occupied by Canada lynx in Montana are primarily in the Northern Cabinet-Yaak Ecosystem, Glacier National Park and the areas south of there, including the Seeley-Swan, and in the Greater Yellowstone Ecosystem (Olson et al., 2021). However, there are other areas in Montana with predicted habitat for Canada Lynx (Olson et al., 2021) (Figure 35). This includes portions of the Bitterroot Mountains, the Sapphire Mountains, the Beaverhead Mountains, the Garnet Range, the Nevada Mountains, the John Long Mountains, and the Flint Creek Range.

Likely corridors for Canada lynx were only modeled for northwest Montana, north of I-90 (Squires et al., 2013) (Figure 36). Roads through the northern portions of the CYE and roads through the NCDE all bisect potential dispersal corridors for Canada lynx. However, for lynx in the Seeley-Swan area to reach suitable habitat south of I-90, mitigation along I-90 between Missoula and Deer Lodge may need to be implemented (Figure 35). If the northern Sapphire Mountains and adjacent ranges are occupied by Canada lynx, they could potentially disperse west to the Bitterroot Mountains. The Bitterroot Mountains may also be reached by animals from the CYE with the Ninemile area as a stepping stone (Figure 35).

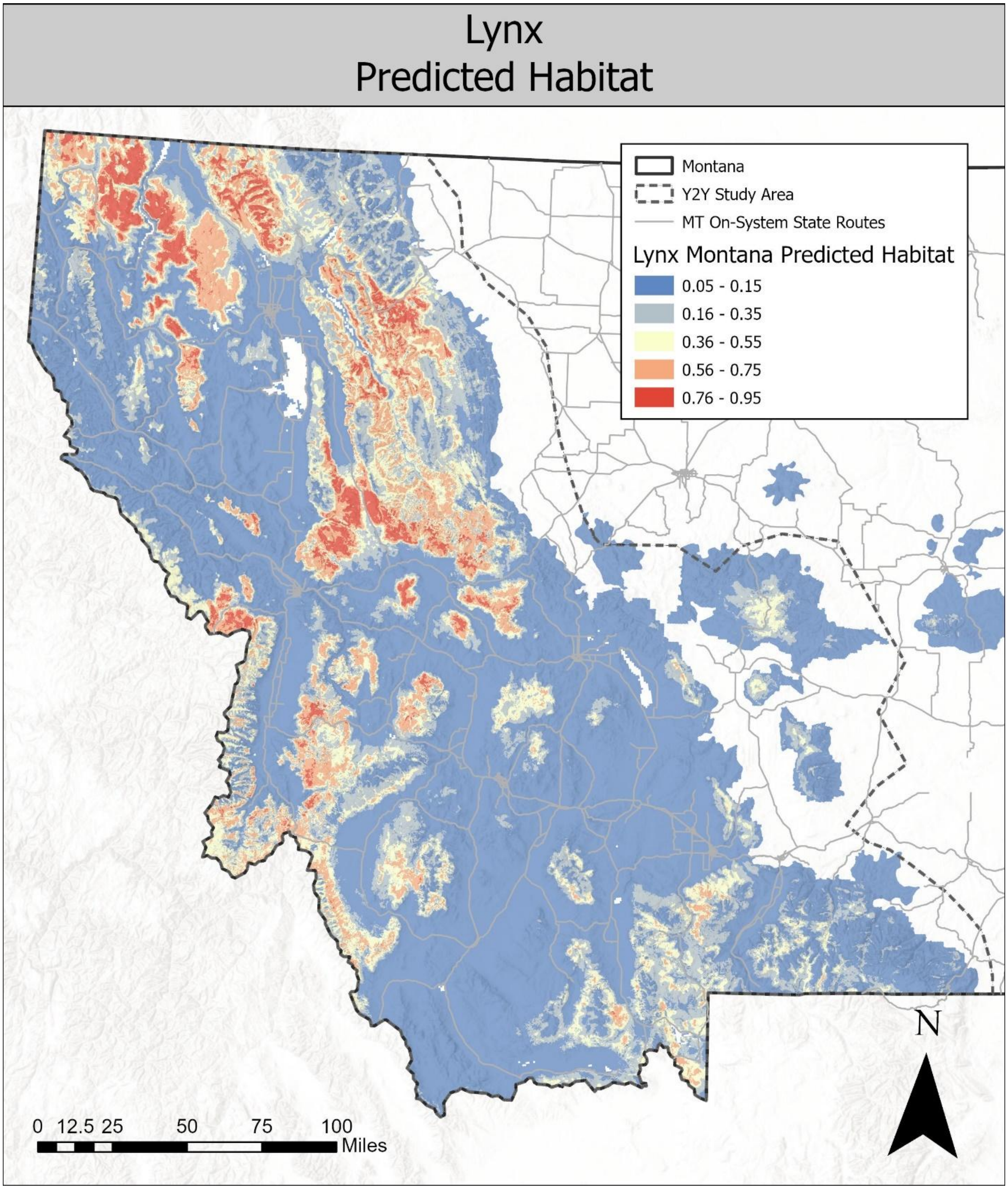


Figure 35: Predicted Canada lynx habitat probability in the Y2Y area in Montana (Olson et al., 2021). Red areas represent relatively high predicted habitat probability, blue areas represent relatively low predicted habitat probability.

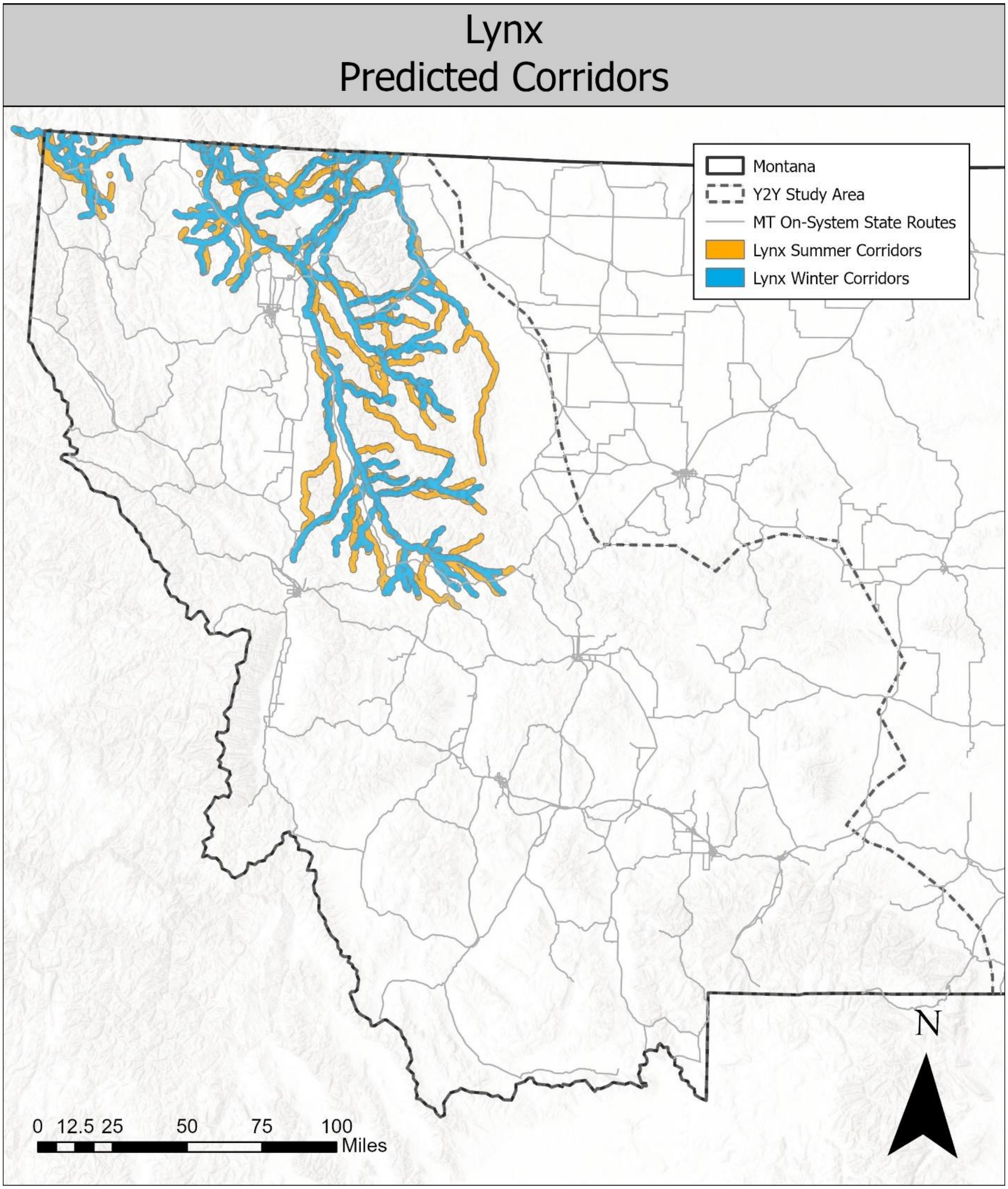


Figure 36: Predicted Canada lynx corridors in summer and winter in northwest Montana (Squires et al., 2023).

6.4 Wolverine

Wolverines are present in remote high elevation areas in western Montana (Lukacs et al., 2020). Specifically, wolverines are present in the CYE, NCDE, BE, GYE, Little Belt Mountains, the Sapphire Range, and the mountain ranges further east (John Long Mountains, Flint Creek Range) and further south (Pioneer Mountains, Beaverhead Mountains) (Lukacs et al., 2020). Predicted wolverine habitat within the Y2Y area in Montana was obtained from MTFWP (2025a) (Figure 37).

When dispersing, wolverines can move through lower quality habitat to reach other high-quality habitat in remote high-elevation areas (Carroll et al., 2020). While predicted wolverine corridors cross many roads in western Montana (Figure 38), the most important predicted corridors along I-90 are:

- From the Idaho border to Tarkio
- Between Bonner and Clinton
- Homestake Pass
- Bozeman Pass

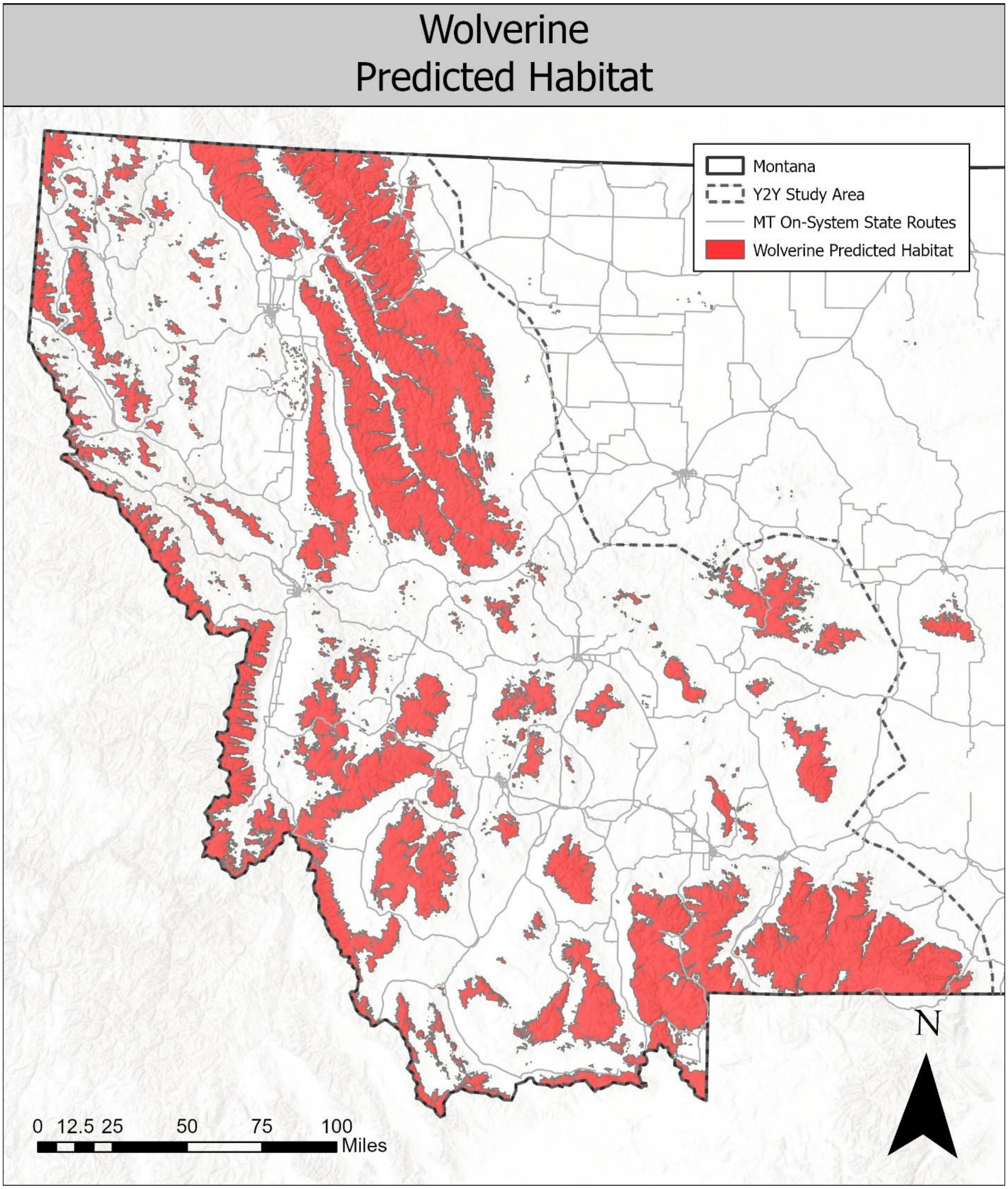


Figure 37: Predicted wolverine habitat in the Y2Y area in Montana (MTFWP 2025a).

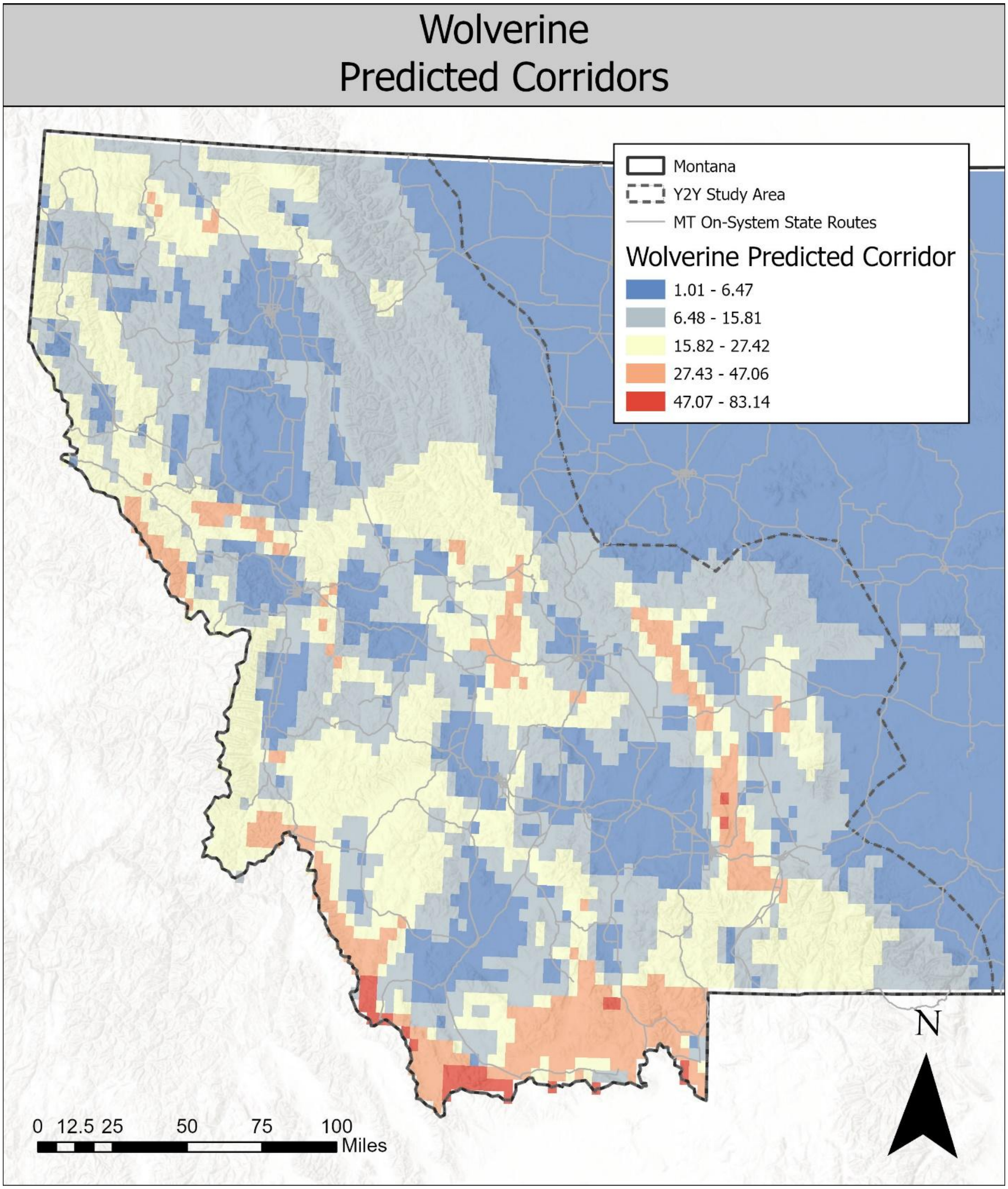


Figure 38: Predicted wolverine corridors (yellow, light red and dark red) in Y2Y area in Montana (Carroll et al., 2020).

7 Distribution of selected other large mammal species

In the previous chapter we summarized existing information on the habitat and corridors for grizzly bear, Canada lynx, and wolverine. In this chapter we summarize existing information on the current distribution of selected other large wild mammals in the Y2Y area in Montana (MTFWP, 2025b). The species include white-tailed deer, mule deer, elk, moose, pronghorn, bighorn sheep, bison, mountain lion and gray wolf. For most species the data differentiated between summer and winter habitat (Figure 39, Figure 40, Figure 41, Figure 42, Figure 43, Figure 44, Figure 45, Figure 46, Figure 47).

The distribution of most species on the maps in this chapter does not show potential presence in National Parks (Glacier National Park, Yellowstone National Park) and Native American Reservations (Flathead Indian Reservation and Blackfeet Indian Reservation). Thus, the absence of these species in these areas does not mean that these species do not occur in these areas. The distribution maps relate to free roaming wild species and do not include game farms or areas in which the species is fenced in (e.g. The Bison Range). White-tailed deer, mule deer, elk, moose, mountain lion and gray wolf are widely spread; they occur, or can occur, almost along the entire length of I-90 in the Y2Y area in Montana. Pronghorn have a much more restricted range. Along I-90, they occur:

- From just west of Drummond to west of Butte. Note that pronghorn mostly occur north of I-90 and that I-90 appears to be a near-absolute barrier to their movements along most of this road section. They do have summer habitat on both sides of I-90 between just north of Anaconda and just west of Butte, suggesting that the cross here in summer, and potentially also to move between summer and winter habitat. At least 2 roadkilled pronghorn have been observed here (winter in early 2025, early 2026 at mile reference post 208.1) (Pers. com. Marcel Huijser). Pronghorn are also present here on both sides of I-90, at least in winter (Pers. com. Marcel Huijser). Pronghorn also have winter habitat south of I-90 south of Drummond and east of Hall. It appears that these animals cross I-90 just east of Drummond, an area that has been fenced with a large ungulate fence in 2025 (completed in August 2025) (Pers. com. Marcel Huijser). This suggests that access to this winter habitat may now have been cut off.
- Between Pipestone and Logan.
- West of Livingston until beyond Big Timber.

Bighorn sheep also have a distinct distribution. Along I-90 they occur:

- West of Alberton until Frenchtown.
- East-Missoula and Bonner (north of I-90).
- Clinton until east of Bearmouth.
- Around Garrison junction.

The distribution of bison based on the map from MTFWP was supplemented with our own knowledge and observations along roads near West Yellowstone and Gardiner. Additional free roaming bison may have access to highways near Chief Mountain on the Blackfoot Indian Reservation, but we do not have data on the geographic boundary of where those bison roam. Free roaming bison are currently not present along I-90.

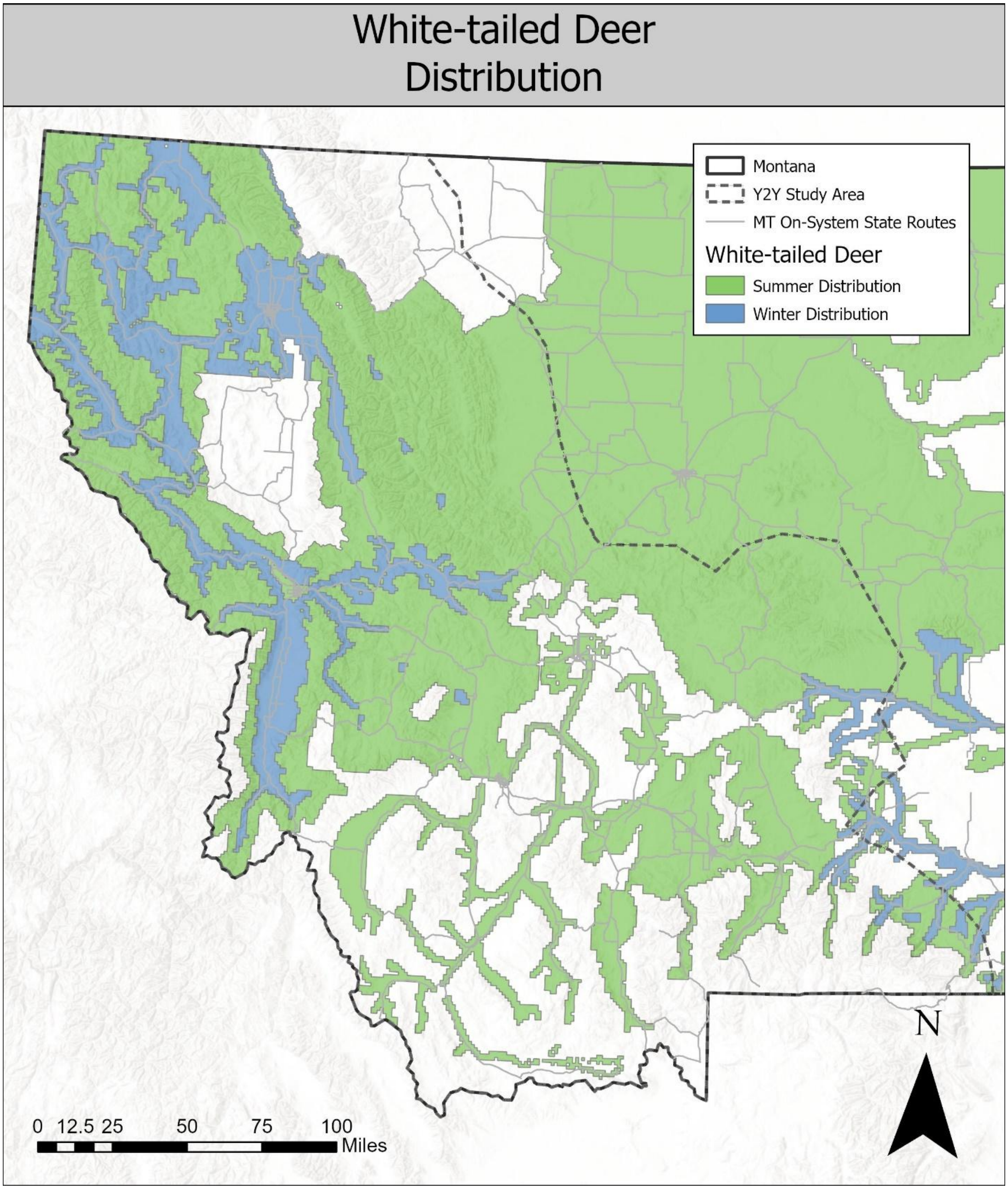


Figure 39: White-tailed deer distribution in the Y2Y area in Montana (MTFWP 2025b).

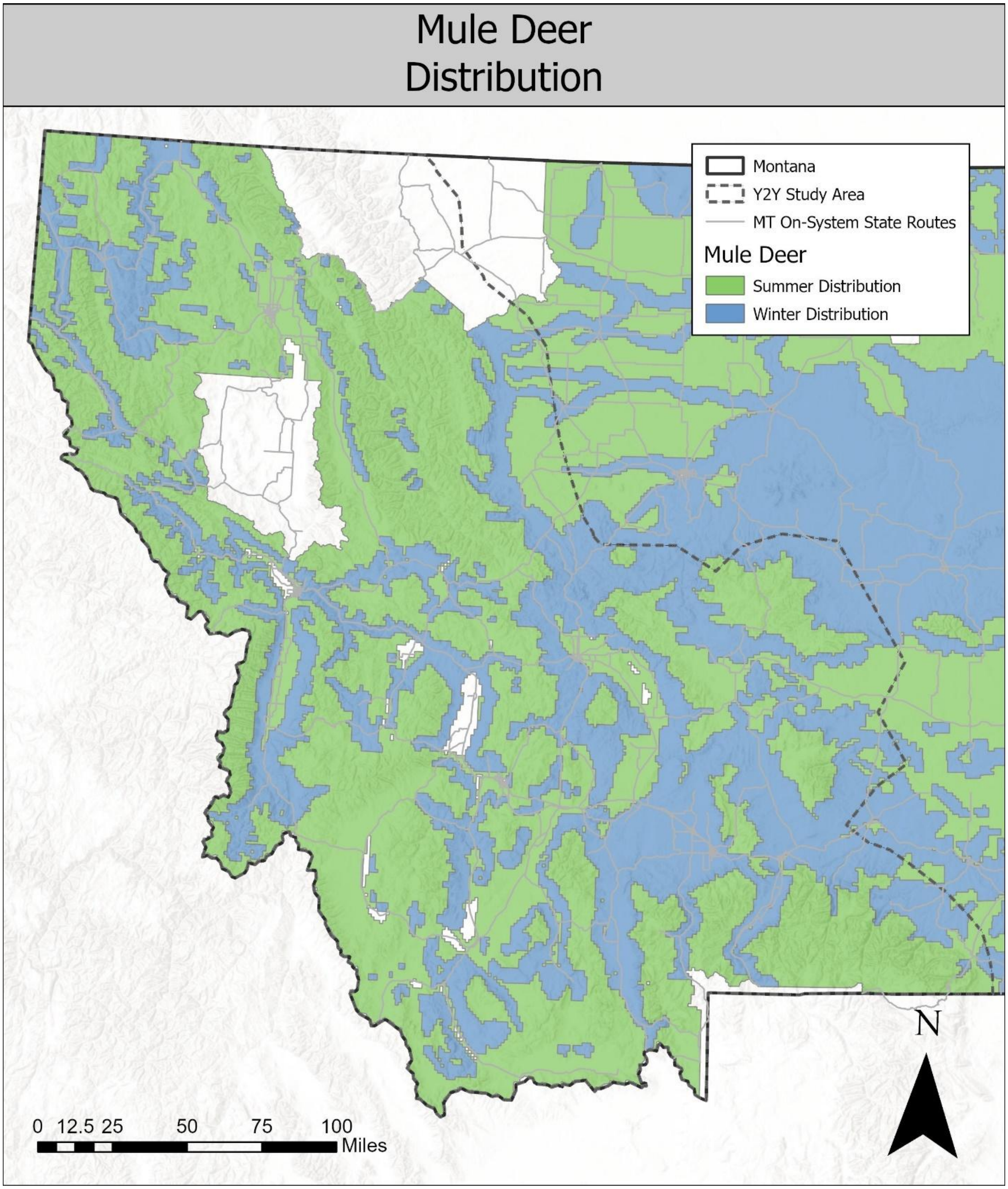


Figure 40: Mule deer distribution in the Y2Y area in Montana (MTFWP 2025b).

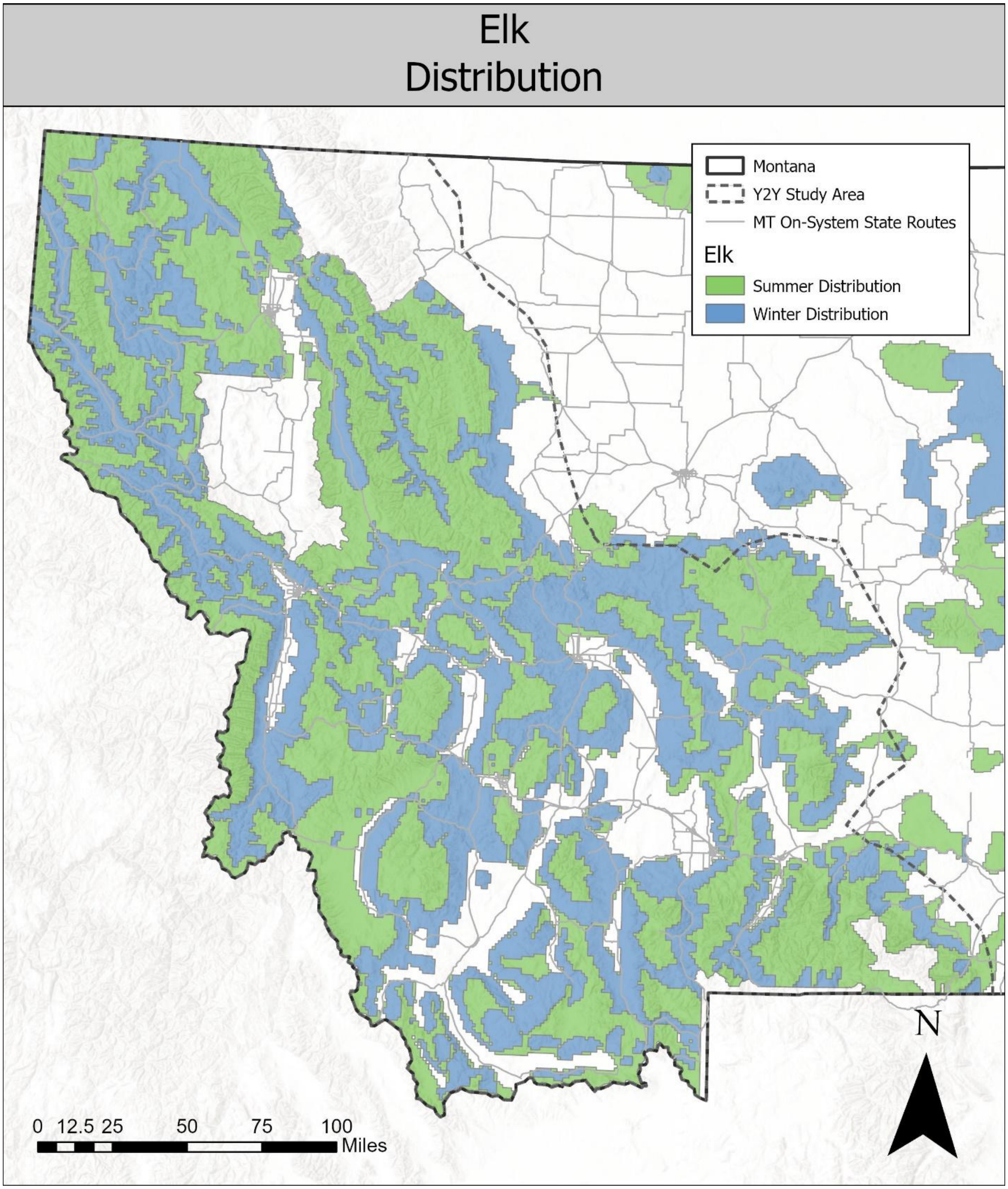


Figure 41: Elk distribution in the Y2Y area in Montana (MTFWP 2025b).

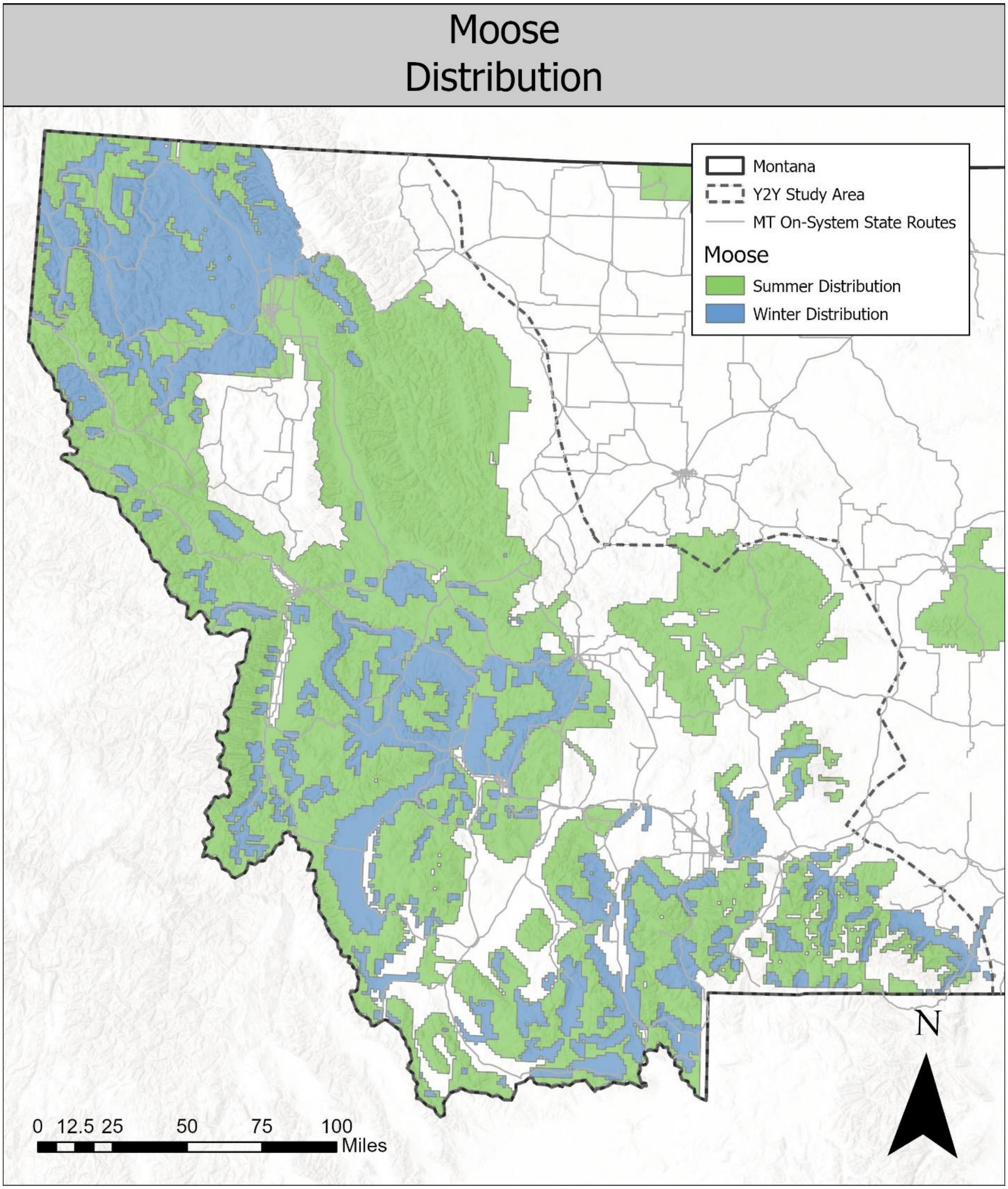


Figure 42: Moose distribution in the Y2Y area in Montana (MTFWP 2025b).

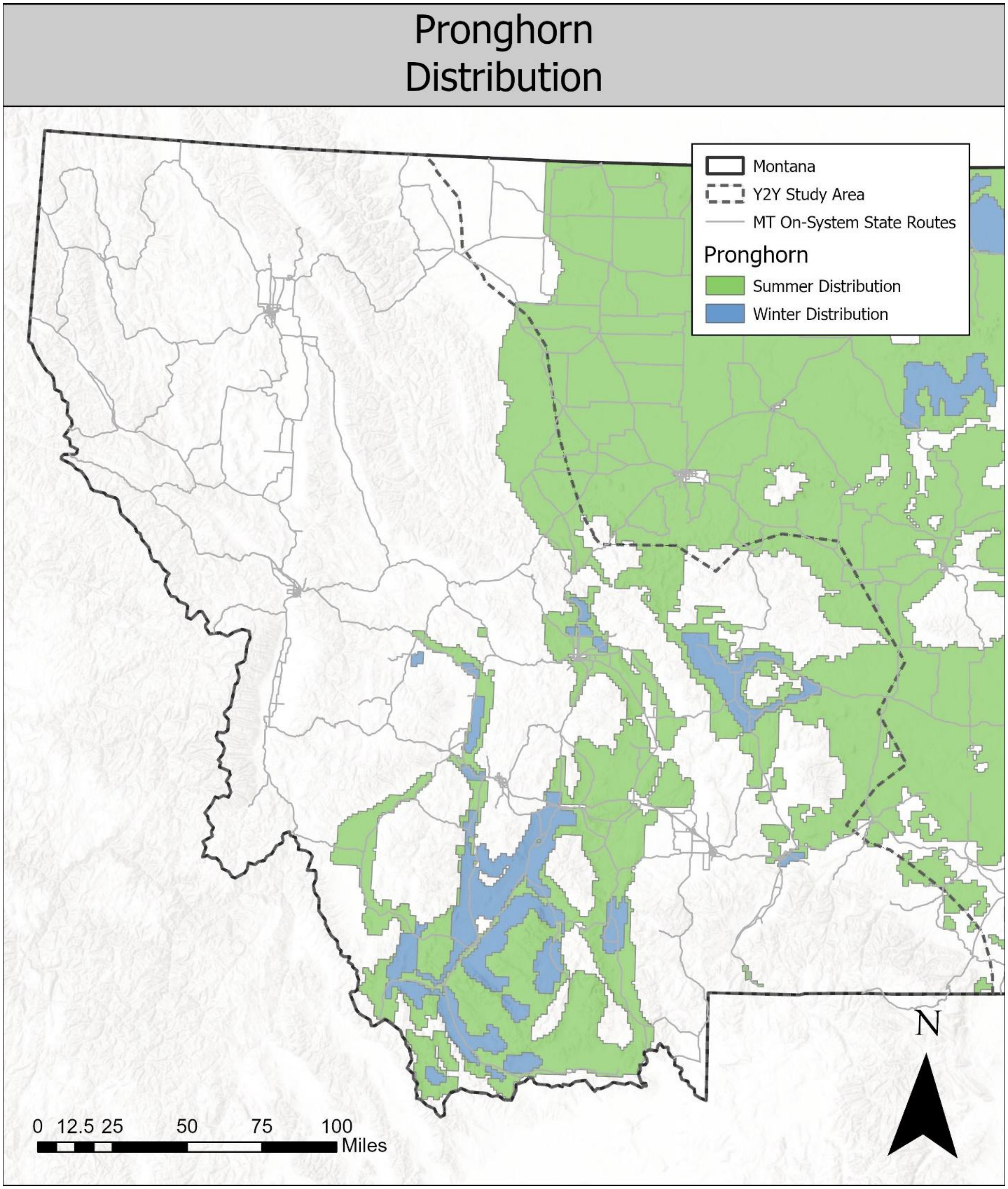


Figure 43: Pronghorn distribution in the Y2Y area in Montana (MTFWP 2025b).

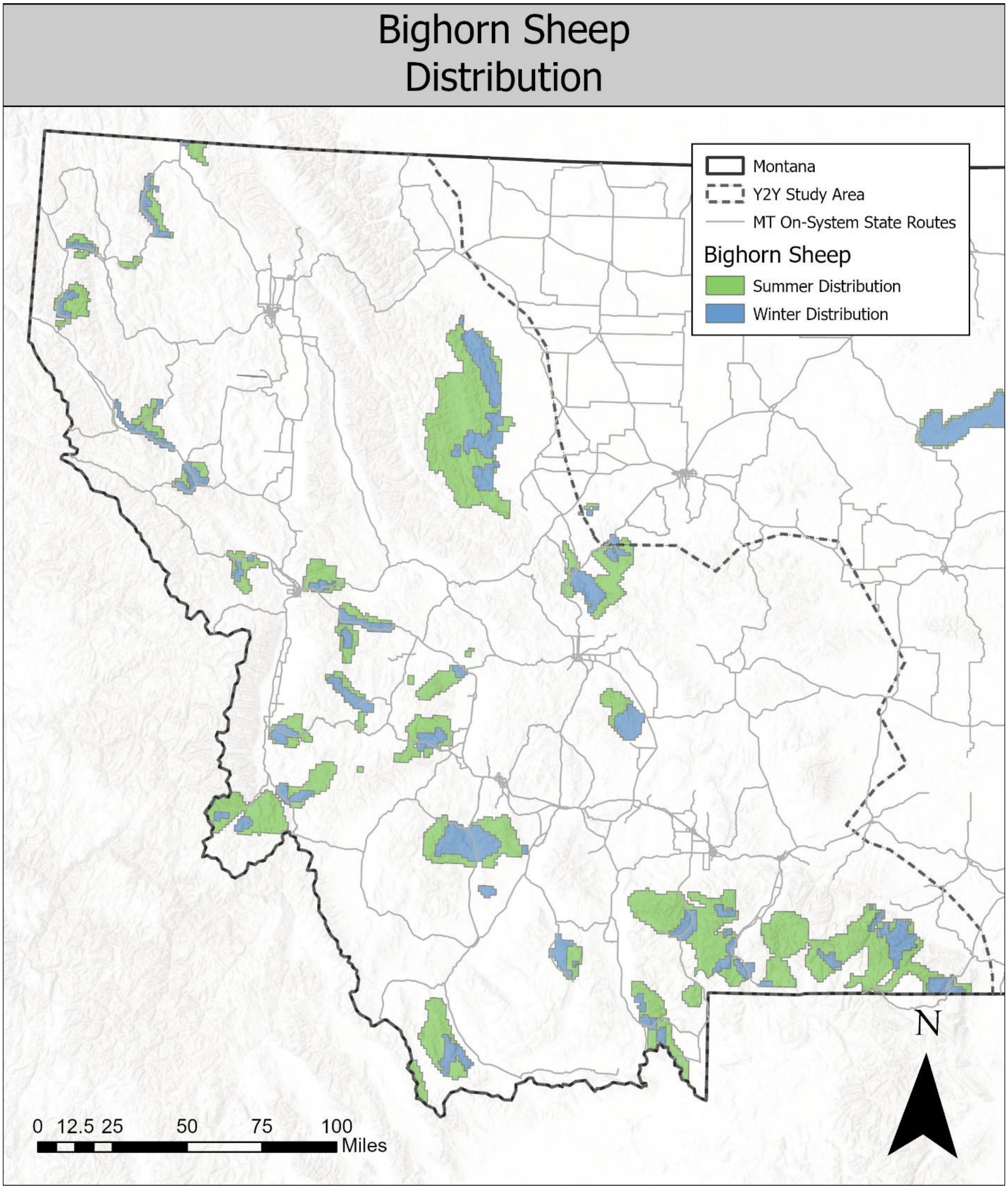


Figure 44: Bighorn sheep distribution in the Y2Y area in Montana (MTFWP 2025b).

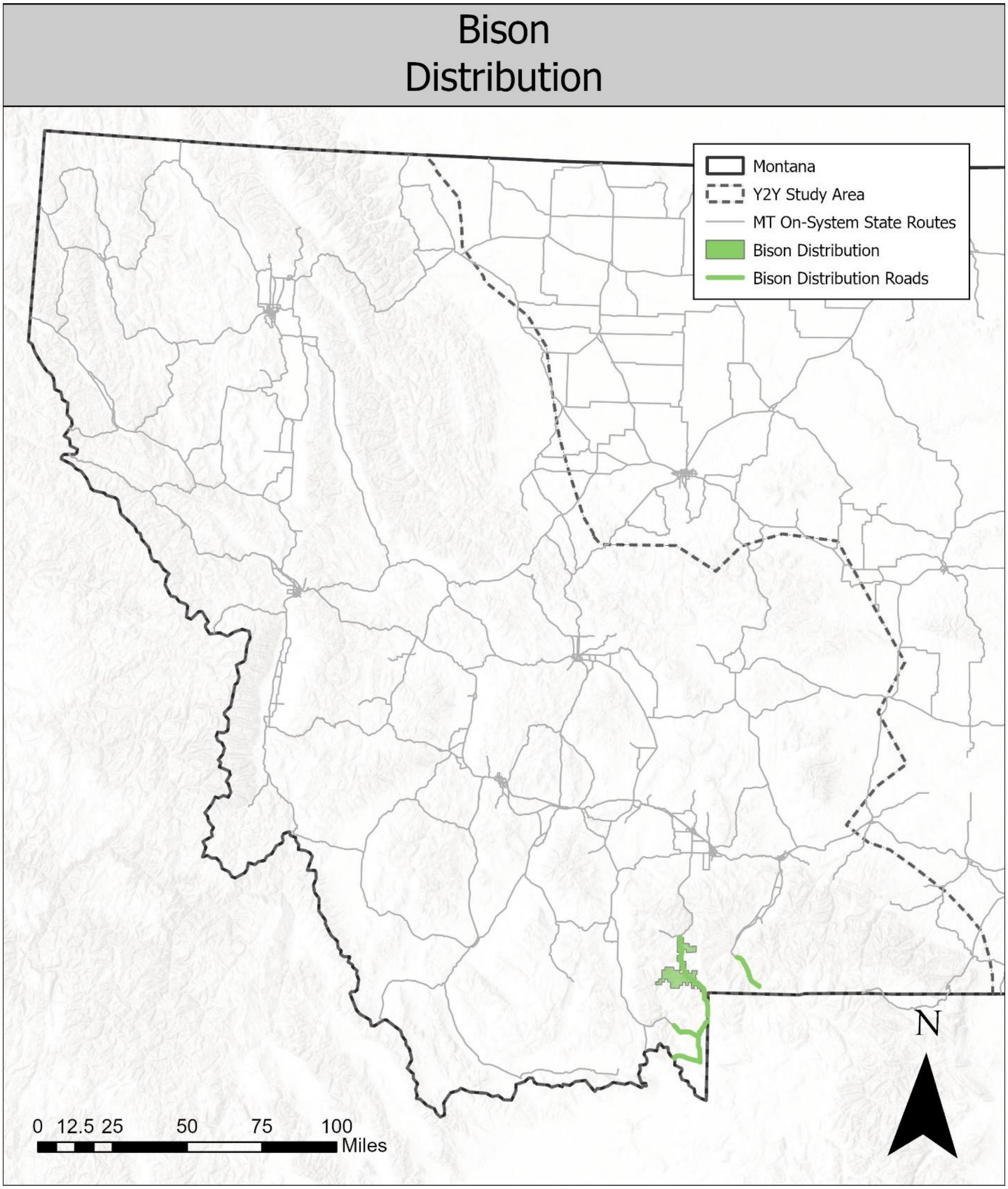


Figure 45: Bison distribution in the Y2Y area in Montana (MTFWP 2025b, Pers. com. Marcel Huijser and Matthew Bell).

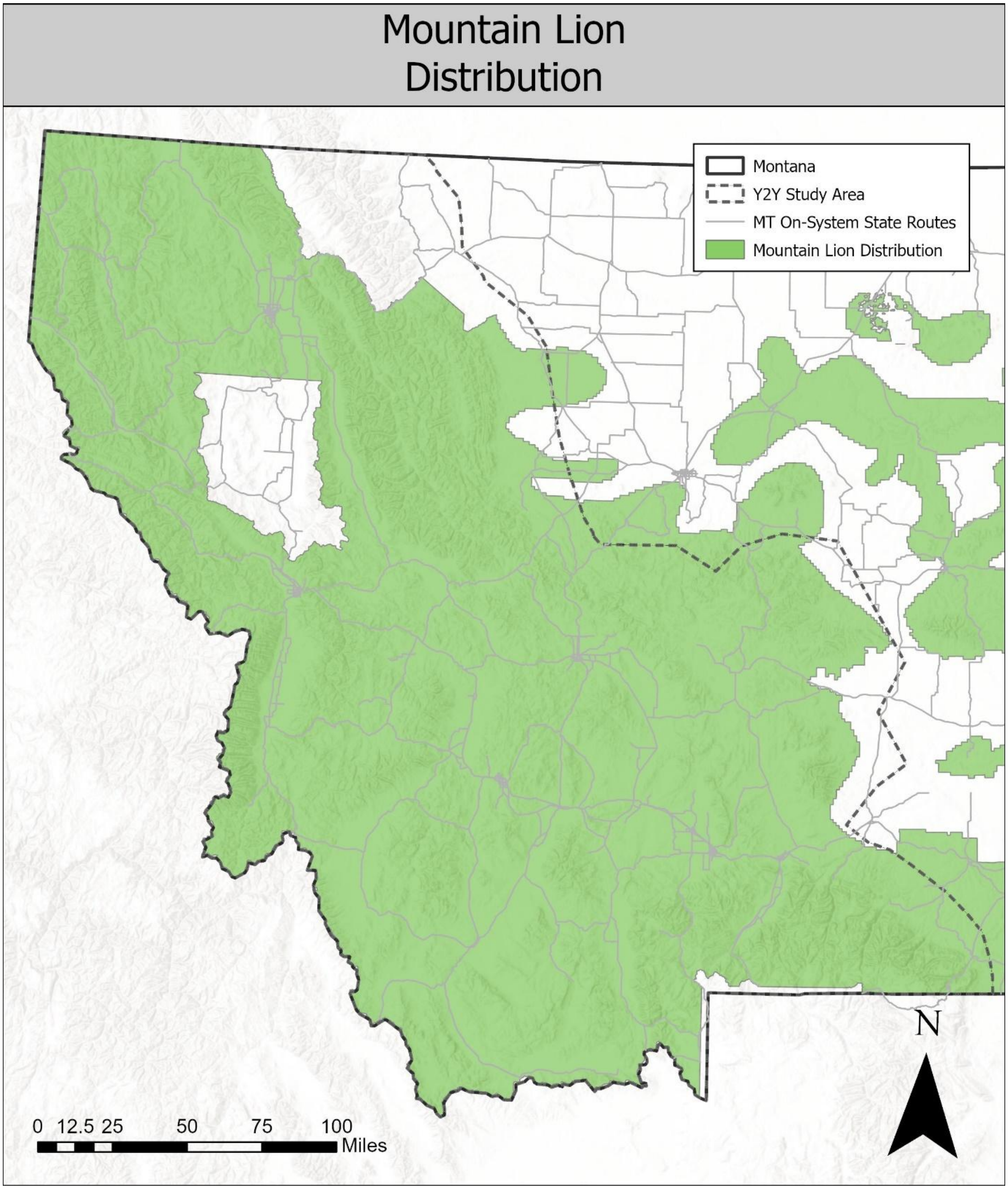


Figure 46: Mountain lion distribution in the Y2Y area in Montana (MTFWP 2025b).

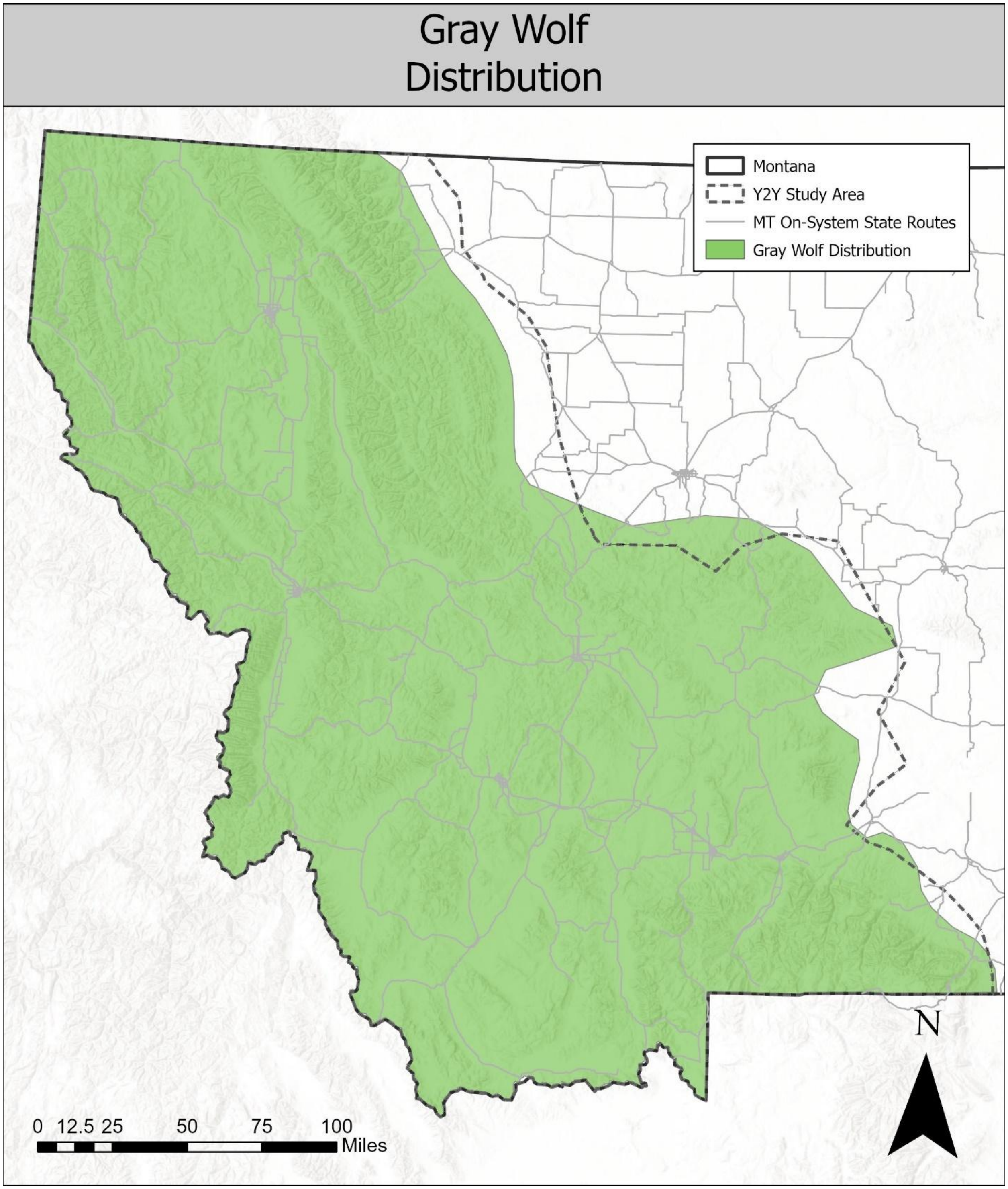


Figure 47: Gray wolf distribution in the Y2Y area in Montana (MTFWP 2025b).

8 Traffic volume as a barrier for grizzly bears

8.1 Introduction

In general, grizzly bears are more likely to cross low volume roads than high volume roads (Chruszcz et al., 2003; Waller & Servheen, 2005). Most highway crossings occur at night when highway traffic volume is lowest (Waller & Servheen, 2005; Northrup et al. 2012; Adams et al., 2023). With increasing traffic volumes, from about 10 vehicles per hour to about 100 vehicles per hour, grizzly bears were exponentially less likely to cross US Highway 2 south of Glacier National Park in Montana. With 100 vehicles per hour or more, this highway became a near-absolute barrier to grizzly bears (Waller & Servheen, 2005). With increasing traffic volume, especially at night, the periods that the highway was permeable, or somewhat permeable, for grizzly bears were shortened (Waller & Miller, 2015). In 2004, there was little evidence of genetic differentiation across the eastern portion of this highway in the NCDE, but some evidence for reduced genetic exchange across the western portion where traffic was higher (about 1,800 vehicles per day in 2016; MDT, 2023) (Kendall et al., 2009). However, genetic diversity along the edges of the occupied range of the NCDE has increased in the last few decades because of dispersal and subsequent breeding (Mikle et al., 2016). Further to the west, grizzly bears in the CYE were found to be completely isolated north and south of this same highway in 2012 (about 3,000 vehicles per day in 2016, MDT, 2023) (Kendall et al., 2016). However, as human-caused mortality was a likely driver of this population fragmentation, it is difficult to know the extent of the direct barrier effect of the highway itself. As these populations have increased in recent years, movements and gene flow across the highway have been documented (Kasworm et al., 2025). Others found that road crossings with grizzly bears were most common for roads that had 20 vehicles per 24 hours or less (Northrup et al., 2012). A highway with an average summer traffic volume of 7,000 vehicles per day was deemed a substantial barrier to grizzly bears; female movement across the highway was “negligible” while male movement was “much reduced from historic levels” (Proctor et al., 2002). Finally, in the Rocky Mountains, grizzly bears are more likely to cross a road if the habitat adjacent to the road is of high quality (e.g. valley bottom habitat) (Chruszcz et al., 2003). Highway crossing locations were flatter, closer to cover in open habitat types, and within grassland or deciduous forest vegetation types (Waller & Servheen, 2005).

We calculated the barrier effect of highways to grizzly bears based on hourly traffic volume counts in southwest Montana, south of Montana Highway 200 and including Montana Highway 200. This area was identified based on two different grizzly bear conservation objectives that both require connectivity across highways in southwest Montana (see also section 6.2).

8.2 Methods

8.2.1 Study area

We selected the Y2Y area in Montana south of Montana Highway 200. We selected all state-maintained highways in this area, including Montana Highway 200. Within this area there were two areas that were of particular interest:

- I-90 and highways both north and south of I-90 between Butte and Three Forks. This area is the most critical for achieving robust functional connectivity for grizzly bears between the NCDE and GYE, at least on relatively short term (see also section 6.2).
- I-90 and highways both north and south of I-90 east and west of Missoula. This area is the most critical for facilitating recolonization of the BE recovery zone by grizzly bears.

8.2.2 Traffic volume data

We selected traffic volume data from traffic counters managed by the Montana Department of Transportation (MDT) along the highways in the Y2Y area in Montana south of Montana Highway 200, including Montana Highway 200 (MDT, 2025a). Most of the traffic counters not only have the Average Annual Daily Traffic volume (AADT) available, but they also have hourly traffic counts (i.e., the number of vehicles per hour for each hour of the day). Only some counters have hourly counts for (nearly) every day of the year. Most counters only have hourly traffic counts for one or a few days per year (sometimes not even for every year). Whenever possible, we selected hourly traffic volume data for days in the active season for grizzly bears in Montana which we defined as between 1 April and 30 November. If hourly traffic volume data were present for multiple days in the active season for grizzly bears we selected days in the height of the summer (July-August) with a preference for mid-July. We also selected weekdays rather than weekend days whenever possible. Finally, we selected data from 2025 over earlier years, if such data were indeed available. We did not evaluate road sections at some population centers as there were many roads, and many traffic counters that only related to short road sections (a lot of work for not a lot of information), traffic volume was likely a near-absolute to absolute barrier anyway, and this is not where we would like to see grizzly bears be present to begin with because of increased possibility of human-grizzly bear conflicts. For each traffic volume counter with hourly data, we counted the number of hours (out of 24 hours) that the traffic volume (both travel directions combined) was below a certain threshold. Based on Waller & Servheen (2005), we used the following thresholds: ≤100 vehicles/hour, ≤50 vehicles/hour, ≤25 vehicles/hour, and ≤10 vehicles/hour. Based on the location of each traffic volume counter, we identified the start and end point (to the tenth of a mile (MDT, 2025b)) along the road that the traffic volume data likely related to. These start and end points were influenced by the location of the previous and the next traffic counter along that road, and intersections with other roads that were most likely to result in a substantial change in the traffic volume. We then calculated what percentage of a day a road section was a barrier to grizzly bears by dividing the number of hours out of the day that traffic counts were above a threshold by 24.

8.3 Results

With a threshold of 100 vehicles per hour, most segments of I-90 were a near-absolute or absolute barrier to grizzly bears (Figure 49, Figure 49). Some segments of I-90 west of Missoula and between Missoula and Butte were “only” a near-absolute or absolute barrier 50-75% of the day. Interestingly, this coincides where grizzly bears are known to have crossed I-90 (Figure 28). Some segments of I-15 between Butte and the border with Idaho were also a near-absolute or absolute barrier to grizzly bears.

There is one section of I-15 between the Pioneer Mountains and the Highland mountains and one section at Monida Pass that were “only” a near-absolute or absolute barrier 50-75% of the day.

When we lower the threshold at which traffic volume becomes a near-absolute barrier to 50 vehicles per hour, almost all sections of I-90 and I-15 were near-absolute or absolute barriers to grizzly bears (Figure 50). Other road sections that became a near-absolute or absolute barrier were US Highway 93, north and south of Missoula, and parts of US Highway 191 and Montana Highway 64 between Bozeman and Big Sky, US Highway 89 between Livingston and Emigrant, US Highway 20 west of West Yellowstone, US Highway 287 between Helena and Three Forks, and Montana Highway 84 between Norris and Four Corners. The map with a threshold of 100 vehicles per hour is useful to identify which road sections are absolute or near-absolute barriers for grizzly bears. The maps with lower thresholds also help identify roads that are a substantial, but not a near-absolute or absolute barrier (Figure 50, Figure 51, Figure 52, Figure 53, Figure 54, Figure 55).

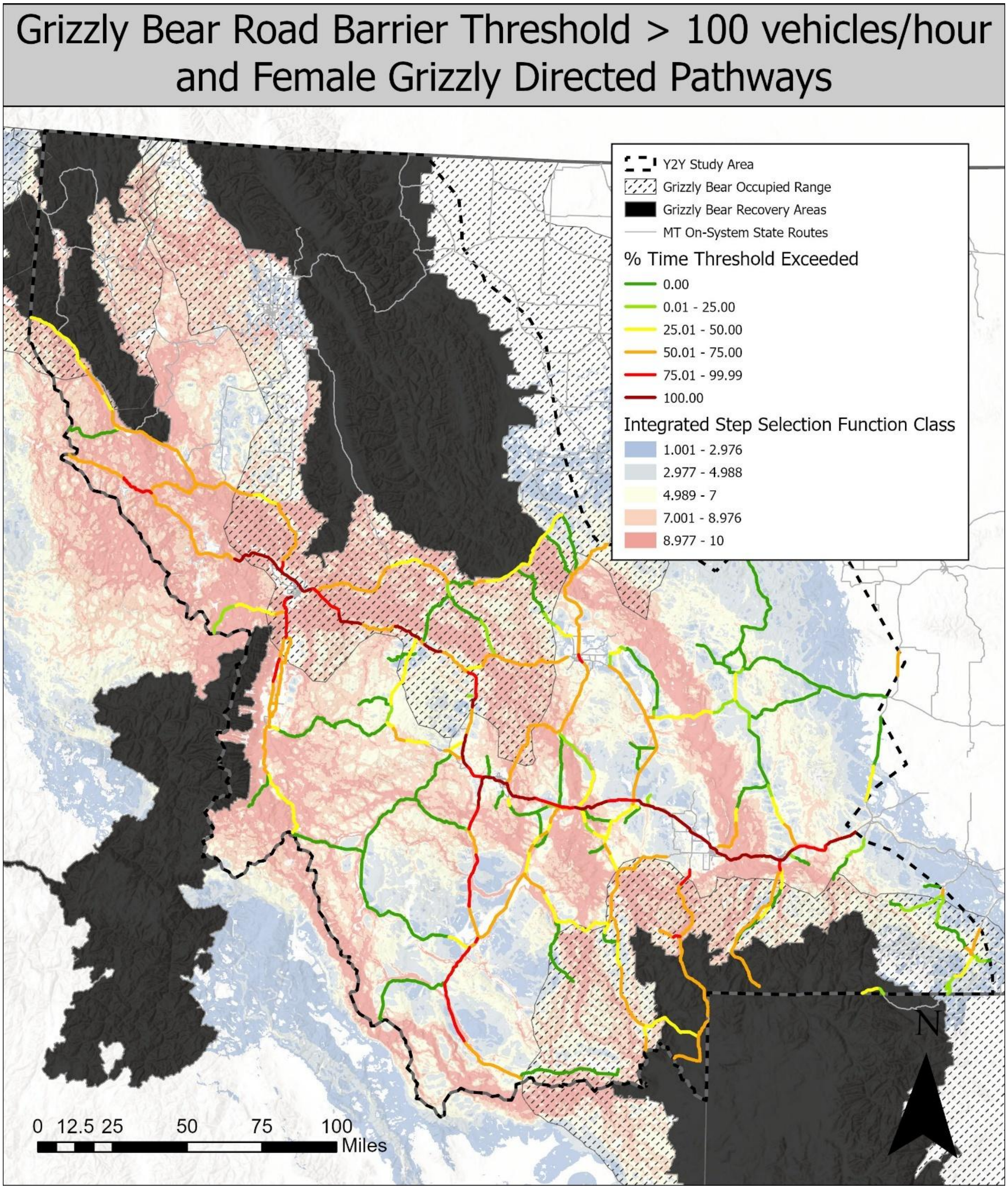


Figure 48: The barrier effect of highways to grizzly bears (threshold 100 vehicles per hour) in the Y2Y area in Montana. The background shows the recovery zones, estimated occupied range in 2024, and directed pathways by female grizzly bears.

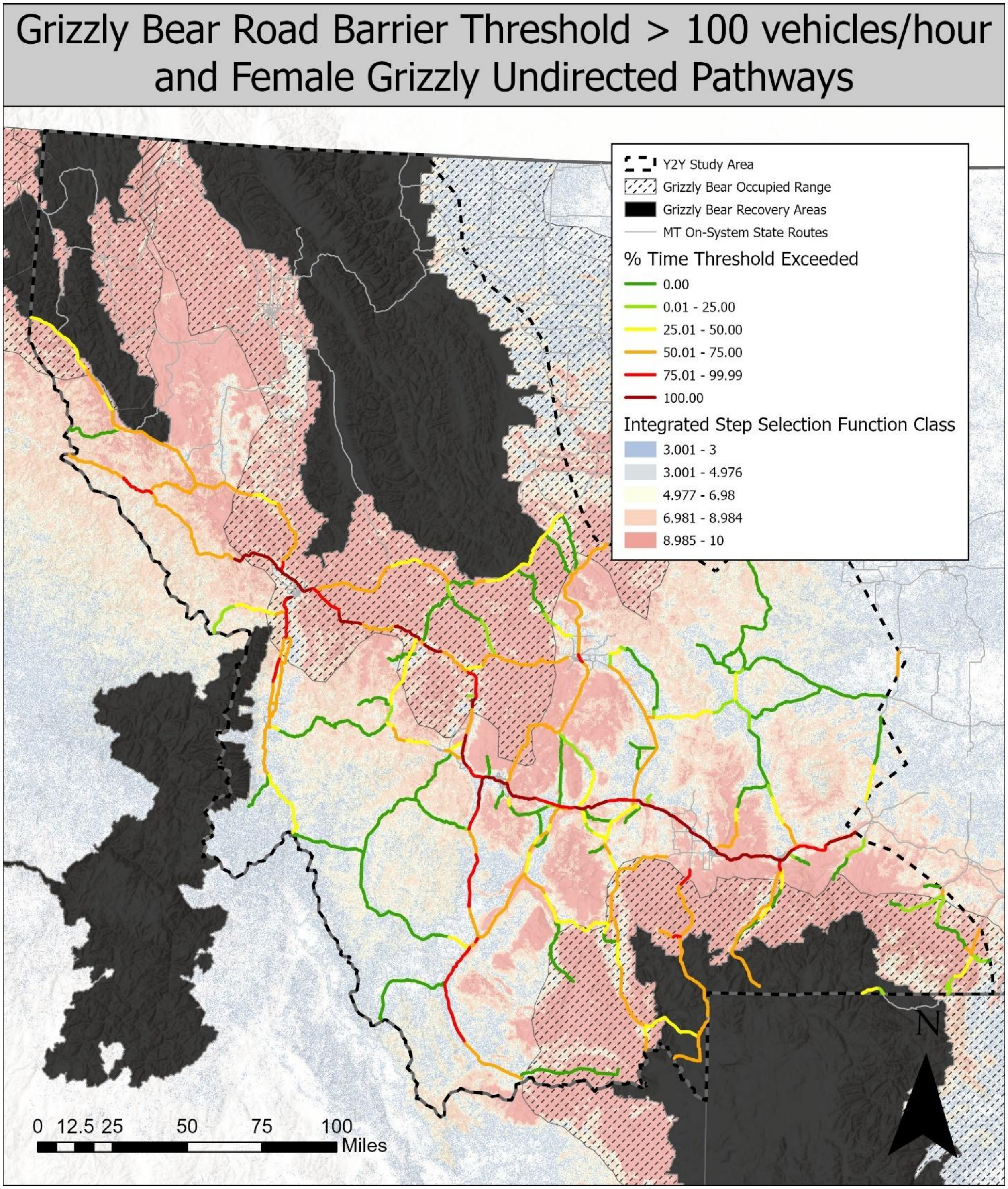


Figure 49: The barrier effect of highways to grizzly bears (threshold 100 vehicles per hour) in the Y2Y area in Montana. The background shows the recovery zones, estimated occupied range in 2024, and undirected pathways by female grizzly bears.

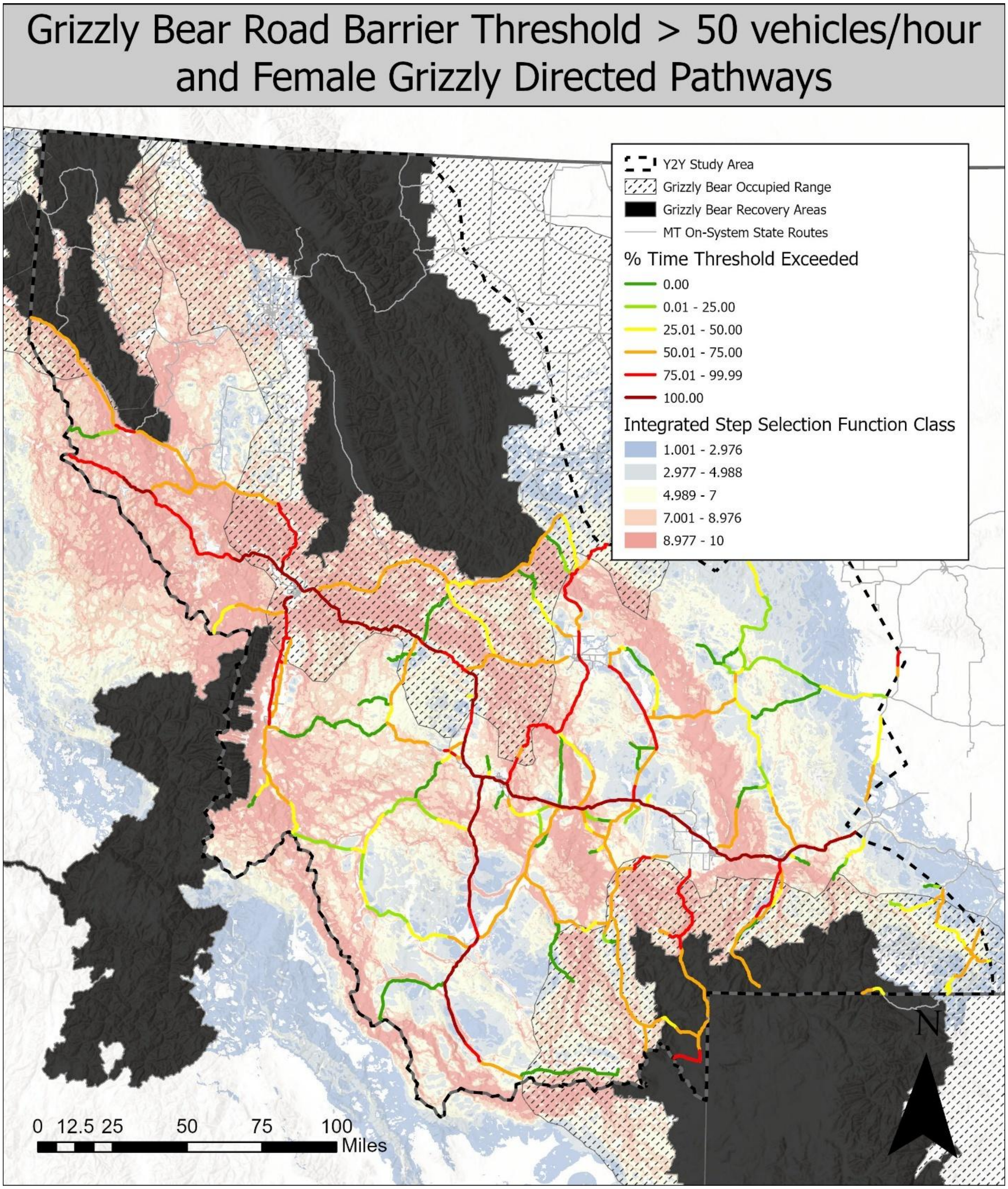


Figure 50: The barrier effect of highways to grizzly bears (threshold 50 vehicles per hour) in the Y2Y area in Montana. The background shows the recovery zones, estimated occupied range in 2024, and directed pathways by female grizzly bears.

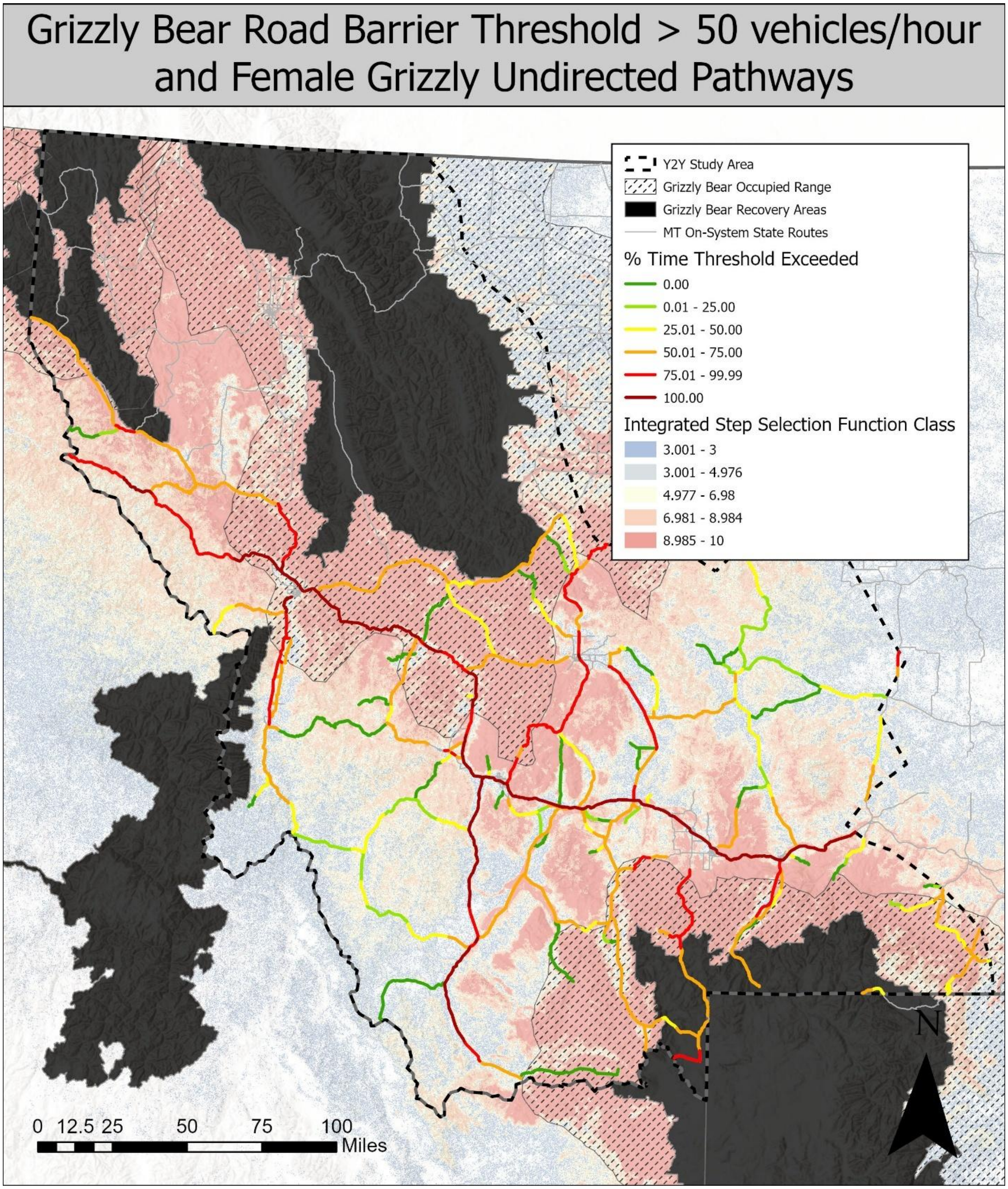


Figure 51: The barrier effect of highways to grizzly bears (threshold 50 vehicles per hour) in the Y2Y area in Montana. The background shows the recovery zones, estimated occupied range in 2024, and undirected pathways by female grizzly bears.

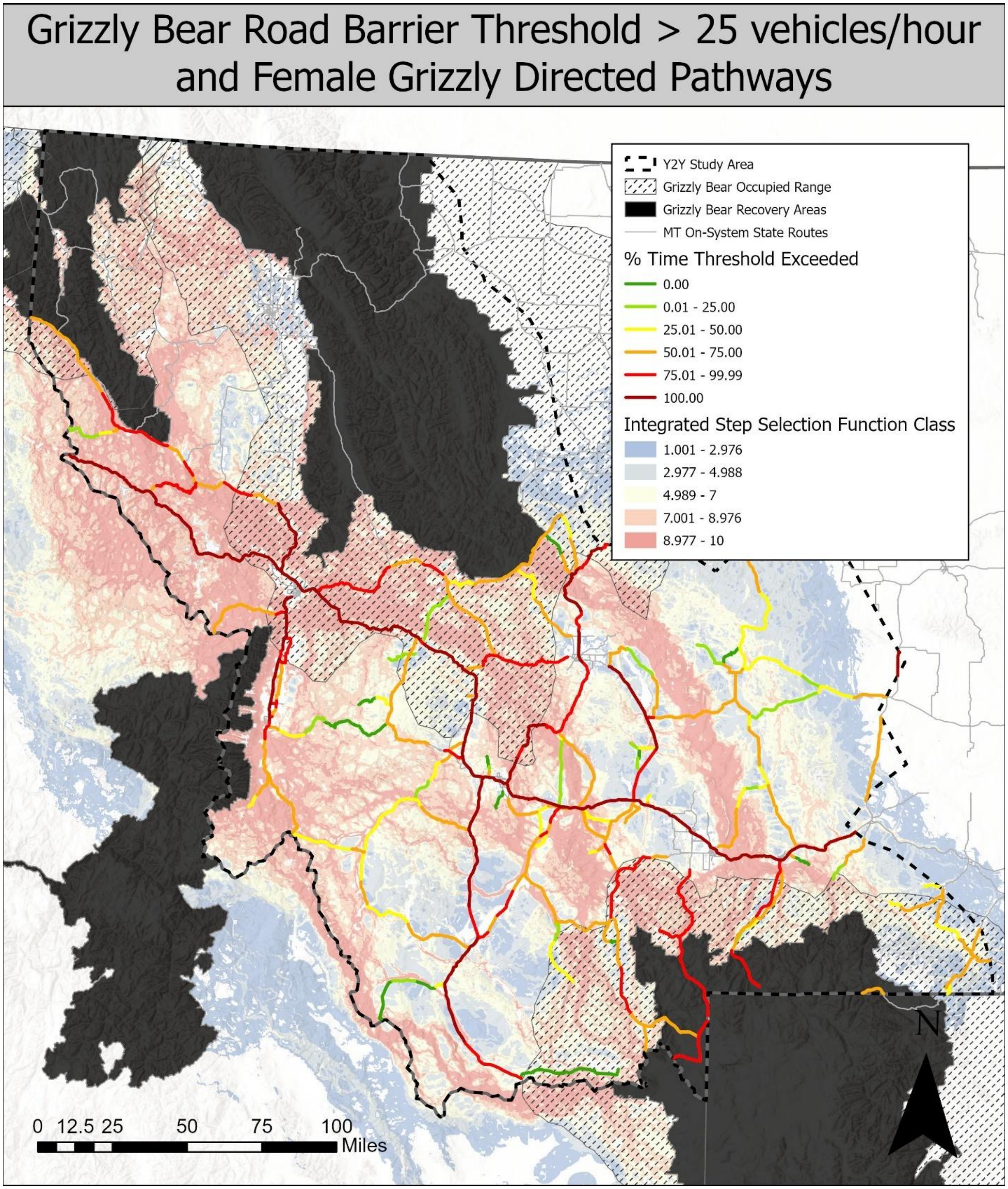


Figure 52: The barrier effect of highways to grizzly bears (threshold 25 vehicles per hour) in the Y2Y area in Montana. The background shows the recovery zones, estimated occupied range in 2024, and directed pathways by female grizzly bears.

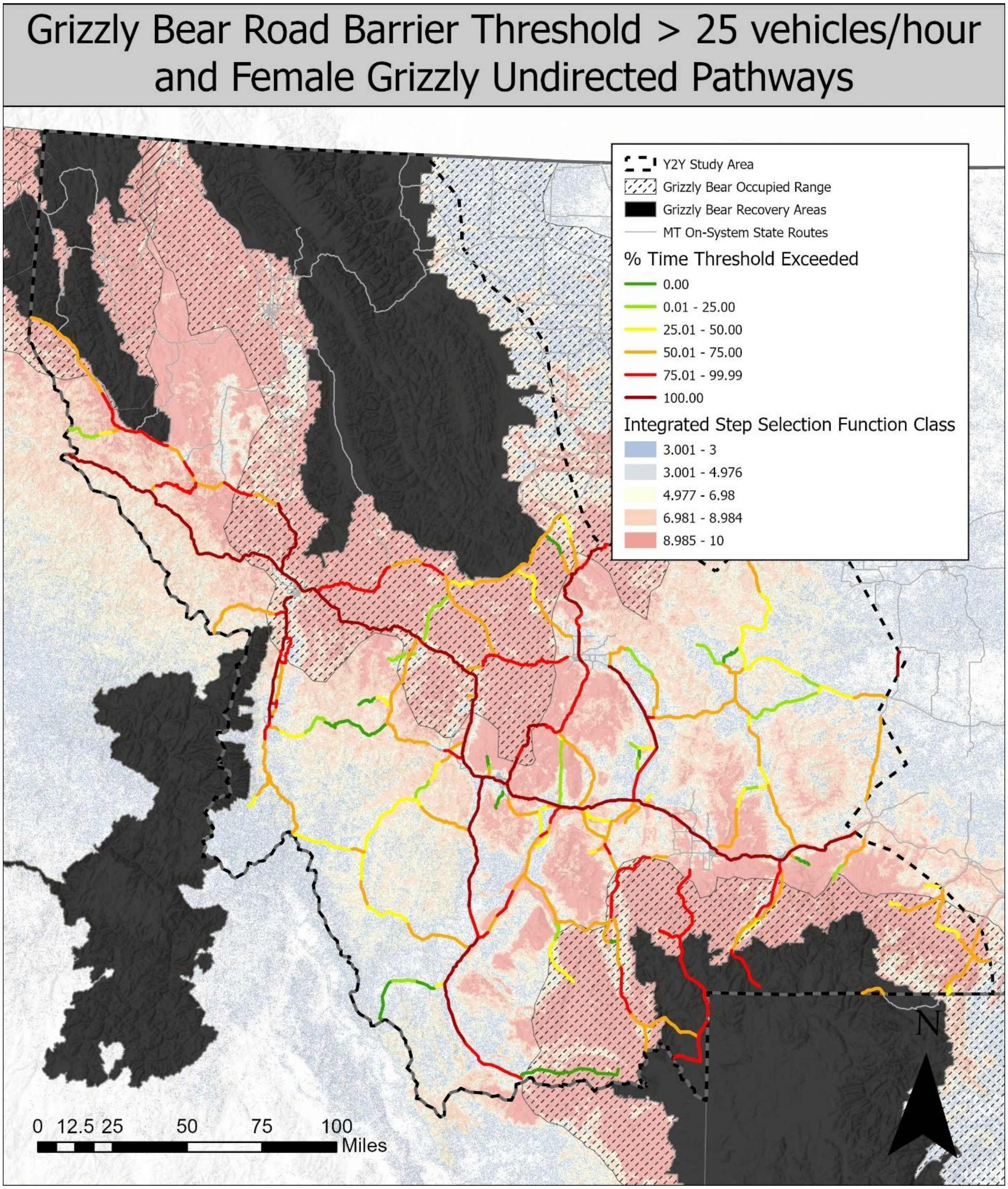


Figure 53: The barrier effect of highways to grizzly bears (threshold 25 vehicles per hour) in the Y2Y area in Montana. The background shows the recovery zones, estimated occupied range in 2024, and undirected pathways by female grizzly bears.

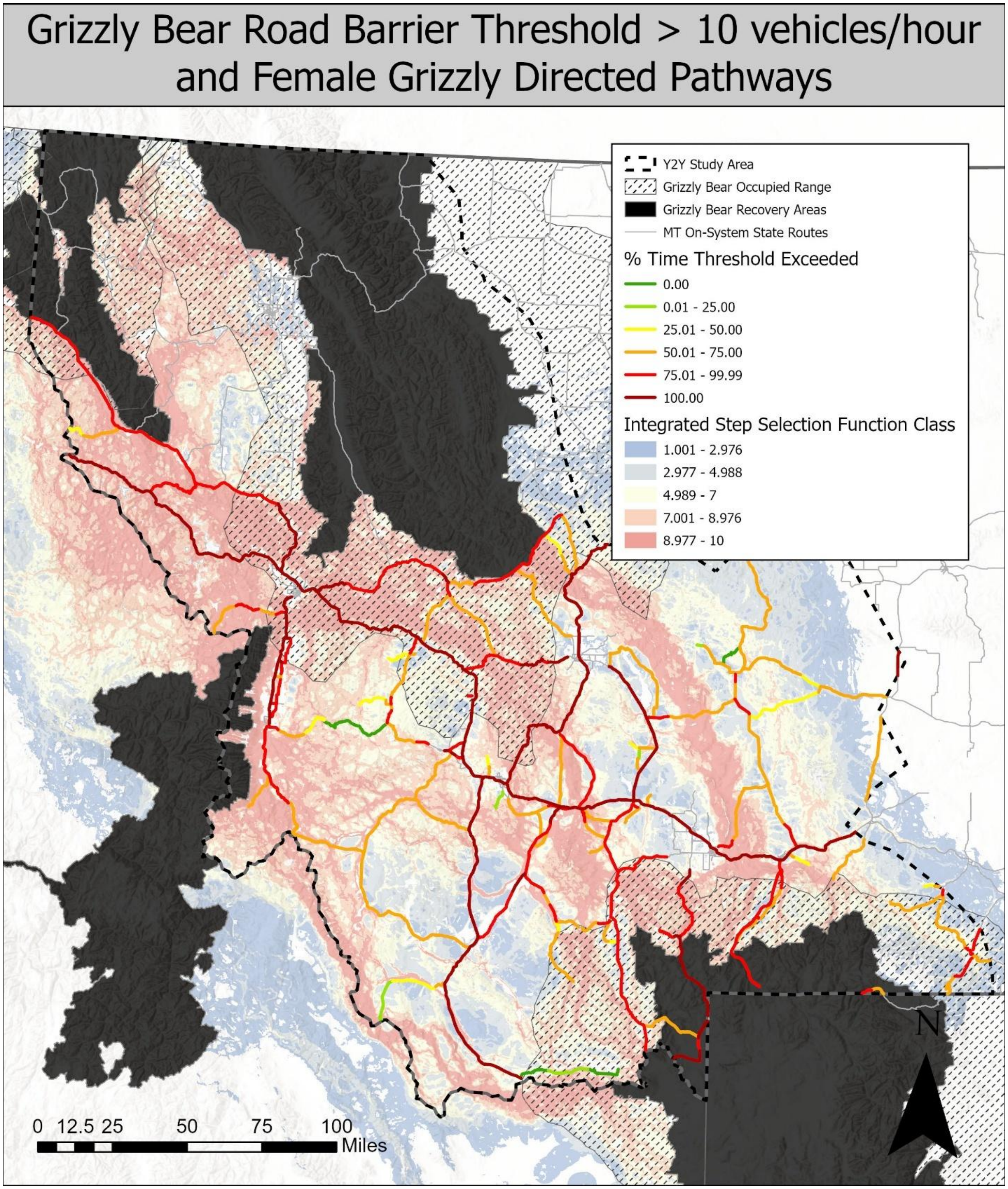


Figure 54: The barrier effect of highways to grizzly bears (threshold 10 vehicles per hour) in the Y2Y area in Montana. The background shows the recovery zones, estimated occupied range in 2024, and directed pathways by female grizzly bears.

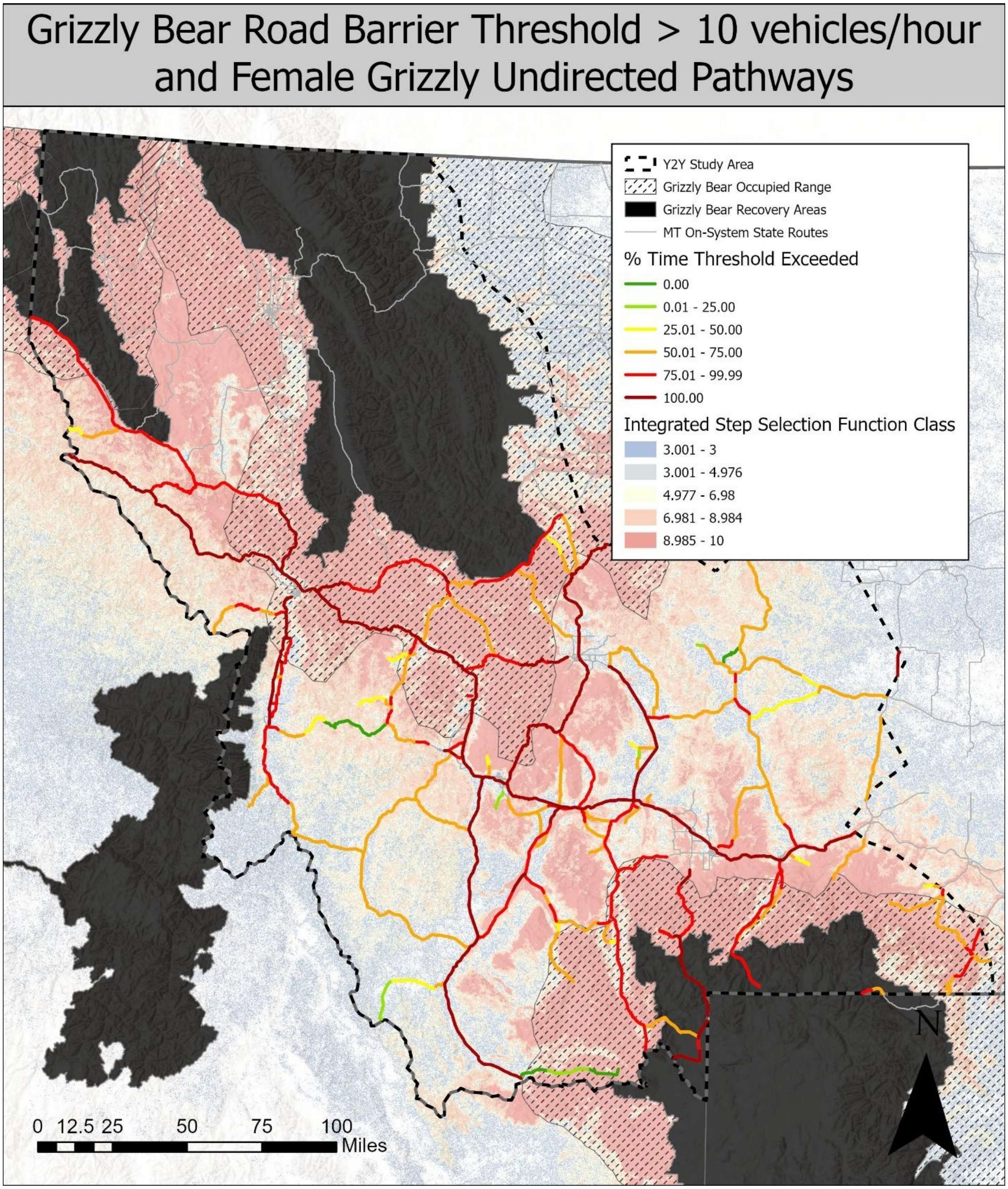


Figure 55: The barrier effect of highways to grizzly bears (threshold 10 vehicles per hour) in the Y2Y area in Montana. The background shows the recovery zones, estimated occupied range in 2024, and undirected pathways by female grizzly bears.

There were two areas that were of particular interest to us given our two objectives; 1. I-90 and highways both north and south of I-90 between Butte and Three Forks and 2. I-90 and highways both north and south of I-90 east and west of Missoula.

Within these areas we identified road sections that were a substantial barrier based on a threshold of 50 vehicles per hour (Figure 56, Figure 57, Figure 58). We indicated road sections that were a barrier to grizzly bears recolonizing areas on the other side of a highway (single arrow) and road sections that were a barrier to grizzly bears but where there is already occupied range (with or without females) present on both sides of the highway (double arrow) (see Figure 27). Note that the density of grizzly bears at the edges of their occupied range is typically much lower than towards the center of their occupied range, and that females may be absent at the edges of the occupied range.

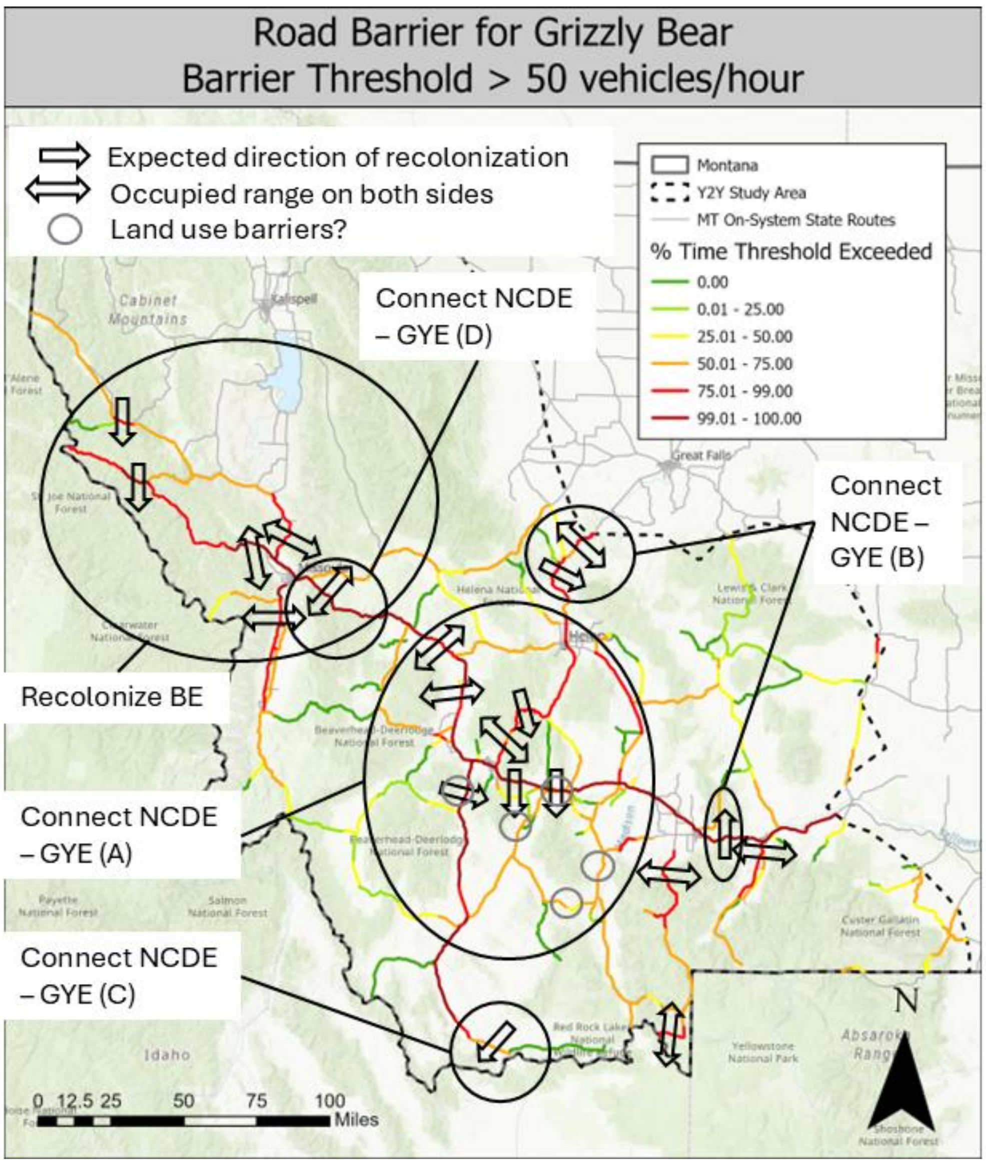


Figure 56: The road sections (indicated by arrows that are a substantial barrier to grizzly bears (based on a threshold of 50 vehicles per hour) in the context of two objectives (i.e., reconnect the NCDE and GYE and recolonize the BE).

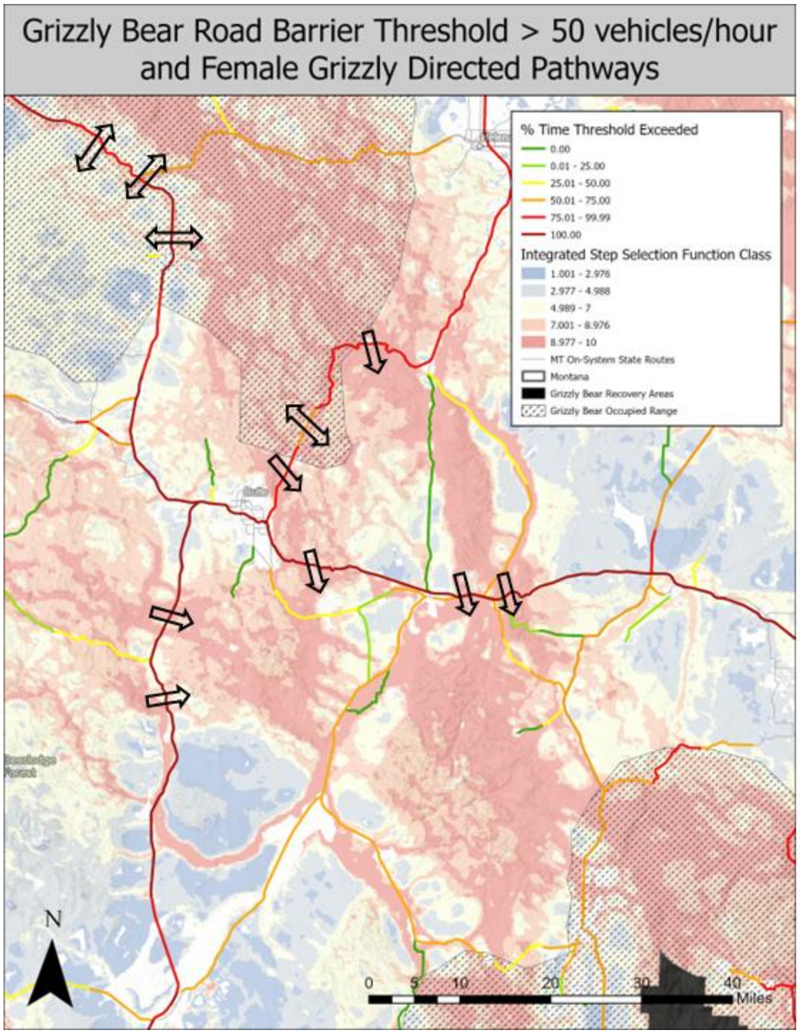


Figure 57: The road sections around Butte – Three Forks. Arrows indicate road sections that are a substantial barrier to grizzly bears (based on a threshold of 50 vehicles per hour) in the context of the objective to reconnect the NCDE and GYE.

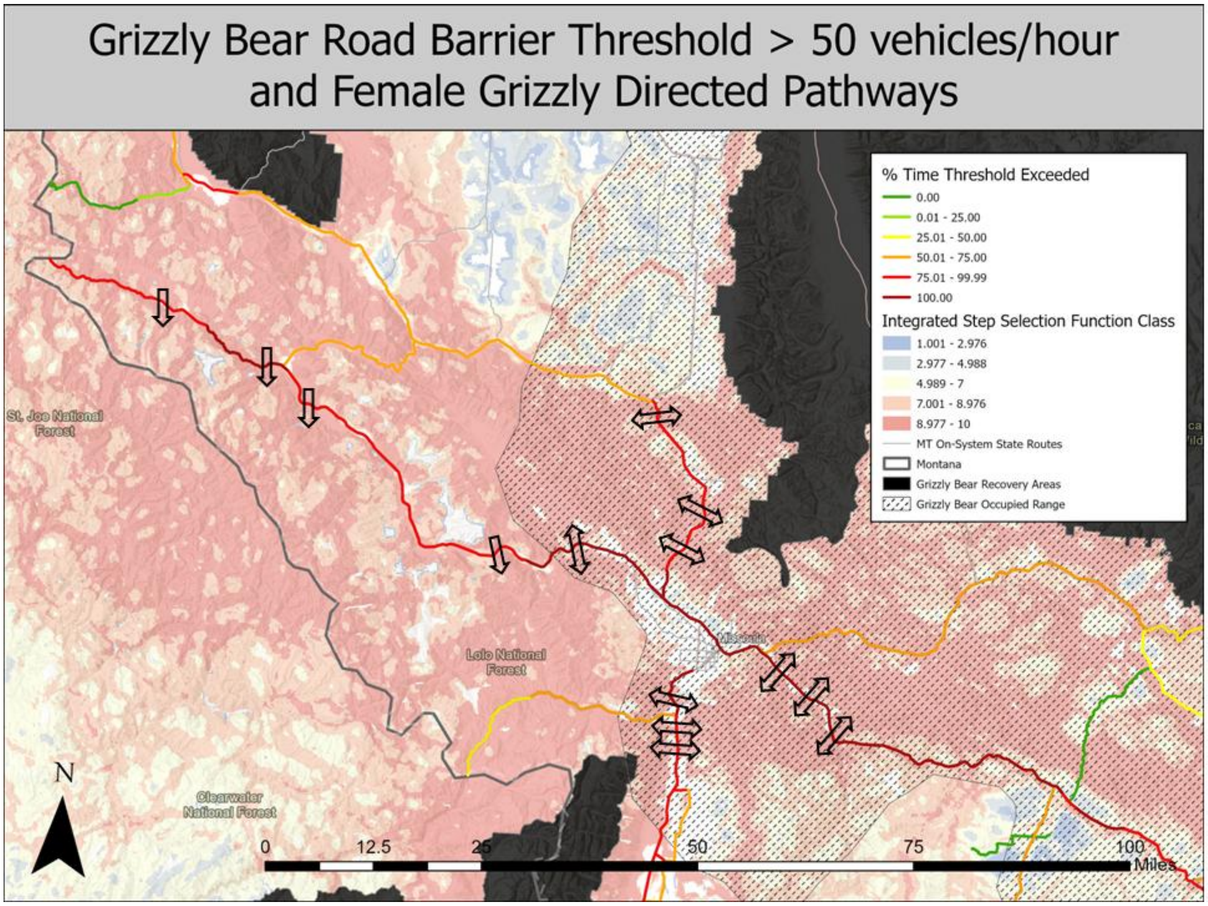


Figure 58: The road sections around Missoula. Arrows indicate road sections that are a substantial barrier to grizzly bears (based on a threshold of 50 vehicles per hour) in the context of the objective to recolonize the BE recovery zone.

The results of the traffic volume analyses have the following implications for the two objectives that were formulated for the selected areas:

Area 1: I-90 and highways both north and south of I-90 between Butte and Three Forks. This area is the most critical for achieving robust functional connectivity on relatively short term for grizzly bears between the NCDE and GYE (see also section 6.2). The distance between the estimated occupied range for the NCDE and GYE populations was about 45 mi (72 km) (Costello et al., 2025; USFWS, 2026) and I-90 is the most substantial traffic volume barrier in this area. Based on directed and undirect movements for female grizzly bears, Homestake Pass and the area around Cardwell are the highest priority road sections to reduce the barrier effect of I-90. The edge of the occupied range has only crossed I-15 between Butte and Helena in recent years, and individual grizzly bears are known to have been present adjacent to I-90 (the north side) at Homestake Pass. However, breeding females are likely further behind, west of I-15. This means that measures along I-90 at Homestake Pass and Cardwell would likely only or mostly allow single grizzly bears, likely predominantly males, to move south of I-90, at least in the immediate future. To allow the occupied range east of I-15 to increase in area and to allow for breeding females to reach the area immediately north of I-90 at Homestake Pass, the overall barrier effect of I-15 and an adjacent zone may also need to be addressed. Addressing the barrier effect of I-90 and I-15 in this area would likely reduce the time for breeding females to move between the NCDE and GYE population. Interestingly, a (small) number of grizzly bears is already present in the Flint Creek

Range west of Butte to the west or south of I-90. Although the origin of these bears is not always known, this is categorized as one of the edges of the occupied range of the NCDE population. Edges of the occupied range tend to be associated with relatively low population densities, especially of reproductive females (Pers. Com. Jennifer Fortin-Noreus, formerly senior wildlife biologist with USFWS). In this context, I-15 between the junction with I-90 and the junction with Montana Highway 43 (to Wise River) may be the most important remaining non-crossed highway barrier to grizzly bears that keep them from contacting the GYE population. Here the distance between the NCDE and GYE populations is about 85 miles (137 km) (Flint Creek Range – Madison Range), but it has only one major traffic volume barrier (I-15) rather than two (I-15 and I-90). On the other hand, the connection may be less robust because the number of grizzly bears in the Flint Creek Range is likely very small and not well connected to the NCDE grizzly bears north of I-90 north of Butte. This then suggests that this route for connectivity also requires measures for both I-15 and I-90.

At present, the boundary of the occupied range for the GYE grizzly bear population and individual bears appears to coincide with US Highway 287 between Norris and Ennis and Montana Highway 287 between Alder and Ennis. However, the traffic volume on these highway sections should not result in an absolute barrier to grizzly bears. Other factors (e.g., low grizzly bear population density, absence or low frequency of dispersal attempts, land use, habitat security, lack of cover) may be the main barrier in these wide-open valleys with agricultural activities. This could mean that robust connectivity between the NCDE and GYE grizzly bear population may not only require measures along highways (especially I-90 and I-15). Programs that focus on habitat security and that reduce the potential for conflict with humans may be critical along these two highway sections. In the context of establishing contact between the NCDE and GYE grizzly bears, the open valleys along Montana Highway 41 (north of Twin Bridges), along I-15 (between the junction with I-90 and the junction with Montana Highway 43 to Wise River), and along I-90 near Cardwell may also require a program focused on habitat security and reducing potential conflict with humans. Note that this does not imply that conflict reduction between humans and grizzly bears is not important elsewhere too.

There are alternative routes with major traffic volume barriers for grizzly bears through which connectivity between the NCDE and GYE population can be established. The first alternative route goes through the Big Belt Mountains, the Bridger Range and the Bangtail Range. Major traffic volume barriers are I-90 at Bozeman Pass and I-15 between Wolf Creek and Siebel. However, the occupied range for the NCDE and GYE populations are relatively far apart, about 99 mi (159 km). Nonetheless, there have been multiple observations of grizzly bears in the Big Belt Mountains and the estimated occupied range of the NCDE population has been increasing south and east in this area in recent years (Pers. Com. Cecily Costelly, Montana Fish, Wildlife and Parks). One GYE grizzly bear has been observed north of I-90 in the Shields Valley and in 2025 two observations of grizzly bear were recorded in the Bangtail Range (population of origin unknown but suspected GYE) (Pers. Com. Cecily Costelly, Montana Fish, Wildlife and Parks).

Another identified alternative pathway follows the Beaverhead Mountains along the border with Idaho. Bears that have reached the BE or the Sapphire range or other areas to the south of I-90 but west of Butte could disperse along this route, although the distance between occupied range for the NCDE and GYE population is long, about 200 miles (322 km). There are no major traffic volume barriers for grizzly bears that would move through the Beaverhead Mountains until they reach I-90 at Monida Pass. Even then, traffic volume at Monida pass may not result in a near-absolute or absolute barrier to grizzly bears. This section of I-15 appears reasonably passable by grizzly bears, at least based on traffic volume. Nonetheless, the GYE population boundary coincides with I-15 here, suggesting that I-15 or the adjacent open lands, may be a substantial barrier anyway. Alternatively, the grizzly bear population is still so low that grizzly bears are not motivated to disperse across I-15 yet.

Area 2: I-90 and highways both north and south of I-90 east and west of Missoula. This area is the most critical for facilitating recolonization of the BE recovery zone by grizzly bears. The occupied range of the NCDE population now slightly overlaps with the BE recovery zone. The route crosses US Highway 93 between Lolo and Florence, and grizzly bears have been present in this area already (identified as "outliers") (Sells et al., 2023b) (Pers. Com. James Jonkel, Montana Fish, Wildlife & Parks). Nonetheless US Highway 93 and the adjacent lands, especially on the west side of US Highway 93 are likely a very substantial barrier to grizzly bears. However, there is only one highway in this area that needs to be crossed as the east side highway parallels US Highway 93 further to the south. Note that the number of grizzly bears in the northern Sapphire Mountains is likely very small and that better connectivity across I-90 east of Missoula may also be required.

Similarly, there is also overlap between the BE recovery zone and the NCDE occupied range across I-90 west of Missoula in the Sixmile and Ninemile area. Since there is likely only a very small number of grizzly bears north of I-90 and west of US Highway 93, connectivity across US Highway 93 in the Evaro area is also important. Note that there are wildlife fences and wildlife crossing structures, including a wildlife overpass, in the Evaro area already.

The third shortest connection (about 80 mi (129 km) between the BE recovery zone and occupied range is across Montana Highway 200 near Thompson Falls and I-90 around St. Regis to the CYE. However, the CYE population is small and therefore not expected to function as a source population for the BE recovery zone, at least not as likely as the much larger NCDE population (Pers. Com. Cecily Costelly, Montana Fish, Wildlife and Parks).

8.4 Discussion

This barrier assessment of highways in western Montana would not have been possible without a foundation of existing knowledge generated by others (i.e., Waller & Servheen, 2005; Sells et al., 2022; 2023a; 2023b; Sells & Costello, 2024). This barrier assessment of highways not only allowed insight into the extent of the barrier effect of different highway segments. It also allowed us to strategize which highway segments require a reduction in barrier effect most to achieve different objectives related to grizzly bear conservation. Finally, it illustrated the need for a spatially coherent approach where measures are implemented along different highways for one common goal.

To achieve robust functional connectivity in the relatively short term for grizzly bears between the NCDE and GYE, the potentially most productive approach would be to reduce the barrier effect for not only I-90 (Homestake Pass, Cardwell area), but also for I-15 (between Butte and Helena). Secondarily, consider reducing the barrier effect of I-15 south of Butte and I-90 northwest of Butte. The open valleys with agricultural activity between Alder and Ennis, between Ennis and Norris, north of Twin Bridges, and along I-15 south of Butte may require measures and collaborative programs with private landowners to increase habitat security, cover, and decrease the potential for conflict between grizzly bears and humans. Other potential routes for connectivity between the NCDE and GYE have much greater distances between the occupied ranges, and establishing connectivity between the NCDE and GYE populations would likely take much longer. Nonetheless, grizzly bears continue to expand their occupied range east and south of Missoula, and in the Big Belt Mountains, and there are individual grizzly bears that have moved considerable distances beyond the occupied range. Therefore, contact between the NCDE and GYE population can also occur along routes other than between Butte and Cardwell (Pers. Com. Cecily Costelly, Montana Fish, Wildlife and Parks; Pers. Com. Jennifer Fortin-Noreus, formerly senior wildlife biologist with USFWS).

To facilitate recolonization of the BE recovery zone, the potentially most productive approach would be to reduce the barrier effect of I-90 east of Missoula in combination with US Highway 93 between Lolo and Florence. Secondarily, consider reducing the barrier effect of I-90 west of Missoula in the Sixmile and Ninemile area. The other potential route for connectivity between the BE recovery zone and the CYE would need to cover a much greater distance and recolonization of the BE recovery zone through that route would likely take much longer.

For the purposes of this report, we formulated two different objectives related to grizzly bear conservation. However, there are other objectives that can be formulated. Other objectives would likely identify different road sections that would require a reduction in the barrier effect.

9 Existing structures

9.1 Introduction

Existing structures are structures under or over roads that currently exist. The vast majority of existing structures have been built for other purposes than wildlife. They are usually built for water (i.e., culverts or bridges at streams or rivers) or to pass vehicles under or over another road. However, if a structure requires rehabilitation or replacement, it would be efficient to incorporate the needs of wildlife into the rehabilitation of the existing structure or the design of a new structure. In addition, existing structures can be integrated into a mitigation project that includes wildlife fences and designated wildlife crossing structures.

9.2 Methods

We obtained the locations of structures under or over roads in the Y2Y area from MDT. We plotted the location of these structures on a map. We distinguished between structures that were and that were not load posted. A load posted structure means that, based on an engineering analysis of a structure (e.g., a bridge), the structure cannot carry loads that would otherwise be legal (in Montana) (MDT, 2025c). A load posting of a bridge may be because of the age of a structure, failing components of a structure, or because it was not built to carry loads that are now legal. Because of the practical and economic implications, load posted bridges may have a priority for rehabilitation or replacement.

9.3 Results

The location of existing structures, including load posted structures, is depicted in Figure 59. Note that the load posted bridges are not always on the road that the map suggests. For example, the load posted bridges may be on a frontage road rather than the interstate. Note that there are no load posted bridges along I-90 in the Y2Y area in Montana.

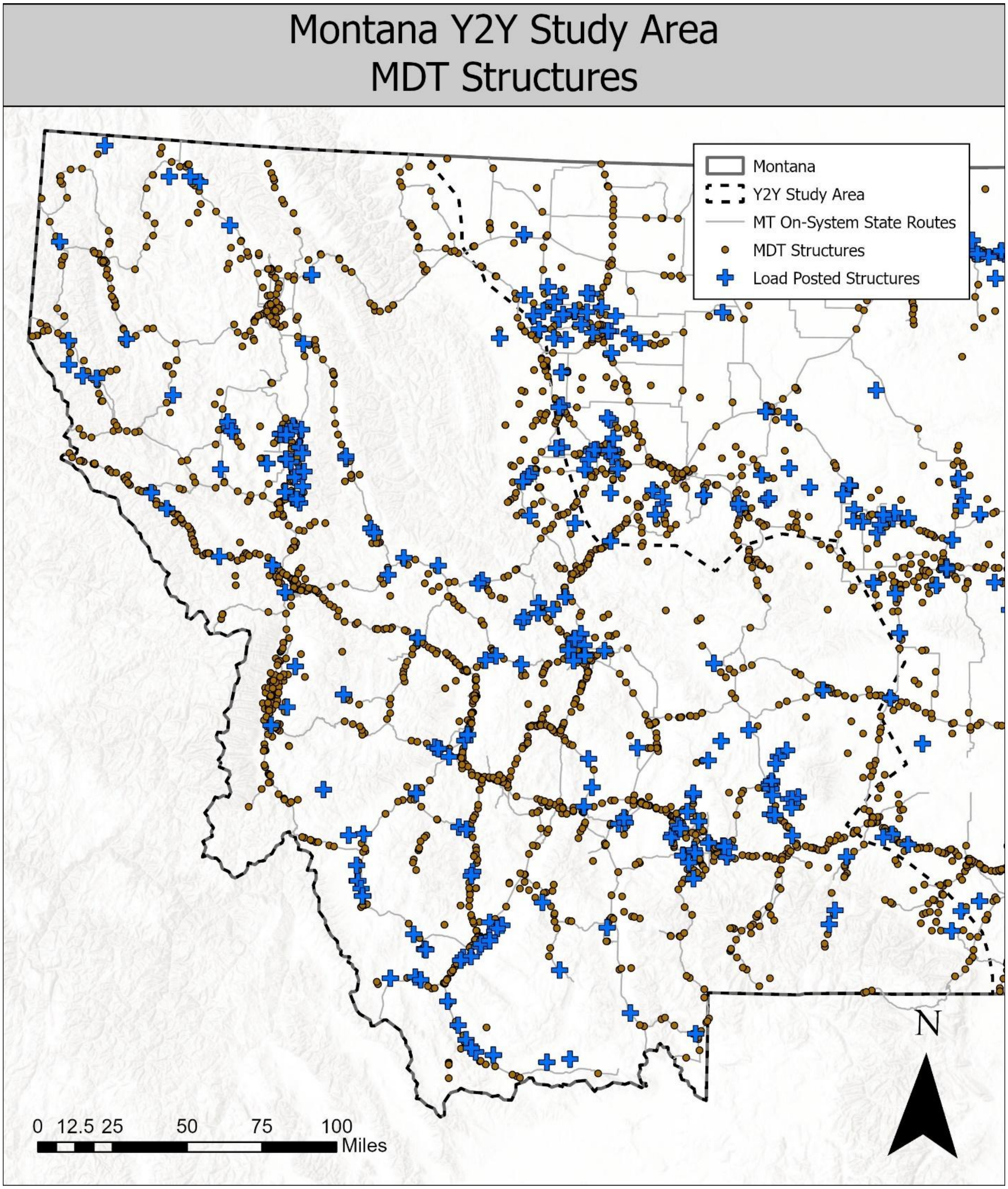


Figure 59: The location of existing structures, including load posted structures, in the Y2Y area in Montana.

9.4 Discussion

All structures, regardless of their original purpose, require rehabilitation during their life span or they require replacement at the end of their life span. If such a structure is in a road section where connectivity for wildlife is a concern, then it would be efficient to incorporate the needs of wildlife into the rehabilitation of the existing structure or the design of a new structure. This could then result in a structure that has been modified for wildlife, or a structure that has included wildlife needs into its purpose, design, and construction, making it a multi-functional structure. Load posted structures are especially interesting as their rehabilitation or replacement may be prioritized.

10 Public land, private land, and conservation easements

10.1 Introduction

If investments are made in wildlife crossing structures, the investments are expected to have benefits in the future, at least for the life span of the crossing structure. A concrete and steel structure has a projected life span of about 75 years. The benefits of a crossing structure are primarily with providing connectivity for wildlife. Therefore, wildlife species need to continue to be present in the areas on either side of a wildlife crossing structure, and they need to be able to continue to access the structure over the life of the structure. If land is developed, or in some other way made unsuitable for wildlife, wildlife may no longer be present in the areas on either side of a wildlife crossing structure, or their access to the structure may be hindered. This would jeopardize the investments in a wildlife crossing structure. That is why wildlife crossing structures tend to be located where wildlife habitat and access for wildlife to wildlife crossing structures is secured, either through the land being "public land" or private land with a "conservation easement". A conservation easement is a voluntary legal agreement that permanently limits the uses of the land to protect its conservation values. While the exact terms can be different between different easement agreements, a conservation easement generally protects wildlife habitat, and in the case of wildlife crossing structures, also protects access for wildlife to the crossing structures.

10.2 Methods

We obtained spatially explicit information on public lands and lands with a conservation easement. We plotted these two categories of protected land on a map in the Y2Y area in Montana.

10.3 Results

Most of the Y2Y area in Montana is either public land or private land with an easement (Figure 60). This means that, in general, there is great opportunity to have protected habitat for wildlife and have corridors for wildlife between large habitat patches. However, in western Montana most roads are in valleys and along rivers, because that was the easiest place to build a road. This is also where the best conditions are for agriculture (fertile soil, water), and relatively flat areas are easiest to farm. This means that much of the land immediately adjacent to roads in the Y2Y area in Montana is private land.

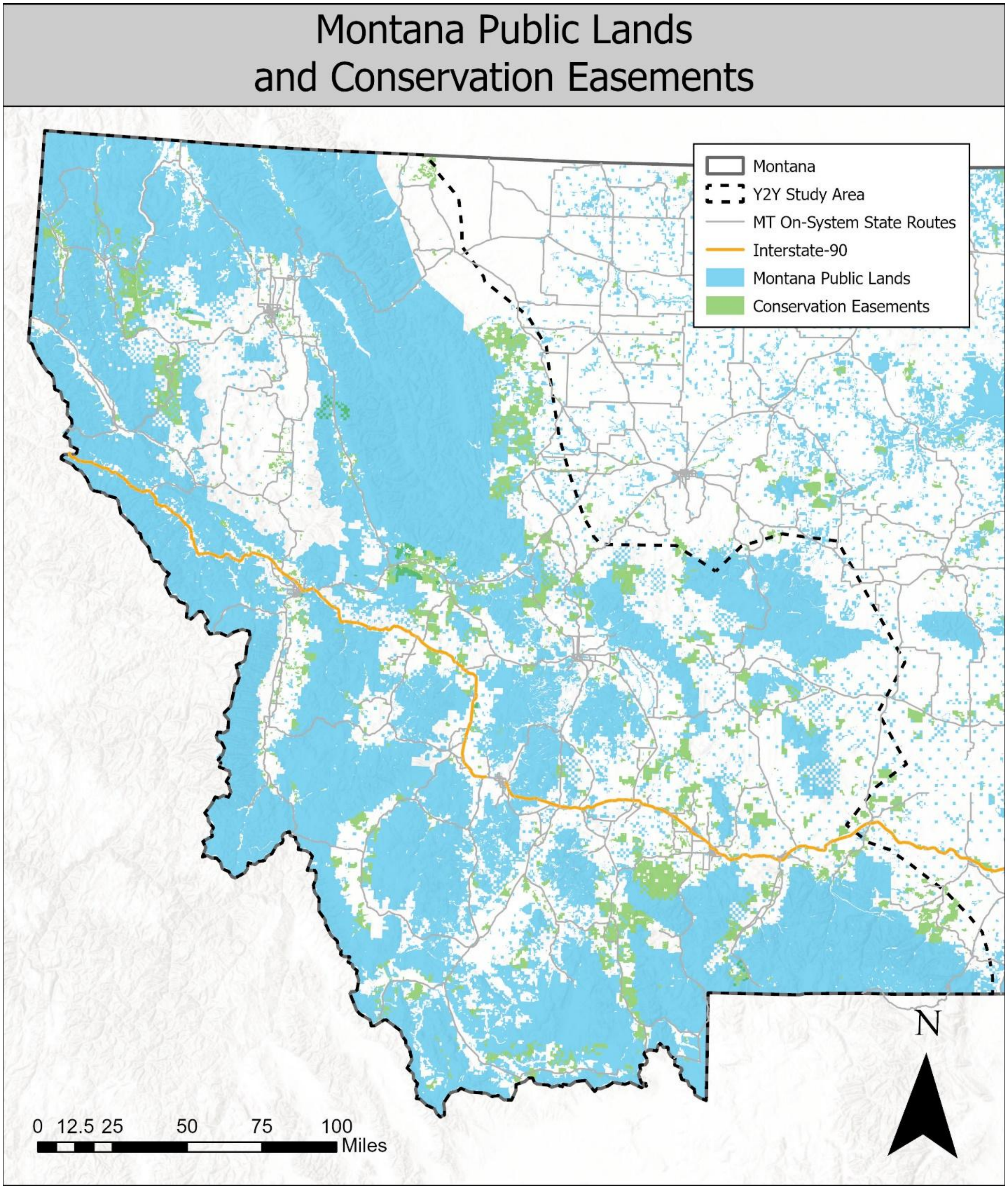


Figure 60: Public land and conservation easements in the Y2Y area in Montana.

10.4 Discussion

For wildlife crossing structures to be functional in the future, it is essential to protect wildlife habitat and to ensure access for wildlife to these wildlife crossing structures. In the Y2Y area in Montana, most of the lands adjacent to major infrastructure is in valleys and along rivers. This is also where private land is concentrated. Therefore, existing and future conservation easements for the lands in the immediate vicinity of wildlife crossing structures are essential for the functioning of wildlife crossing structures in the future and having viable and well-connected wildlife populations.

11 Field review

11.1 Introduction

We selected sections of I-90 that were either of greatest concern for grizzly bear connectivity or for human safety because of collisions with large wild mammals. We then compared these road sections to investigate where there would be spatial overlap and differences for connectivity needs for grizzly bear and human safety because of collisions with large wild mammals. We also examined the number of crashes with large wild mammals, the number of carcasses, and the presence of bridges, including load posted bridges in the selected road sections.

11.2 Methods

We selected sections of I-90 that were most important for connectivity for grizzly bear based on areas on both sides of I-90 (north and south) that have secure grizzly bear habitat based on predicted undirected movements for females (see Figure 33). This process was somewhat subjective, selecting more substantive areas only, while ignoring smaller areas. We selected the undirected pathways because they are more representative of how bears are really moving when they leave the occupied range (see Figure 31 for comparison). We selected females rather than males as females tend to disperse over shorter distances and are more critical of secure habitat. However, based on the modelling, the predicted pathways, both undirected and directed) were quite similar for male and female grizzly bears. If the undirected pathways for female grizzly bears (partially) overlapped with directed pathways for female grizzly bears we identified the directed pathways (see Figure 31) based on the connecting recovery zones and the areas in between, mostly mountain ranges (for names of the mountain ranges see Wally, 2024). We also describe the distance to where grizzly bears have been confirmed in the previous decade (see Figure 28), both north and south of I-90.

We also selected sections of I-90 with a concentration of collisions with large wild mammals. We identified road sections of multiple miles or even dozens of miles that contained multiple shorter road segments that fell into the top 5 or top 25% of crashes with large wild mammals or carcasses. This process was at least partially subjective. For both the grizzly bear connectivity zones and the zones with a relatively high concentration of collisions with large wild mammals we summarized the wildlife-vehicle crash and carcass removal data.

We also identified existing structures under or over the selected road sections of I-90. We reviewed the individual structures for their main purpose, and their potential as a suitable crossing structure for grizzly bears and for “deer” (i.e. white-tailed deer and mule deer combined). We also noted the main problems if a structure was not rated high or very high with regard to suitability for grizzly bears or deer.

11.3 Results

11.3.1 Grizzly bear connectivity and large wild mammal collision zones

We identified six different road sections of I-90 as the most important grizzly bear connectivity zones (in order from west to east):

1. Cyr- Alberton – Ninemile – Sixmile – Huson (mile reference posts 70.1-85.2)

   Directed pathway connecting the CYE and NCDE recovery zones (north of I-90) to the BE recovery zone (south of I-90). The pathway includes the Reservation Divide, Ninemile Divide, Grave Creek Range, and Bitterroot Mountains.

   - I-90 south side: Grizzly bears have been present adjacent to I-90 and some are crossing (having come from the north or northeast originally), and part of this area is now occupied range of the NCDE population (in 2024).
   - I-90 north side: Grizzly bears have been present adjacent to I-90 and some are crossing (having come from the north originally), and part of this area is now occupied range of the NCDE population (in 2024). Note: Females with cubs are likely present east of US Highway 93 in the Evaro area (about 18 mi (29 km) from this section of I-90). Females with cubs are also present north of Montana Highway 200 (about 65 mi (105 km) from this section of I-90) (Pers. Com. Jennifer Fortin-Noreus, formerly senior wildlife biologist with USFWS). Note that there are also females south of Montana Highway 200 further west between Trout Creek and the border with Idaho (Pers. Com. Jennifer Fortin-Noreus, formerly senior wildlife biologist with USFWS).

2. Bonner – Drummond (especially Bonner-Rock Creek area) (mile reference post 108.0-153.6).

   Directed pathway connecting the NCDE recovery zone (north of I-90) to the BE and GYE recovery zones (south of I-90). The pathway includes the Garnet Range, Sapphire Mountains, John Long Mountains and across the Bitterroot Valley to the BE recovery zone. Other directed pathways connect to the GYE recovery zone, through the Sapphire Mountains, Beaverhead Mountains and Centennial Mountains. An additional pathway runs through the Anaconda Range, Fleecer Mountains, Pioneer Mountains, Highland Mountains, Tobacco Root Mountains and the Madison Range.

   - I-90 south side: Grizzly bears have been present adjacent to I-90 and some are crossing (including females) (having come from the north originally), and part of this area is now occupied range of the NCDE population (in 2024).
   - I-90 north side: Grizzly bears have been present adjacent to I-90 and some are crossing (having come from the north originally) and this area is now occupied range of the NCDE population (in 2024). Note: Females with cubs are present close to I-90 on the north side (Pers. Com. Jennifer Fortin-Noreus, formerly senior wildlife biologist with USFWS) and at least one female with cub has been observed on the south side in 2018 (Pers.

Com. James Jonkel, Montana Fish, Wildlife & Parks). This section of I-90 is the most likely pathway for females (with or without cubs) to cross I-90 anywhere in the Y2Y area in Montana, at least in the immediate future.

3. Drummond – Deerlodge (mile reference post 155.9-184.3).

   No strong directed pathway crossing I-90 in this area.

   - I-90 south side: Grizzly bears have been present adjacent to I-90 and some are crossing (having come from the north originally), and part of this area is now occupied range of the NCDE population (in 2024).
   - I-90 north side: Grizzly bears have been present adjacent to I-90 and some are crossing (having come from the north originally), and this area is now occupied range of the NCDE population (in 2024).

4. Homestake Pass (mile reference post 230.0-240.6).

   Directed pathway connecting the NCDE recovery zone (north of I-90) to the GYE recovery zone (south of I-90). The pathway includes the area south of Lincoln ("Nevada Mountains"), Boulder Mountains, Highland Mountains, and the Tobacco Root Mountains.

   - I-90 south side: Occupied range is 45-52 mi (72-84 km) to south and south-east from I-90) (Greenhorn Range - Madison Range).
   - I-90 north side: Grizzly bears have been present adjacent to I-90, but occupied range is a bit further north, on the east side of I-15, about halfway between Butte and Boulder. About 13 mi (21 km) to the north from I-90 (Boulder Mountains).

   Together with the Whitehall-Cardwell Hill area, this is the most likely road section of I-90 to establish direct connectivity between the NCDE and GYE recovery zones, at least in the near future.

5. East of Whitehall – west slopes of Cardwell Hill (mile reference post 251.3-264.1).

   There are two sub areas:

   - South of Golden Sunlight mine.
   - On the west slope Cardwell Hill.

   Directed pathway connecting the NCDE recovery zone (north of I-90) to the GYE recovery zone (south of I-90). The pathway includes the area south of Lincoln ("Nevada Mountains"), Boulder Mountains, Elkhorn Mountains, Tobacco Root Mountains, Greenhorn Range and Gravelly Range, Madison Range.

- I-90 south side: Occupied range is about 38-43 mi (61-69 km) to south-east and south from I-90) (Madison Range - Greenhorn Range).
- I-90 north side: Grizzly bears have been present 15 km (9 mi) to north, but occupied range is about 31 mi (50 km) to the northwest.

6. Bozeman Pass (mile reference post 313.4-324.6).
   Directed pathway connecting the NCDE recovery zone (north of I-90) to the GYE recovery zone (south of I-90). The pathway includes the Big Belt Mountains, Bridger Mountains, Bangtail Range, Bozeman Pass, and the Gallatin Range.

    - I-90 south side: Grizzly bears have been present adjacent to I-90, and occupied range is about 5 mi (8 km) south of I-90.
    - I-90 north side: Grizzly bears have been present east of Helena, and occupied range is now north east of Helena and southeast of I-15. Occupied range of the NCDE population is about 100 mi (161 km) from I-90. In addition, one GYE grizzly bear has been observed north of I-90 in the Shields Valley and in 2025 two observations of grizzly bear were recorded in the Bangtail Range (population of origin unknown but suspected GYE) (Pers. Com. Cecily Costelly, Montana Fish, Wildlife and Parks)

We identified five different road sections of I-90 as having a relatively high concentration of collisions with large wild mammals (in order from west to east):

1. St. Regis – Tarkio (mile reference post 32.0-58.4).
2. East Missoula – Beavertail (mile reference post 105.5-130.6).
3. Drummond – Warm Springs (mile reference post 153.7-196.1).
4. Manhattan – Bear Canyon Road (mile reference post 290.1-313.0).
5. West of Livingston – west of Big Timber (mile reference post 327.9-362.8).

The location of the selected road sections for grizzly bear connectivity and collisions with large wild mammals have partial overlap (Figure 61, Table 6). The overlap is between Bonner and Beavertail, between Drummond and Deerlodge, and a very short segment on the west side of Bozeman Pass. Other selected road sections are either important for grizzly bear connectivity or collisions with large wild animals, but not both. This has implications and suggests a two-track system for policy, funding, and implementation; one track that is rooted in human safety, and a second track that is rooted in biological conservation (in this case improving connectivity across highways for grizzly bears). Overall, grizzly bear connectivity zones have a slightly higher percentage of public land, a similar percentage of private land with a conservation easement, and a slightly lower percentage of private land without a conservation easement. The number of existing structures that is estimated to be highly or very highly suitable for grizzly bears in grizzly bear connectivity zones is relatively low (4) compared to the number of existing structures that is estimated to be highly or very highly suitable for deer in human safety zones (24).

Table 6: The characteristics of the combined grizzly bear connectivity zones and combined wildlife-vehicle collision zones.

	I-90 grizzly bear zones	I-90 wildlife-vehicle collision zones
Length of I-90	123.5 mi of the 360 mi length of I-90 in Y2Y area in Montana is a grizzly bear zone (34.3%).	151.7 mi of the 360 mi length of I-90 in Y2Y area in Montana is a wildlife-vehicle collision zone (42.1%).
Spatial overlap	41.9% of the length of all grizzly bear zones is also a wildlife-vehicle collision zone.	34.2% of the length of all wildlife-vehicle collision zones is also a grizzly bear zone.
Public Land	In an area up to 1-mile from I-90 (on either side) 23.7% is public	In an area up to 1-mile from I-90 (on either side) 18.8% is public
Private Land with Conservation Easement	In an area up to 1-mile from I-90 (on either side) 5.3% of surface is private land with an easement	In an area up to 1-mile from I-90 (on either side) 5.6% of surface is private land with an easement
Private Land without Conservation Easement	In an area up to 1-mile from I-90 (on either side) 71.1% of surface is private land without an easement	In an area up to 1-mile from I-90 (on either side) 75.7% of surface is private land without an easement
Existing structures	Along I-90 within Grizzly Bear Priority Zones, there are 4 existing structures that are estimated to be highly or very highly suitable for grizzly bears and 13 that that are estimated to be highly or very highly suitable for deer (out of a total of 114 existing structures).	Along I-90 within WVC Safety Priority Zones, there are 12 existing structures that are estimated to be highly or very highly suitable for grizzly bears and 24 that are estimated to be highly or very highly suitable for deer (out of a total of 198 existing structures).

Along individual grizzly bear connectivity zones, zone 4 (Homestake Pass) stands out because of its very high percentage (76.36%) of public land (Table 6). Of the five grizzly bear connectivity zones, zone 3 (Deer Lodge, 7.48%) and zone 5 (Bozeman Pass, 10.92%), have the lowest percentage of public land. This has implications for the habitat security on the lands adjacent to potential future designated wildlife crossing structures.

Table 7: The characteristics of the individual grizzly bear connectivity zones and individual wildlife-vehicle collision zones.

I-90 Priority Site	I-90 Priority Site Name	Road Section Length (mi)	1-mile Buffer Area (mi²)	Public Land Area (mi²)	Public Land in Buffer (%)	Public Land Owners	Conservation Easement Area (mi²)	Conservation Easement in Buffer (%)	Conservation Easement Land Owners	Number of Existing MDT Structures	Exisiting Structures for Deer	Existing Structures for Grizzly Bear
Grizzly 1	Ninemile	14.9	32.81	11.21	34.16	8	0.58	1.77	3	12	5	3
Grizzly 2	Bonner	45.6	93.99	20.75	22.08	9	3.35	3.57	3	44	2	1
Grizzly 3	Deer Lodge	28.4	59.78	4.47	7.48	7	6.63	11.09	3	31	6	0
Grizzly 4	Homestake Pass	10.6	23.97	18.31	76.36	3	0	0	0	2	0	0
Grizzly 5	Cardwell	12.8	28.54	5.09	17.82	3	0.61	2.13	1	10	0	0
Grizzly 6	Bozeman Pass	11.2	25.45	2.78	10.92	7	2.80	11.01	1	15	0	0
Safety 1	Riverbend	26.4	55.82	22.28	39.92	8	0	0	0	45	16	10
Safety 2	East Missoula	25.1	53.28	16.17	30.36	11	3.08	5.78	4	29	0	0
Safety 3	Drummond	42.4	87.75	7.57	8.62	11	10.15	11.57	5	50	6	0
Safety 4	Bozeman	22.9	48.90	5.06	10.35	9	2.32	4.74	2	35	0	0
Safety 5	Livingston	34.9	72.76	8.64	11.87	9	2.24	3.08	1	39	2	2

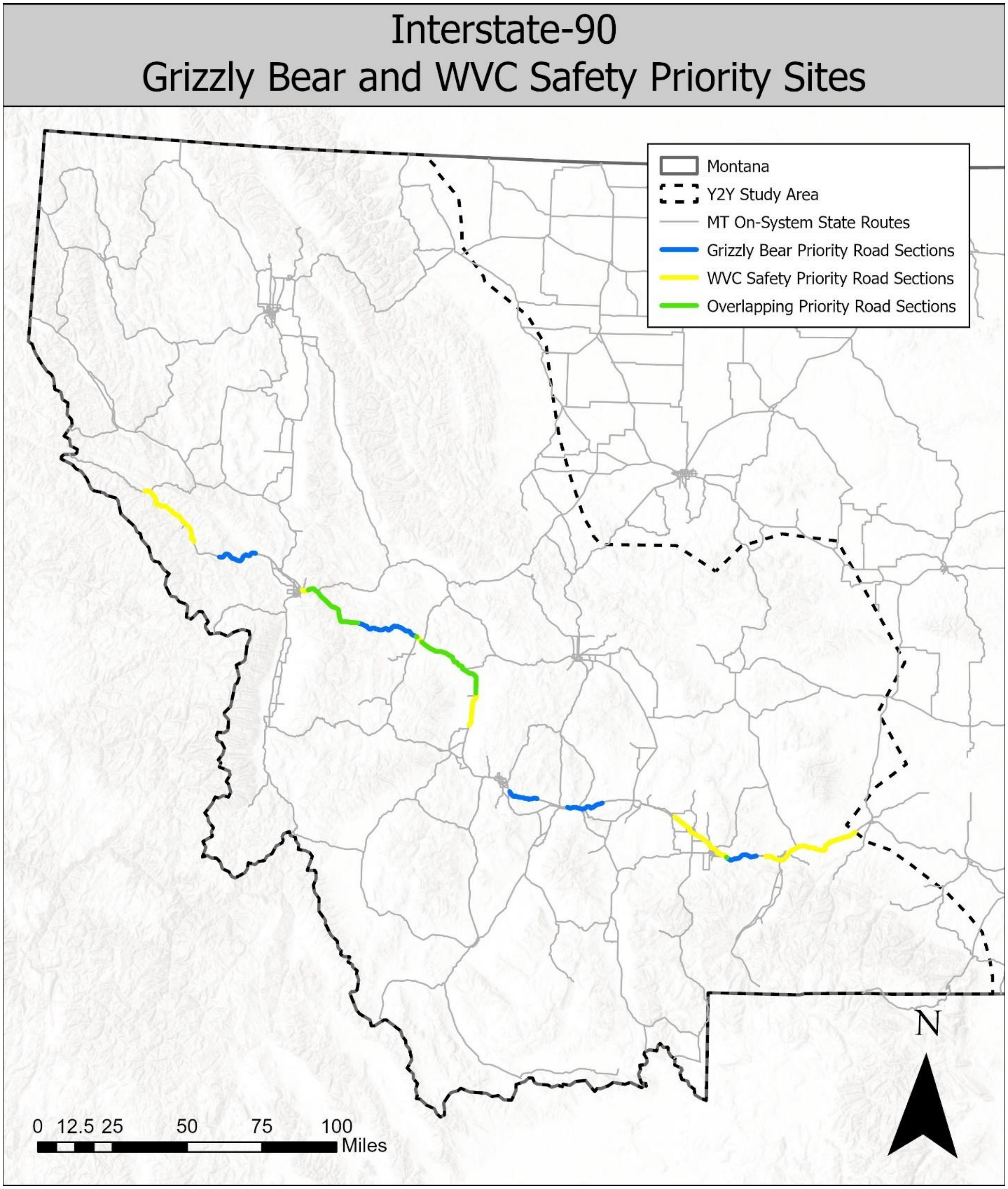


Figure 61: The overlap and differences in the priority road zones for grizzly bear connectivity and collisions with large wild mammals along I-90.

11.3.2 Crash and carcass data for the selected road sections

The number of crashes and carcasses in each selected road section involving large wild mammals are summarized in Table 8 and Table 9).

Table 8: The number of recorded crashes with large wild mammals and the number of carcasses removed in each of the grizzly bear connectivity zones and wildlife-vehicle collision zones.

Priority road zone	Name	Length (mi)	Mile Marker		Crashes with large wild mammals				Carcasses			
			Start	End	Crashes (N)	0.1 mi segment Max	0.1 mi segment Mean	Average crashes (N/mi/yr	Carcasses (N)	0.1 mi segment Max	0.1 mi segment Mean	Average carcasses (N/mi/yr)
Grizzly 1	Ninemile	14.9	70.1	85.2	226	9	1.52	1.01	244	19	1.64	1.09
Grizzly 2	Bonner	45.6	108	153.6	523	10	1.15	0.76	1408	62	3.09	2.06
Grizzly 3	Deer Lodge	28.4	155.9	184.3	338	8	1.19	0.79	641	28	2.26	1.5
Grizzly 4	Homestake Pass	10.6	230	240.6	42	4	0.4	0.26	64	6	0.6	0.4
Grizzly 5	Cardwell	12.8	251.3	264.1	106	5	0.83	0.55	241	21	1.88	1.26
Grizzly 6	Bozeman Pass	11.2	313.4	324.6	125	7	1.12	0.74	117	11	1.04	0.7
Safety 1	Riverbend	26.4	32	58.4	454	7	1.72	1.15	1387	38	5.25	3.5
Safety 2	East Missoula	25.1	105.5	130.6	409	10	1.63	1.09	1138	62	4.53	3.02
Safety 3	Drummond	42.4	153.7	196.1	522	8	1.23	0.82	1067	28	2.52	1.68
Safety 4	Bozeman	22.9	290.1	313	491	12	2.14	1.43	474	28	2.07	1.38
Safety 5	Livingston	34.9	327.9	362.8	455	9	1.3	0.87	1147	94	3.29	2.19

Table 9: The number of recorded carcasses by species in each priority road zone.

Priority road zone	Name	Number of carcasses by species in each priority road zone										
		Pronghorn	White-tailed deer	Mule deer	Unknown deer	Elk	Moose	Bighorn Sheep	Canada lynx	Mountain lion	Wolf	Black bear
Grizzly 1	Ninemile	0	211	2	0	24	1	0	0	1	0	5
Grizzly 2	Bonner	0	980	315	19	45	5	3	1	3	0	37
Grizzly 3	Deer Lodge	1	251	276	7	101	2	0	0	1	0	2
Grizzly 4	Homestake Pass	1	3	46	2	5	5	0	0	1	0	1
Grizzly 5	Cardwell	1	126	92	1	13	8	0	0	0	0	0
Grizzly 6	Bozeman Pass	0	62	29	0	15	3	0	0	1	0	7
Safety 1	Riverbend	0	1115	154	19	71	6	1	0	4	1	16
Safety 2	East Missoula	0	896	182	8	20	2	3	0	1	0	26
Safety 3	Drummond	2	535	416	5	101	3	0	0	2	0	3
Safety 4	Bozeman	0	410	50	3	1	0	0	0	2	0	8
Safety 5	Livingston	4	712	364	3	32	1	0	0	1	0	30

11.3.3 Existing structures

There are no load posted structures along I-90 in the Y2Y area in Montana. However, there are many existing structures along I-90 that are not load posted. These structures can be incorporated in a mitigation project, potentially after modifications to make them better suited for the target species, Alternatively, if a structure needs to be replaced, wildlife requirements can be integrated into the purpose, design, and construction of the new structure.

Relatively few of the existing structures were estimated to be highly or very highly suitable for grizzly bears or deer (Table 10).

Table 10: The existing crossing structures in the selected road sections and their estimated suitability for grizzly bear and white-tailed deer and mule deer.

Grizzly bear zone	Collision zone	MDT ID	Type from wildlife perspective	Function	Width from animal's perspective	Year built	Potential for grizzly bear use (reason)	Potential for deer use
	Collisions 1	01327	underpass	water	212.4	1981	very low (riprap)	very low (riprap)
	Collisions 1	03664	overpass	paved road	314.9	1983	very low (narrow, road)	very low (narrow, road)
	Collisions 1	01328	underpass	water	21.3	1986	very low (narrow)	very low (narrow)
	Collisions 1	01329	underpass	paved road	124.5	1983	very low (development, road, narrow)	low (development, road)
	Collisions 1	01330	underpass	paved road	124.5	1983	very low (development, road, narrow)	low (development, road)
	Collisions 1	01331	underpass	water	243.9	1983	very low (riprap)	very low (riprap)
	Collisions 1	01332	underpass	water	245.9	1983	very low (riprap)	very low (riprap)
	Collisions 1	01335	underpass	water, railroad, unpaved road	884.8	1982	low (development, unpaved road)	medium (development, unpaved road)
	Collisions 1	01336	underpass	water, railroad, unpaved road	901.8	1982	low (development, unpaved road)	medium (development, unpaved road)
	Collisions 1	01337	underpass	paved road	78	1978	low (paved road, narrow)	low (paved road)
	Collisions 1	01338	underpass	paved road	78	1978	low (paved road, narrow)	low (paved road)
	Collisions 1	01339	underpass	paved road	128	1978	low (paved road, narrow)	low (paved road)
	Collisions 1	01340	underpass	paved road	128	1978	low (paved road, narrow)	low (paved road)
	Collisions 1	01341	underpass	water, paved road	1282.7	1982	medium (road)	high
	Collisions 1	01342	underpass	water, paved road	1144.7	1984	medium (road)	high
	Collisions 1	01343	underpass	paved road	78	1984	very low (road, narrow)	low (road)
	Collisions 1	01344	underpass	paved road	78	1984	very low (road, narrow)	low (road)
	Collisions 1	01345	underpass	paved road	134.6	1983	very low (road, narrow)	low (road)
	Collisions 1	01346	underpass	paved road	134.6	1983	very low (road, narrow)	low (road)
	Collisions 1	01347	underpass	water	1091.7	1982	high	very high
	Collisions 1	01348	underpass	water	1091.7	1984	high	very high
	Collisions 1	01349	underpass	water	16.1	1984	not possible (to small)	not possible (to small)
	Collisions 1	01350	underpass	water	10.5	1984	not possible (to small)	not possible (to small)
	Collisions 1	01351	underpass	water	544.9	1976	high	high
	Collisions 1	01352	underpass	water	620.8	1960	high	high
	Collisions 1	01353	underpass	unpaved road	18	1960	very low (narrow, road)	low (narrow, road)
	Collisions 1	01354	underpass	paved road	154	1960	very low (development, narrow, road)	low (development, narrow, road)
	Collisions 1	01355	underpass	paved road	154	1960	very low (development, narrow, road)	low (development, narrow, road)
	Collisions 1	01356	underpass	water	169	1966	medium (development)	high
	Collisions 1	01357	underpass	water	169	1960	medium (development)	high
	Collisions 1	01358	underpass	water, unpaved road	800.8	1966	medium (development)	very high
	Collisions 1	01359	underpass	water, unpaved road	800.8	1960	medium (development)	very high
	Collisions 1	01360	underpass	paved road	18	1966	very low (narrow, road)	low (narrow, road)
	Collisions 1	01361	underpass	water	756.8	1967	very high	very high
	Collisions 1	01362	underpass	water	756.8	1967	very high	very high
	Collisions 1	06297	overpass	railroad	158	1967	very low (narrow, railroad)	very low (narrow, railroad)
	Collisions 1	01363	underpass	paved road	128	1967	low (road, development)	low (road, development)
	Collisions 1	01364	underpass	paved road	128	1967	low (road, development)	low (road, development)
	Collisions 1	01365	underpass	water	8.5	1967	not possible (to small)	not possible (to small)

Grizzly bear zone	Collision zone	MDT ID	Type from wildlife perspective	Function	Width from animal's perspective	Year built	Potential for grizzly bear use (reason)	Potential for deer use
	Collisions 1	01366	underpass	water	13.1	1967	not possible (to small)	not possible (to small)
	Collisions 1	01367	underpass	railroad	312.9	1967	high	very high
	Collisions 1	01368	underpass	railroad	312.9	1967	high	very high
	Collisions 1	01369	underpass	unpaved road	16	1978	very low (narrow, road)	very low (narrow, road)
	Collisions 1	01370	underpass	water	825.8	1967	very high	very high
	Collisions 1	01371	underpass	water	825.8	1967	very high	very high
Grizzly bear 1		01384	underpass	water, paved road	780.8	1981	medium (roads)	high
Grizzly bear 1		01385	underpass	water, paved road	761.8	1965	medium (roads)	high
Grizzly bear 1		06870	overpass	paved road	221.9	1963	very low (narrow, road)	very low (narrow, road)
Grizzly bear 1		01386	underpass	paved road	143	1975	very low (road, narrow)	low (road, narrow)
Grizzly bear 1		01387	underpass	paved road	123	1963	very low (road, narrow)	low (road, narrow)
Grizzly bear 1		01388	underpass	unpaved road	18	1963	very low (road, narrow)	low (road, narrow)
Grizzly bear 1		01389	underpass	water	1019.7	1979	very high	very high
Grizzly bear 1		01390	underpass	water	878.8	1964	very high	very high
Grizzly bear 1		01391	underpass	water	981.7	1964	high	very high
Grizzly bear 1		01392	underpass	water	124	1964	very low (road, narrow)	very low (road, narrow)
Grizzly bear 1		01393	underpass	water	124	1964	very low (road, narrow)	very low (road, narrow)
Grizzly bear 1		03729	overpass	paved road	224.9	1971	very low (narrow, road)	very low (narrow, road)
	Collisions 2	01422	underpass	paved road	165	1964	very low (development, road)	very low (development, road)
	Collisions 2	01423	underpass	paved road	165	1964	very low (development, road)	very low (development, road)
	Collisions 2	01424	underpass	paved road	195.6	1964	very low (development, road)	very low (development, road)
	Collisions 2	01425	underpass	paved road	195.6	1964	very low (development, road)	very low (development, road)
Grizzly bear 2	Collisions 2	01426	underpass	water, paved trail	454.9	1965	low (development, steep banks)	low (steep banks)
Grizzly bear 2	Collisions 2	01427	underpass	water, paved trail	454.9	1965	low (development, steep banks)	low (steep banks)
Grizzly bear 2	Collisions 2	01428	underpass	paved road	143	1964	low (development, road, narrow)	low (development, road, narrow)
Grizzly bear 2	Collisions 2	01429	underpass	paved road	143	1964	low (development, road, narrow)	low (development, road, narrow)
Grizzly bear 2	Collisions 2	05628	overpass	paved road	243.9	1965	very low (narrow, road)	very low (narrow, road)
Grizzly bear 2	Collisions 2	01430	underpass	water, paved road	408.9	1965	low (development, road, steep banks)	low (development, road, steep banks)
Grizzly bear 2	Collisions 2	01431	underpass	water, paved road	398.9	1965	low (development, road, steep banks)	low (development, road, steep banks)
Grizzly bear 2	Collisions 2	01432	underpass	railroad	328.9	1963	low (development, railroad)	low (development, railroad)
Grizzly bear 2	Collisions 2	01433	underpass	railroad	358.9	1963	low (development, railroad)	low (development, railroad)
Grizzly bear 2	Collisions 2	01434	underpass	water, paved trail	486.13	2018	low (development, riprap, steep banks)	low (development, riprap, steep banks)
Grizzly bear 2	Collisions 2	01435	underpass	water, paved trail	468.13	2019	low (development, riprap, steep banks)	low (development, riprap, steep banks)
Grizzly bear 2	Collisions 2	01436	underpass	unpaved road	153	1964	low (development, narrow)	low (development)
Grizzly bear 2	Collisions 2	01437	underpass	unpaved road	153	1964	low (development, narrow)	low (development)
Grizzly bear 2	Collisions 2	01438	underpass	paved road	119.6	1964	low (development, road, narrow)	low (development)
Grizzly bear 2	Collisions 2	01439	underpass	paved road	119.6	1964	low (development, road, narrow)	low (development)
Grizzly bear 2	Collisions 2	01440	underpass	paved road	118	1964	low (development, road, narrow)	low (development)
Grizzly bear 2	Collisions 2	01441	underpass	paved road	120.1	1964	low (development, road, narrow)	low (development)
Grizzly bear 2	Collisions 2	01442	underpass	paved road	130	1963	low (development, road, narrow)	low (development)
Grizzly bear 2	Collisions 2	01443	underpass	paved road	130	1963	low (development, road, narrow)	low (development)

Grizzly bear zone	Collision zone	MDT ID	Type from wildlife perspective	Function	Width from animal's perspective	Year built	Potential for grizzly bear use (reason)	Potential for deer use
Grizzly bear 2	Collisions 2	01444	underpass	railroad	350.9	1963	low (development, railroad)	low (development, railroad)
Grizzly bear 2	Collisions 2	01445	underpass	railroad	355.4	1963	low (development, railroad)	low (development, railroad)
Grizzly bear 2	Collisions 2	03734	overpass	paved road	285.9	1972	very low (narrow, road)	very low (narrow, road)
Grizzly bear 2	Collisions 2	06383	overpass	paved road	275.9	1972	very low (narrow, road)	very low (narrow, road)
Grizzly bear 2	Collisions 2	01446	underpass	paved road	125	1972	low (development, road, narrow)	low (development)
Grizzly bear 2	Collisions 2	01447	underpass	paved road	125	1972	low (development, road, narrow)	low (development)
Grizzly bear 2		01448	underpass	water	348.3	1970	medium (steep banks, riprap)	medium (steep banks, riprap)
Grizzly bear 2		01449	underpass	paved road	120	1970	medium (road, narrow)	medium (road)
Grizzly bear 2		01450	underpass	paved road	120	1970	medium (road, narrow)	medium (road)
Grizzly bear 2		01451	underpass	unpaved road	14.1	1970	low (narrow, road)	low (narrow, road)
Grizzly bear 2		01452	underpass	water	22.6	1970	very low (narrow)	low (narrow)
Grizzly bear 2		01454	underpass	water	25.3	1971	very low (narrow)	low (narrow)
Grizzly bear 2		01455	underpass	unpaved road	119	1970	medium (narrow)	high
Grizzly bear 2		01456	underpass	water	254.5	1970	very high	very high
Grizzly bear 2		01457	underpass	unpaved road	20.9	1971	very low (narrow)	very low (narrow)
Grizzly bear 2		01458	underpass	unpaved road	17.4	1966	very low (narrow)	very low (narrow)
Grizzly bear 2		01459	underpass	paved road	125	1966	low (development, road)	low (development, road)
Grizzly bear 2		01460	underpass	paved road	125	1966	low (development, road)	low (development, road)
Grizzly bear 2	Collisions 3	01461	underpass	paved road	128	1966	low (development, road)	low (development, road)
Grizzly bear 2	Collisions 3	01462	underpass	paved road	130	1966	low (development, road)	low (development, road)
Grizzly bear 2	Collisions 3	01463	underpass	water	9.2	1966	very low (narrow)	very low (narrow)
	Collisions 3	01464	underpass	paved road	135	1966	low (development, road)	low (development, road)
	Collisions 3	01465	underpass	paved road	135	1966	low (development, road)	low (development, road)
	Collisions 3	01466	underpass	paved road	130	1966	low (development, road)	medium (development, road)
	Collisions 3	01467	underpass	paved road	130	1966	low (development, road)	medium (development, road)
	Collisions 3	01468	underpass	water	10.2	1966	very low (narrow)	very low (narrow)
Grizzly bear 3	Collisions 3	01469	underpass	unpaved road	18	1959	very low (narrow)	low (narrow)
Grizzly bear 3	Collisions 3	01470	underpass	unpaved road	18	1959	very low (narrow)	low (narrow)
Grizzly bear 3	Collisions 3	01471	underpass	water	9	2021	not possible (to small)	not possible (to small)
Grizzly bear 3	Collisions 3	01472	underpass	paved road	18	1959	very low (narrow)	low (narrow)
Grizzly bear 3	Collisions 3	01473	underpass	paved road	18	1959	very low (narrow)	low (narrow)
Grizzly bear 3	Collisions 3	01474	underpass	paved road	114	1959	low (development, road)	medium (development, road)
Grizzly bear 3	Collisions 3	01475	underpass	paved road	114	1959	low (development, road)	medium (development, road)
Grizzly bear 3	Collisions 3	01476	underpass	unpaved road	18	1959	very low (narrow)	low (narrow)
Grizzly bear 3	Collisions 3	01477	underpass	paved road	155	1959	low (road, narrow)	medium (road, narrow)
Grizzly bear 3	Collisions 3	01478	underpass	paved road	155	1959	low (road, narrow)	medium (road, narrow)
Grizzly bear 3	Collisions 3	01479	underpass	unpaved road	12.1	1965	very low (narrow)	low (narrow)
Grizzly bear 3	Collisions 3	01480	underpass	railroad	249.9	1973	medium (railroad)	high
Grizzly bear 3	Collisions 3	01481	underpass	railroad	264.9	1973	medium (railroad)	high
Grizzly bear 3	Collisions 3	01482	underpass	paved road	128	1973	low (road, narrow)	medium (road, narrow)
Grizzly bear 3	Collisions 3	01483	underpass	paved road	143	1973	low (road, narrow)	medium (road, narrow)

Grizzly bear zone	Collision zone	MDT ID	Type from wildlife perspective	Function	Width from animal's perspective	Year built	Potential for grizzly bear use (reason)	Potential for deer use
Grizzly bear 3	Collisions 3	01484	underpass	paved road	78	1973	low (road, narrow)	medium (road, narrow)
Grizzly bear 3	Collisions 3	01485	underpass	paved road	78	1973	low (road, narrow)	medium (road, narrow)
Grizzly bear 3	Collisions 3	01486	underpass	paved road, railroad	709.8	1979	low (road, railroad, development)	low (road, railroad, development)
Grizzly bear 3	Collisions 3	01487	underpass	paved road, railroad	709.8	1979	low (road, railroad, development)	low (road, railroad, development)
Grizzly bear 3	Collisions 3	01488	underpass	paved road, railroad	132.5	1979	medium (riprap, narrow)	high
Grizzly bear 3	Collisions 3	01489	underpass	paved road, railroad	131	1979	medium (riprap, narrow)	high
Grizzly bear 3	Collisions 3	01490	underpass	paved road, railroad	597.8	1979	medium (road, railroad)	high
Grizzly bear 3	Collisions 3	01491	underpass	paved road, railroad	581.8	1979	medium (road, railroad)	high
Grizzly bear 3	Collisions 3	04053	overpass	paved road	304	1978	very low (narrow, road)	very low (narrow, road)
Grizzly bear 3	Collisions 3	01492	underpass	unpaved road	22.7	1961	low (road, narrow)	low (road, narrow)
Grizzly bear 3	Collisions 3	01493	underpass	unpaved road	22.5	1961	low (road, narrow)	low (road, narrow)
Grizzly bear 3	Collisions 3	01494	underpass	paved road	123	1961	very low (development, road, narrow)	very low (development, road, narrow)
Grizzly bear 3	Collisions 3	01495	underpass	paved road	123	1974	very low (development, road, narrow)	very low (development, road, narrow)
	Collisions 3	01496	underpass	paved road	118	1961	very low (development, road, narrow)	very low (development, road, narrow)
	Collisions 3	01497	underpass	paved road	118	1974	very low (development, road, narrow)	very low (development, road, narrow)
	Collisions 3	01498	underpass	paved road	168	1961	very low (development, road, narrow)	very low (development, road, narrow)
	Collisions 3	01499	underpass	paved road	143	1974	very low (development, road, narrow)	very low (development, road, narrow)
	Collisions 3	01500	underpass	water	153	1961	low (development, riprap)	medium (development, riprap)
	Collisions 3	01501	underpass	water	153	1961	low (development, riprap)	medium (development, riprap)
	Collisions 3	06553	overpass	paved road	255.9	1961	very low (narrow, road)	very low (narrow, road)
	Collisions 3	01502	underpass	paved road	78	1975	low (road, narrow)	medium (road)
	Collisions 3	01503	underpass	paved road	78	1975	low (road, narrow)	medium (road)
	Collisions 3	01504	underpass	water	29.7	1973	not possible (to small)	not possible (to small)
	Collisions 3	04043	overpass	paved road	279.9	1978	very low (narrow, road)	very low (narrow, road)
	Collisions 3	01505	?	?	393.9	1978	?	?
	Collisions 3	01506	?	?	388.9	1978	?	?
Grizzly bear 4		03194	overpass	paved road	230.9	1966	very low (narrow, road)	very low (narrow, road)
Grizzly bear 4		01529	underpass	water	8	1965	not possible (to small)	not possible (to small)
Grizzly bear 5		01540	underpass	paved road	215.9	1968	low (road, narrow)	medium (road)
Grizzly bear 5		01541	underpass	paved road	199.9	1968	low (road, narrow)	medium (road)
Grizzly bear 5		01542	underpass	paved road	139	1968	low (development, road, narrow)	medium (road)
Grizzly bear 5		01543	underpass	paved road	139	1968	low (development, road, narrow)	medium (road)
Grizzly bear 5		01544	underpass	water	123.8	1968	low (riprap, steep banks, development, narrow)	low (riprap, steep banks, development, narrow)
Grizzly bear 5		01545	underpass	water	114	1968	low (riprap, steep banks, development, narrow)	low (riprap, steep banks, development, narrow)
Grizzly bear 5		01546	underpass	cattle	8	1969	very low (narrow)	very low (narrow)
Grizzly bear 5		01548	underpass	unpaved road	16.4	1968	very low (narrow)	very low (narrow)
Grizzly bear 5		01549	underpass	unpaved road	79	1969	very low (narrow)	very low (narrow)
Grizzly bear 5		01550	underpass	unpaved road	79	1969	very low (narrow)	very low (narrow)
	Collisions 4	01575	underpass	water	83	1965	very low (riprap, low clearance, narrow)	very low (riprap, low clearance)
	Collisions 4	01576	underpass	water	83	1965	very low (riprap, low clearance, narrow)	very low (riprap, low clearance)
	Collisions 4	01577	underpass	water	93	1965	very low (riprap, low clearance, narrow)	very low (riprap, low clearance)

Grizzly bear zone	Collision zone	MDT ID	Type from wildlife perspective	Function	Width from animal's perspective	Year built	Potential for grizzly bear use (reason)	Potential for deer use
	Collisions 4	01578	underpass	water	93	1965	very low (riprap, low clearance, narrow)	very low (riprap, low clearance)
	Collisions 4	01579	underpass	unpaved road	115	1965	very low (narrow, development, road)	low (road)
	Collisions 4	01580	underpass	unpaved road	115	1965	very low (narrow, development, road)	low (road)
	Collisions 4	01581	underpass	water	205.9	1965	low (riprap, narrow)	low (riprap)
	Collisions 4	01582	underpass	water	205.9	1965	low (riprap, narrow)	low (riprap)
	Collisions 4	01583	underpass	paved road	114	1965	very low (road, narrow)	medium (road)
	Collisions 4	01584	underpass	paved road	114	1965	very low (road, narrow)	medium (road)
	Collisions 4	06237	overpass	paved road	330	1998	very low (narrow, road)	very low (narrow, road)
	Collisions 4	01585	underpass	paved road	148.6	2014	very low (development, road)	very low (development, road)
	Collisions 4	01586	underpass	paved road	148.5	2014	very low (development, road)	very low (development, road)
	Collisions 4	01587	underpass	paved road	114	1966	very low (development, road, narrow)	very low (development, road, narrow)
	Collisions 4	01588	underpass	paved road	114	1966	very low (development, road, narrow)	very low (development, road, narrow)
	Collisions 4	06763	overpass	paved road	341.9	1994	very low (development, narrow, road)	very low (development, narrow, road)
	Collisions 4	06961	overpass	paved road	200	2014	very low (development, narrow, road)	very low (development, narrow, road)
	Collisions 4	01589	underpass	paved road, railroad	434.6	2011	very low (development, road, railroad)	very low (development, road, railroad)
	Collisions 4	01590	underpass	paved road, railroad	434.6	2010	very low (development, road, railroad)	very low (development, road, railroad)
	Collisions 4	01591	underpass	unpaved road/trail	31.7	2011	very low (development, narrow, road)	very low (development, narrow, road)
	Collisions 4	01592	underpass	paved road	143	1968	very low (development, narrow, road)	very low (development, road)
	Collisions 4	01593	underpass	paved road	145	1968	very low (development, narrow, road)	very low (development, road)
	Collisions 4	01594	underpass	railroad	297.5	1971	very low (development, railroad)	very low (development, railroad)
	Collisions 4	01595	underpass	railroad	297.5	1971	very low (development, railroad)	very low (development, railroad)
	Collisions 4	01596	underpass	paved road	204.5	1971	very low (development, road)	very low (development, road)
	Collisions 4	01597	underpass	paved road	205.9	1971	very low (development, road)	very low (development, road)
	Collisions 4	01598	underpass	paved road	79	1971	very low (development, road, narrow)	low (development, road, narrow)
	Collisions 4	01599	underpass	paved road	79	1971	very low (development, road, narrow)	low (development, road, narrow)
	Collisions 4	01600	underpass	cattle	12	1962	very low (narrow)	very low (narrow)
	Collisions 4	01601	underpass	water	17.3	1962	very low (narrow)	very low (narrow)
		01602	underpass	paved road	113	1962	very low (development, road, narrow)	low (development, road, narrow)
		01603	underpass	paved road	113	1962	very low (development, road, narrow)	low (development, road, narrow)
Grizzly bear 6		01604	underpass	railroad, unpaved road	426.4	2006	low (railroad, development, road)	medium (railroad, development, road)
Grizzly bear 6		01605	underpass	railroad, unpaved road	426.4	2006	low (railroad, development, road)	medium (railroad, development, road)
Grizzly bear 6		01606	underpass	water	37	1962	very low (narrow)	very low (narrow)
Grizzly bear 6		01607	underpass	paved road	129	1962	very low (development, road, narrow)	very low (development, road)
Grizzly bear 6		01608	underpass	paved road	129	1962	very low (development, road, narrow)	very low (development, road)
Grizzly bear 6		01609	underpass	paved road	130	1979	low (development, road, narrow)	low (development, road)
Grizzly bear 6		01610	underpass	paved road	130	1979	low (development, road, narrow)	low (development, road)
Grizzly bear 6		01611	underpass	unpaved road	114	2022	low (development, road, narrow)	low (development, road)
Grizzly bear 6		01612	underpass	unpaved road	158	2022	low (development, road, narrow)	low (development, road)
Grizzly bear 6		01613	underpass	unpaved road	17.2	1978	low (development, road, narrow)	low (development, road)
Grizzly bear 6		01614	underpass	paved road	126	1978	low (development, road, narrow)	low (development, road)
Grizzly bear 6		01615	underpass	paved road	126	1978	low (development, road, narrow)	low (development, road)

Grizzly bear zone	Collision zone	MDT ID	Type from wildlife perspective	Function	Width from animal's perspective	Year built	Potential for grizzly bear use (reason)	Potential for deer use
	Collisions 5	01616	underpass	unpaved road	78	1977	low (development, road, narrow)	low (development, road)
	Collisions 5	01617	underpass	unpaved road	78	1977	low (development, road, narrow)	low (development, road)
	Collisions 5	01618	underpass	cattle	11	1977	very low (narrow, development, road)	very low (narrow, development, road)
	Collisions 5	01619	underpass	cattle	11	1977	very low (narrow, development, road)	very low (narrow, development, road)
	Collisions 5	01620	underpass	paved road	115	1962	very low (development, road, narrow)	very low (development, road)
	Collisions 5	01621	underpass	paved road	114	1962	very low (development, road, narrow)	very low (development, road)
	Collisions 5	01622	underpass	paved road, railroad	250.9	1962	very low (development, road, railroad)	very low (development, road, railroad)
	Collisions 5	01623	underpass	paved road, railroad	250.9	1962	very low (development, road, railroad)	very low (development, road, railroad)
	Collisions 5	01624	underpass	water, unpaved road	730	1962	high (riprap)	high (riprap)
	Collisions 5	01625	underpass	water, unpaved road	730	1962	high (riprap)	high (riprap)
	Collisions 5	01626	underpass	unpaved road	17	1962	very low (narrow, road)	very low (narrow, road)
	Collisions 5	01627	underpass	paved road	128	1962	very low (development, narrow, road)	very low (development, road)
	Collisions 5	01628	underpass	paved road	128	1962	very low (development, narrow, road)	very low (development, road)
	Collisions 5	05376	overpass	paved road	278.9	1962	very low (narrow, road)	very low (narrow, road)
	Collisions 5	06063	overpass	paved road	210.9	1962	very low (narrow, road)	very low (narrow, road)
	Collisions 5	01629	underpass	water, unpaved road	119	1987	low (road, narrow)	medium (road)
	Collisions 5	01630	underpass	water, unpaved road	118	1959	low (road, narrow)	medium (road)
	Collisions 5	01632	underpass	paved road	135	1987	very low (narrow, road)	low (road)
	Collisions 5	01633	underpass	paved road	135	1987	very low (narrow, road)	low (road)
	Collisions 5	01634	underpass	cattle	13.8	1987	not possible (to small)	not possible (to small)
	Collisions 5	01635	underpass	unpaved road	62	1987	very low (narrow, road)	low (road)
	Collisions 5	01636	underpass	unpaved road	62	1987	very low (narrow, road)	low (road)
	Collisions 5	01637	underpass	cattle	13.8	1987	not possible (to small)	not possible (to small)
	Collisions 5	01638	underpass	unpaved road	16.5	1960	very low (narrow, road)	very low (narrow, road)
	Collisions 5	01639	underpass	water	45	1987	very low (narrow, riprap, low clearance)	very low (riprap, low clearance)
	Collisions 5	01640	underpass	water	60	2012	very low (narrow, riprap, low clearance)	very low (riprap, low clearance)
	Collisions 5	01641	underpass	cattle	14	1987	not possible (to small)	not possible (to small)
	Collisions 5	01642	underpass	paved road	79	1987	very low (narrow, road)	very low (narrow, road)
	Collisions 5	01643	underpass	paved road	79	1987	very low (narrow, road)	very low (narrow, road)
	Collisions 5	01644	underpass	paved road	16.5	1960	very low (narrow, road)	very low (narrow, road)
	Collisions 5	01645	underpass	paved road	124	1981	very low (narrow, road)	low (road)
	Collisions 5	01646	underpass	paved road	124	1981	very low (narrow, road)	low (road)
	Collisions 5	01647	underpass	cattle	10.2	1981	not possible (to small)	not possible (to small)
	Collisions 5	01648	underpass	unpaved road	115	1981	very low (narrow, road)	low (road)
	Collisions 5	01649	underpass	unpaved road	115	1981	very low (narrow, road)	low (road)
	Collisions 5	01650	underpass	water, unpaved road	78	1983	very low (narrow, road)	low (road)
	Collisions 5	01651	underpass	water, unpaved road	78	1983	very low (narrow, road)	low (road)
	Collisions 5	01652	underpass	water	10.2	1983	not possible (to small)	not possible (to small)
	Collisions 5	04534	overpass	paved road	295.9	1981	very low (narrow, road)	very low (narrow, road)

11.4 Discussion

The location of the road selected road sections for grizzly bear connectivity and collisions with large wild mammals have partial overlap. The overlap is between Bonner and Beavertail, and between Drummond and Deerlodge. Other selected road sections are either important for grizzly bear connectivity or collisions with large wild animals, but not both. If the objectives related to wildlife and roads include both:

1. Improving human safety along I-90 through reducing collisions with large wild mammals
2. Reducing the barrier effect of I-90 for grizzly bears

Then the development of a two-track system for policy, funding, and implementation is required. One track would be rooted in human safety, and the other in biological conservation.

The selected road sections were selected because of their importance to grizzly bear connectivity or because of their relatively high concentration of collisions with large wild mammals. Obviously, mitigation in the road sections selected for grizzly bear should be designed for grizzly bear. However, data on other roadkilled large mammals in each road section (this chapter) and data on important habitat and corridors for other species (Chapter 6, Chapter 7) should also guide the design of mitigation measures in those road sections. The same applies to the road sections selected based on collisions with large wild mammals.

While there are many existing structures in the selected road sections only a few were estimated to be highly or very highly suitable for either grizzly bears or deer. This suggests that designated wildlife crossing structures are likely needed. However, some existing structures can be retrofitted to enhance wildlife use (e.g. a wildlife trail through riprap).

12 Recommendations

12.1 Actions aimed at acquiring more and better data

12.1.1 Pinpoint locations along road sections that require measures to improve connectivity for grizzly bears

Conduct more detailed movement modeling for where grizzly bears are most likely to approach roads. To establish connectivity between the NCDE and GYE population, detailed movement modelling is especially needed along I-90 (Homestake Pass, Cardwell), and along I-15 (between Butte and Helena). Additional movement modelling may be needed along I-15 south of Butte and along I-90 northwest of Butte. To establish connectivity between the BE recovery zone and the NCDE population, detailed movement modelling is especially needed along I-90 (Between Missoula and Drummond), and along US Highway 93 (between Lolo and Florence, potentially also directly north of Lolo). Additional movement modelling may be needed along I-90 west of Missoula (in the Sixmile and Ninemile area). Consult with Sarah Sells at the Montana Cooperative Wildlife Research Unit, University of Montana and Cecily Costello at Montana Fish, Wildlife and Parks.

Conduct interviews with grizzly bear experts (e.g., Jamie Jonkel, Cecily Costello and Justine Vallieres, Montana Fish Wildlife & Parks; USFWS personnel or former employees; USGS personnel or former employees), enquire about potential GPS collar data from grizzly bears, enquire about possible local attractants, including productive huckle berry patches. Enquire about the potential for enhancing grizzly bear habitat security and movements in large open valleys with agricultural activities. The latter is especially relevant in the wide-open valleys between Norris, Ennis, and Alder, and north of Twin Bridges.

12.1.2 Acquire data on current and historic migratory movements of large wild mammals

Conduct interviews with employees of Montana Fish Wildlife & Parks and acquire data on current and historic migratory movements of large wild mammals in western Montana. Migration routes of pronghorn are of specific concern (e.g. between summer and winter range north and south of I-90 near Drummond and Hall, and north (or east) and south (or west) of I-90 between Anaconda and Nissler (the junction between I-90 and I-15), including other roads between Anaconda and I-90 that may hinder pronghorn movements to and from areas to the southeast (towards Melrose and Dillon) and the southwest (towards the Big Hole).

12.2 Actions aimed at establishing a strategic framework

12.2.1 Further develop policy, funding and implementation to enhance biological conservation

Recognize that while there can be overlap between road sections that may require mitigation for large wild mammal-vehicle collisions and road sections that may require mitigation for biological conservation, there are also road sections that are important to mitigate for either collisions or biological conservation but not both. While the policy, funding and implementation framework for measures aimed at collisions has become somewhat established over the last few decades, the framework for measures aimed at enhancing biological conservation, including reducing the barrier effect of roads and traffic for wildlife, is still underdeveloped. Actions that help further develop policy, funding and implementation framework for biological conservation are required to achieve objectives related to biological conservation. This should ultimately result in two tracks for policy, funding and implementation. One track is based on reducing collisions with large common mammals (e.g., white-tailed deer) and improving human safety, and the second track is based on biological conservation for rare, and potentially small species. Objectives related to biological conservation can only succeed if spatially coherent measures are taken on a landscape level. This means that the measures can include multiple roads or road sections, in an area and that they can include both high and low volume roads. Furthermore, the land use of the areas between roads influences the likelihood that conservation objectives are reached. Therefore, some measures may be directed at improving habitat security for selected wildlife species, including through a reduction in the potential for human-wildlife conflict.

12.2.2 Select specific conservation objectives and develop strategies to achieve these objectives.

Objectives related to biological conservation that relate to a specific area, and a specific species tend to be more actionable than those that are more general. Even then, there are often multiple possible objectives that would require action in different areas and different roads or road sections. E.g., for grizzly bears:

- Reduce grizzly bear road mortality in areas where they have been killed by vehicles in the last few decades: Reduce road mortality along US Highway 93 (Ninepipe area), Montana Highway 83 (Seeley-Swan), Montana Highway 200 (between Mineral Hill and Lincoln), and US Highway 2 (west of East Glacier).
- Increase the grizzly bear population size in western Montana (and the lower-48 States): Encourage recolonization of the BE recovery zone through reducing the barrier effect of I-90 (Ninemile-Sixmile area and East Missoula – Drummond) and US Highway 93 (Lolo – Florence and potentially north of Lolo).
- Establish functional connectivity for grizzly bears between the Northern Continental Divide Ecosystem and the Greater Yellowstone Ecosystem: Reduce the barrier effect of I-90 (Homestake Pass, Cardwell) and I-15 (Butte-Boulder).

Depending on the objective, actions are required along different road sections and adjacent areas.

12.3 Actions aimed at increasing connectivity for large wild mammals

12.3.1 Secure habitat adjacent to potential future crossing structures and along dispersal or migratory routes

Consult with land trusts, other NGOs or other organizations that can engage with private landowners to secure habitat for wildlife and reduce the potential for human-wildlife conflict. Depending on the objectives, specific areas or areas along (projected) wildlife dispersal or migratory routes may be prioritized.

Enhancing grizzly bear movement and habitat security may include reducing the potential for human-wildlife conflicts and allowing for more trees and shrubs along creeks in open grassland areas. Enhancing grizzly bear habitat security for grizzly bears is especially relevant for establishing connectivity between grizzly bears from the Northern Continental Divide Ecosystem and the Greater Yellowstone Ecosystem along I-90 between Butte and Three Forks. Apart from I-90, the following open valleys may (still) be a substantial barrier to grizzly bears:

- The Madison Valley between Ennis and the southern end of the Madison Vally (connecting the Madison Range in the east to the Gravelly Range/Greenhorn Range in the west).
- The Madison Valley between Norris and Ennis (connecting the Madison Range in the east to the Tobacco Root Mountains in the northwest).
- The areas along the road corridor between Ennis, Virginia City, Alder, Sheridan and Twin Bridges (connecting the Gravelly Range/Greenhorn Range/Ruby Range in the south to the Tobacco Root Mountains in the north.
- The areas along the road corridor between Twin Bridges and Whitehall (connecting Tobacco Root Mountains in the east to the Highland Mountains in the west).
- The areas along the I-15 corridor between the junction with I-90 and Montana Highway 43 to Wise River.
- The areas along the road corridor between Cardwell and Harrison (connecting the Tobacco Root Mountains in the south to the areas north of Montana Highway 359, the Jefferson River, and Montana Highway 2).

13 References

Adams, P.J., M.P. Huijser & S.C. Getty. 2023. An assessment of existing and potential future mitigation measures related to grizzly bears along US Highway 93, Flathead Indian Reservation, Montana, USA. Confederated Salish and Kootenai Tribes, Pablo, Montana, USA.

Boyce, M.S. & J.S. Waller. 2003. Grizzly bears for the Bitterroot: Predicting potential abundance and distribution. Wildlife Society Bulletin 31(3): 670-683.

Carroll, K.A. , A.J. Hansen, R.M. Inman, R.L. Lawrence & A.B. Hoegh. 2020. Testing landscape resistance layers and modeling connectivity for wolverines in the western United States. Global Ecology and Conservation 23 (2020) e01125.

Cramer, P.C. & R. Hamlin. 2016. Evaluation of wildlife crossing structures on US 93 in Montana's Bitterroot Valley. Montana Department of Transportation and Federal Highway Administration. Report Number : FHWA/MT-17-003/8194. DOI : https://doi.org/10.21949/1518235

Chruszcz, B., A.P. Clevenger, K.E. Gunson & M.L. Gibeau. 2003. Relationships among grizzly bears, highways, and habitat in the Banff-Bow Valley, Alberta, Canada. Canadian Journal of Zoology 81: 1378-1391.

Costello, C.M., J.A. Dellinger, J.K. Fortin-Noreus, M.A. Haroldson, B.E. Karabensh, W.F. Kasworm, L.L. Roberts, J.E. Teisberg, F.T. van Manen & T.J. Vent. 2025. A summary of grizzly bear distribution in the lower-48 US states in 2024, 7 p.

Duffield, J. & C. Neher. 2019. Incorporating wildlife passive use values in collision mitigation benefit-cost calculations. NDOT Research Report No. 701-18-803 TO 1. Bioeconomics, Inc., Missoula, Montana, USA.

Duffield, J. & C. Neher. 2021. Incorporating deer and turtle total value in collision mitigation benefit-cost calculations. NDOT Research Report No. 701-18-803 TO 5. Bioeconomics, Inc., Missoula, Montana, USA.

Fairbank, E., K. Penrod, M. Huijser, M. Bell, D. Fick, L. Swartz, A. Bunce, S. Doyle, B. Hance & A. Wearn. 2024. US 89 Wildlife & Transportation Assessment. Yellowstone Safe Passages. https://static1.squarespace.com/static/601f17c13f51f617d9516abe/t/65ee37604039a95ab3a20d44/1710110570166/US+89+Wildlife+and+Transportation+Assessment_Final+Report_March+2024.pdf

Gomes L., C. Grilo, C. Silva & A. Mira. 2009. Identification methods and deterministic factors of owl roadkill hotspot locations in Mediterranean landscapes. Ecological Research 24(2): 355-370.

Huijser, M.P. & J.S. Begley. 2022. Implementing wildlife fences along highways at the appropriate spatial scale: A case study of reducing road mortality of Florida Key deer. In: Santos S., C. Grilo, F. Shilling, M. Bhardwaj & C.R. Papp (Eds.). Linear Infrastructure Networks with Ecological Solutions. Nature Conservation 47: 283–302. https://doi.org/10.3897/natureconservation.47.72321

Huijser, M.P. & M.A. Bell. 2024. Identification and prioritization of road sections with a relatively high concentration of large wild mammal-vehicle collisions in Gallatin County, Montana, USA. Report number 4WA834. Western Transportation Institute, Montana State University, Bozeman, Montana, USA. DOI: https://doi.org/10.15788/1727734814 https://westerntransportationinstitute.org/wp-content/uploads/2024/10/4WA834_Identification-and-Prioritization-of-Road-Sections_20240930.pdf

Huijser, M.P., J. Fuller, M.E. Wagner, A. Hardy, & A.P. Clevenger. 2007. Animal-vehicle collision data collection. A synthesis of highway practice. NCHRP Synthesis 370. Project 20-05/Topic 37-12. Transportation Research Board of the National Academies, Washington DC, USA.

Huijser, M.P., P. McGowen, J. Fuller, A. Hardy, A. Kociolek, A.P. Clevenger, D. Smith & R. Ament. 2008. Wildlife-vehicle collision reduction study. Report to Congress. U.S. Department of Transportation, Federal Highway Administration, Washington D.C., USA.

Huijser, M.P., J.W. Duffield, A.P. Clevenger, R.J. Ament & P.T. McGowen. 2009. Cost–benefit analyses of mitigation measures aimed at reducing collisions with large ungulates in the United States and Canada; a decision support tool. Ecology and Society 14(2): 15. [online] URL: http://www.ecologyandsociety.org/viewissue.php?sf=41

Huijser, M.P., E.R. Fairbank, W. Camel-Means, J. Graham, V. Watson, P. Basting & D. Becker. 2016. Effectiveness of short sections of wildlife fencing and crossing structures along highways in reducing wildlife-vehicle collisions and providing safe crossing opportunities for large mammals. Biological Conservation 197: 61-68.

Huijser, M.P., R.J. Ament, M. Bell, A.P. Clevenger, E.R. Fairbank, K.E. Gunson & T. McGuire. 2021. Animal vehicle collision reduction and habitat connectivity study. Literature review. Report No. 701-18-803 TO 1. Transportation Pooled-Fund Project TPF-5(358), Administered by the Nevada Department of Transportation. Western Transportation Institute, Montana State University, Bozeman, Montana, USA.

Huijser, M.P., J.W. Duffield, C. Neher, A.P. Clevenger & T. McGuire. 2022a. Cost–benefit analyses of mitigation measures along highways for large animal species: An update and an expansion of the 2009 model. Report No. 701-18-803 TO 1 Part 3. Transportation Pooled-Fund Project TPF-5(358), Administered by the Nevada Department of Transportation. Western Transportation Institute, Montana State University, Bozeman, Montana, USA.

Huijser, M.P., E.R. Fairbank & K.S. Paul. 2022b. Best practices manual to reduce animal-vehicle collisions and provide habitat connectivity for wildlife. Report No. 701-18-803 TO 1 Part 3. Transportation Pooled-Fund Project TPF-5(358), Administered by the Nevada Department of Transportation. Western Transportation Institute, Montana State University, Bozeman, Montana, USA.

Kasworm, W.F., T.G. Radandt, J.E. Teisberg, T. Vent, M. Proctor, H. Cooley & J.K. Fortin-Noreus. 2025. Cabinet-Yaak grizzly bear recovery area 2024 research and monitoring progress report. U.S. Fish and Wildlife Service, Missoula, Montana. https://www.fws.gov/sites/default/files/documents/2025-09/cabinet-yaak-grizzly-bear-recovery-area-2024-research-and-monitoring-progress-report.pdf

Kendall, K.C., J.B. Stetz, J. Boulanger, A.C. Macleod, D. Paetkau & G.C. White. 2009. Demography and genetic structure of a recovering grizzly bear population. Journal of Wildlife Management 73(1): 3-17.

Kendall, K.C., A.C. Macleod, K.L. Boyd, J. Boulanger, J.A. Royle, W.F. Kasworm, D. Paetkau, M.F. Proctor, K. Annis & T.A. Graves. 2016. Density, distribution, and genetic structure of grizzly bears in the Cabinet-Yaak Ecosystem. The Journal of Wildlife Management 80(2): 314-331.

Lee, T.S., K. Rondeau, R. Schaufele, A.P. Clevenger & D. Duke. 2021. Developing a correction factor to apply to animal-vehicle collision data for improved road mitigation measures. Wildlife Research 48: 501–510. https://doi.org/10.1071/WR20090

Lukacs, P.M., D. Evans Mack, R. Inman, J.A. Gude, J.S. Ivan, R.P. Lanka, J.C. Lewis, R.A. Long, R. Sallabanks, Z. Walker, S. Courville, S. Jackson, R. Kahn, M.K. Schwartz, S.C. Torbit, J.S. Waller & K. Carroll. 2020. Wolverine occupancy, spatial distribution, and monitoring design. The Journal of Wildlife Management 84(5):841–851; 2020; DOI: 10.1002/jwmg.21856

MDT. 2023. 2018 Traffic by sections report: On system. Montana Department of Transportation, Helena, Montana, USA. https://www.mdt.mt.gov/other/webdata/external/Planning/traffic_reports/2018TRAFFICBYSECTIONS.pdf

MDT. 2025a. Traffic count (TCDS). https://mdt.public.ms2soft.com/tcds/tsearch.asp?loc=Mdt&mod=

MDT. 2025c. MDT spatial data map. https://mdt.maps.arcgis.com/apps/mapviewer/index.html?webmap=1eab4f286f61456b87fa28dc42e49e8f

MDT. 2025c. Montana bridge load posting program. https://www.mdt.mt.gov/business/contracting/bridge/loadrating/load-posting-program.aspx

Mikle, N., T.A. Graves, R. Kovach, K.C. Kendall & A.C. Macleod. 2016 Demographic mechanisms underpinning genetic assimilation of remnant groups of a large carnivore. Proceedings of the Royal Society B 283: 20161467. http://dx.doi.org/10.1098/rspb.2016.1467

Montana Fish, Wildlife & Parks. 2023. Vehicle-Killed Wildlife Salvage Permit. https://fwp.mt.gov/buyandapply/vehiclekilledsalvagepermit

MTFWP. 2025a. Predicted wolverine habitat. Montana Fish, Wildlife and Parks (MTFWP). Maps and GIS Resources. https://gis-mtfwp.hub.arcgis.com/datasets/36b958493beb4755839523442dacff5c_0/explore?location=39.482336%2C-110.622862%2C4.97

Moore, L.J., A.Z.A. Arietta, D.T. Spencer, M.P. Huijser, B.L. Walder & F.D. Abra. 2021. On the road without a map: Why we need an “Ethic of Road Ecology”. Frontiers in Ecology and Evolution 9: 774286. doi: 10.3389/fevo.2021.774286 https://www.frontiersin.org/article/10.3389/fevo.2021.774286

Northrup, J.M., J. Pitt, T.B. Muhly, G.B. Stenhouse, M. Musiani & M.S. Boyce. 2012. Vehicle traffic shapes grizzly bear behaviour on a multiple-use landscape. Journal of Applied Ecology 49: 1159-1167.

Olson, L.E., N. Bjornlie, G. Hanvey, J.D. Holbrook, J.S. Ivan, S. Jackson, B. Kertson, T. King, M. Lucid, D. Murray, R. Naney, J. Rohrer, A. Scully, D. Thornton, Z. Walker & J.R. Squires. 2021. Improved prediction of Canada lynx distribution through regional model transferability and data efficiency. Ecology and Evolution 2021;11: 1667-1690. https://doi.org/10.1002/ece3.7157

Pashby, J. 2022. Stymied. A grizzly’s blocked journey highlights the need for more wildlife road crossings. Montana Outdoors March-April 2022: 20-21.

Proctor, M.F., B.N. McLellan & C. St-robeck. 2002. Population fragmentation of grizzly bears in Southeastern British Columbia, Canada. Ursus 13: 153-160.

Servheen, C., A. Hamilton, R. Knight & B. McLellan. 1991. Report of the Technical Review Team Evaluation of the Bitterroot and North Cascades to Sustain Viable Grizzly Bear Populations. Missoula, Montana, USA.

State of Montana. 2023. Montana Code Annotated 2023. Permit To Salvage Game Animals. https://leg.mt.gov/bills/mca/title_0870/chapter_0030/part_0010/section_0450/0870-0030-0010-0450.html

Squires, J.R., N.J. DeCesare, L.E. Olson, J.A. Kolbe, M. Hebblewhite & S.A. Parks. 2013. Combining resource selection and movement behavior to predict corridors for Canada lynx at their southern range periphery. Biological Conservation 157: 187-195.

USFWS. 1993. Grizzly bear recovery plan. Missoula, Montana, U.S.A., 181 pp. (URL: https://www.fws.gov/mountain-prairie/es/species/mammals/grizzly/Grizzly_bear_recovery_plan.pdf) https://www.sciencebase.gov/catalog/item/5a5fa2d9e4b06e28e9bfc454

U.S. Fish and Wildlife Service. 2018. Grizzly bear recovery plan supplement: Habitat-based recovery criteria for the Northern Continental Divide Ecosystem. Missoula, Montana, USA

USFWS. 2021. Grizzly bear “area of influence”. Created: January 11, 2021. https://www.arcgis.com/home/item.html?id=79b9761bee2249a0b6b25e657ff558d8

USFWS. 2024a. Grizzly bear recovery program. 2023 Annual report. U.S. Fish and Wildlife Service, University of Montana, Missoula, MT.

USFWS. 2024b. Endangered and threatened wildlife and plants; Establishment of an experimental population of the grizzly bear in the Bitterroot Ecosystem of the States of Idaho and Montana; Environmental Impact Statement . A Notice by the Fish and Wildlife Service on 01/18/2024. Federal Register. Published Document: 2024-00873 (89 FR 3411). https://www.federalregister.gov/documents/2024/01/18/2024-00873/endangered-and-threatened-wildlife-and-plants-establishment-of-an-experimental-population-of-the

USFWS. 2025. Grizzly bear (Ursus arctos horribilis). US Fish and Wildlife Service. https://ecos.fws.gov/ecp/species/7642

USFWS. 2026. Grizzly bear (Ursus arctos horribilis). Current occupied range (situation 2024). US Fish and Wildlife Service.

Sells, S.N. & C.M. Costello. 2024. Predicting future grizzly bear habitat use in the Bitterroot Ecosystem under recolonization and reintroduction scenarios. PLoS ONE 19(9): e0308043. https://doi.org/10.1371/journal.pone.0308043

Sells, S.N., C.M. Costello, P.M. Lukacs, L.L. Roberts & M.A. Vinks. 2022. Grizzly bear habitat selection across the Northern Continental Divide Ecosystem. Biological Conservation 276 (2022) 109813

Sells, S.N., C.M. Costello, P.M. Lukacs, F.T. van Manen, M. Haroldson, W. Kasworm, J. Teisberg, M.A. Vinks, D. Bjornlie. 2023a. Grizzly bear movement models predict habitat use for nearby populations. Biological Conservation 279(2023): 109940

Sells, S.N., C.M. Costello, P.M. Lukacs, L.L. Roberts & M.A. Vinks. 2023b. Predicted connectivity pathways between grizzly bear ecosystems in Western Montana. Biological Conservation 284(2023) 110199

Waller, J.S. & C.S. Miller. 2015. Decadal growth of traffic volume on US Highway 2 in Northwestern Montana. Intermountain Journal of Sciences 21(1-4): 29-37.

Waller, J.S. & C. Servheen. 2005. Effects of transportation infrastructure on grizzly bears in northwestern Montana. Journal of Wildlife Management 69(3): 985-1000.

Wally, A. 2024. Montana Mountain Ranges. Created by Amy Wally, Missoula, Montana, USA. https://www.google.com/maps/d/u/1/viewer?mid=1cyCmHFGlcrCHQAsCsCt4fNB3MfCW84Mm&ll=46.66250667915522%2C-113.49714805548552&z=10

14 Appendix A: detailed maps grizzly bear connectivity zones

Grizzly bear priority site 1 (Ninemile) maps are in Figure 62, Figure 63, Figure 64, Figure 65, Figure 66, Figure 67, Figure 68, Figure 69, Figure 70
Grizzly bear priority site 2 (Bonner) maps are in Figure 71, Figure 72, Figure 73, Figure 74, Figure 75, Figure 76, Figure 77, Figure 78, Figure 79
Grizzly bear priority site 3 (Deer Lodge) maps are in Figure 80, Figure 81, Figure 82, Figure 83, Figure 84, Figure 85, Figure 86, Figure 87, Figure 88
Grizzly bear priority site 4 (Homestake Pass) maps are in Figure 89, Figure 90, Figure 91, Figure 92, Figure 93, Figure 94, Figure 95, Figure 96, Figure 97
Grizzly bear priority site 5 (Cardwell) maps are in Figure 98, Figure 99, Figure 100, Figure 101, Figure 102, Figure 103, Figure 104, Figure 105, Figure 106
Grizzly bear priority site 6 (Bozeman Pass) maps are in Figure 107, Figure 108, Figure 109, Figure 110, Figure 111, Figure 112, Figure 113, Figure 114, Figure 115

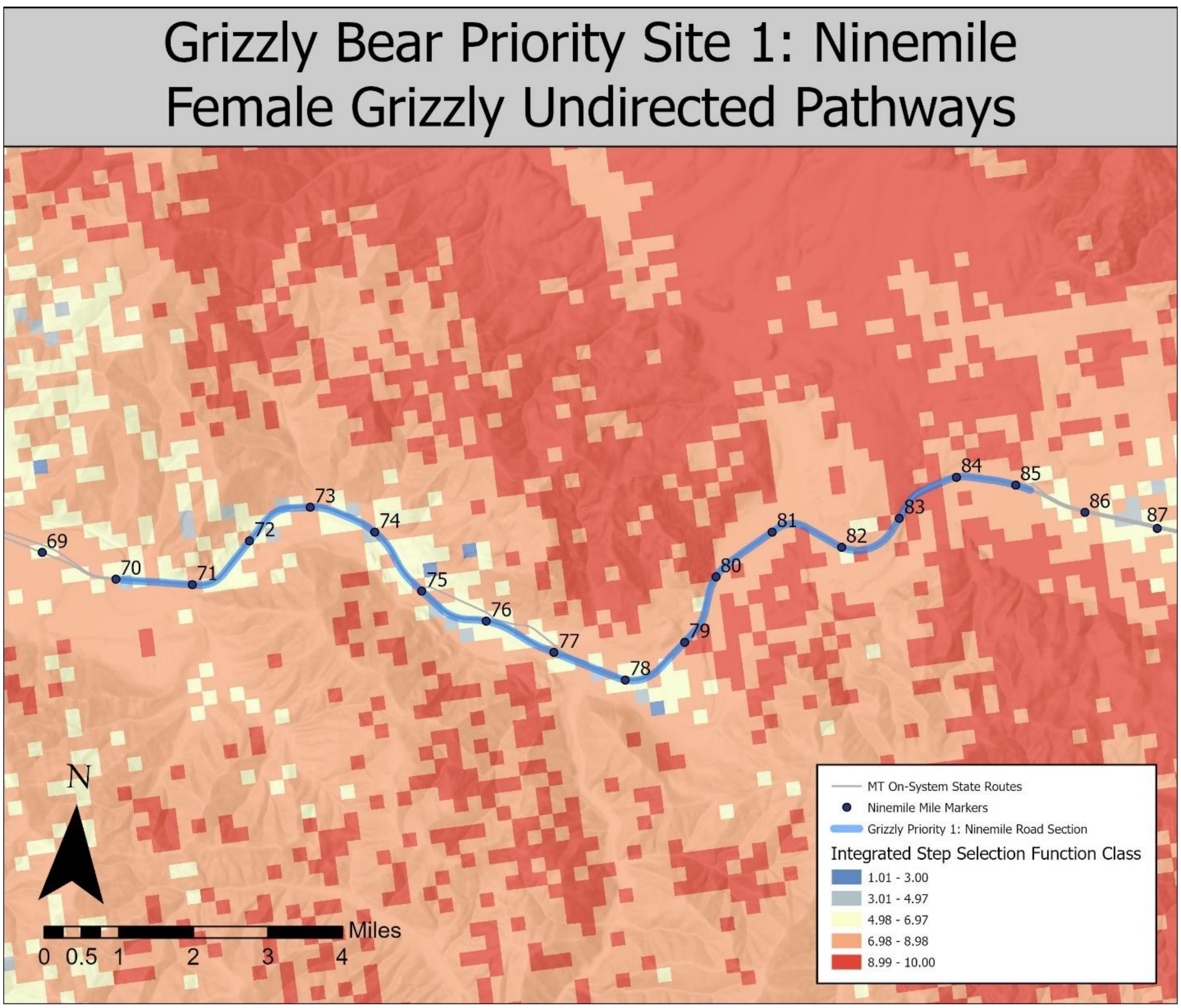


Figure 62: Grizzly bear priority site 1 (Ninemile), undirected pathways for female grizzly bears.

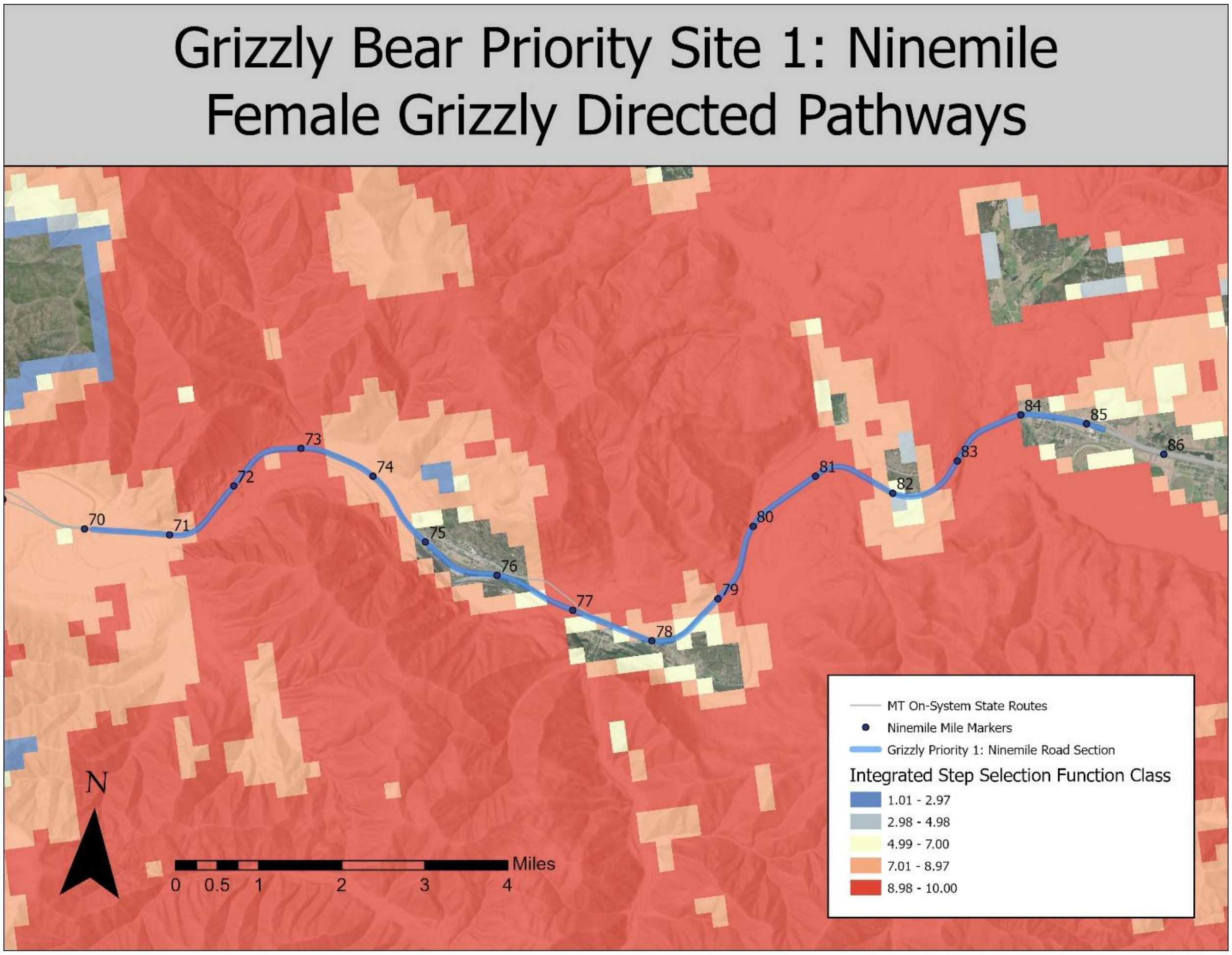


Figure 63: Grizzly bear priority site 1 (Ninemile), directed pathways for female grizzly bears.

Figure 64: Grizzly bear priority site 1 (Ninemile), conservation easements and public lands.

Figure 65: Grizzly bear priority site 1 (Ninemile), top 25% crash locations.

Figure 66: Grizzly bear priority site 1 (Ninemile), top 25% carcass locations.

Figure 67: Grizzly bear priority site 1 (Ninemile), MDT structures.

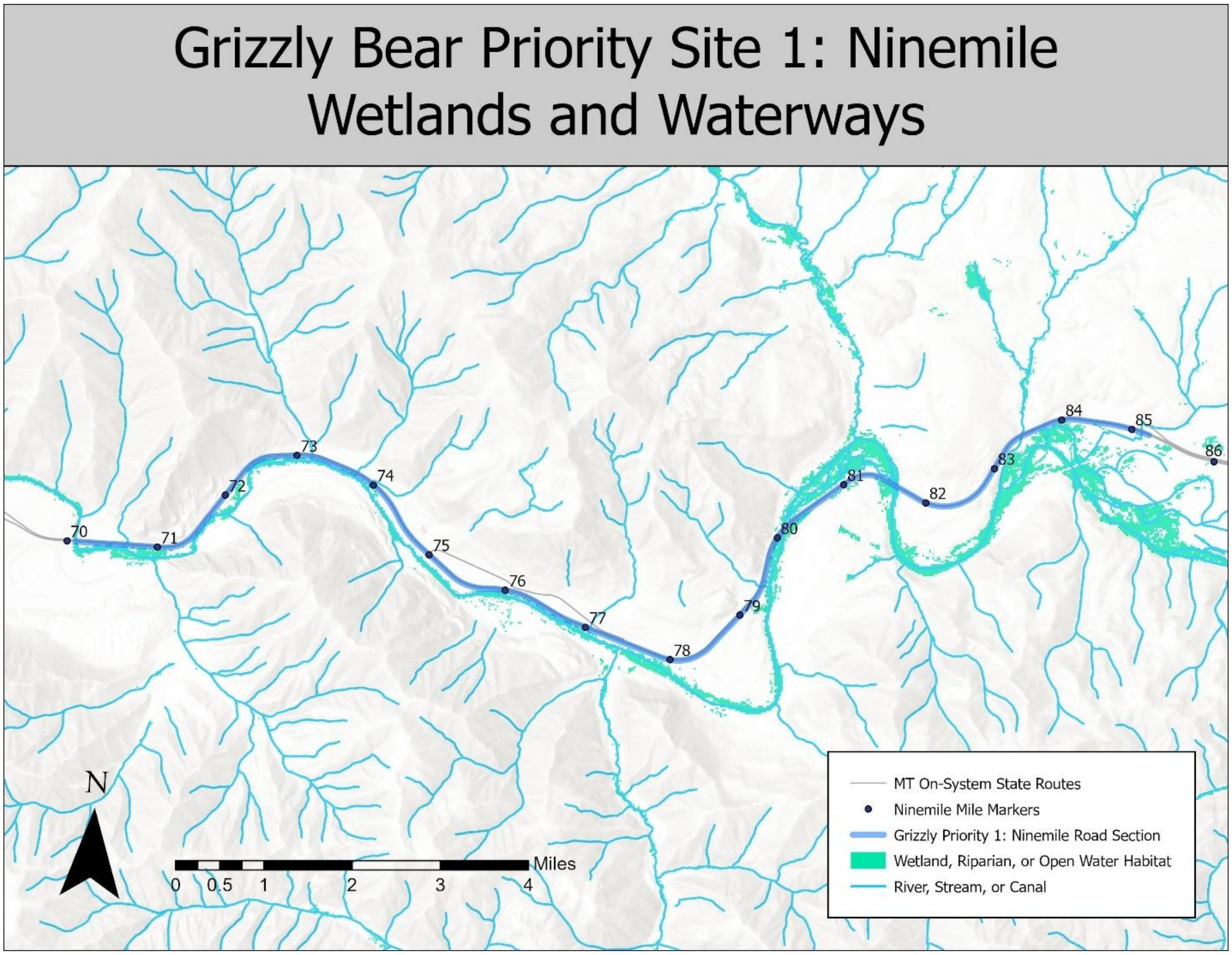


Figure 68: Grizzly bear priority site 1 (Ninemile), wetlands and waterways.

Figure 69: Grizzly bear priority site 1 (Ninemile), estimated suitability of existing structures for grizzly bears.

Figure 70: Grizzly bear priority site 1 (Ninemile), estimated suitability of existing structures for deer.

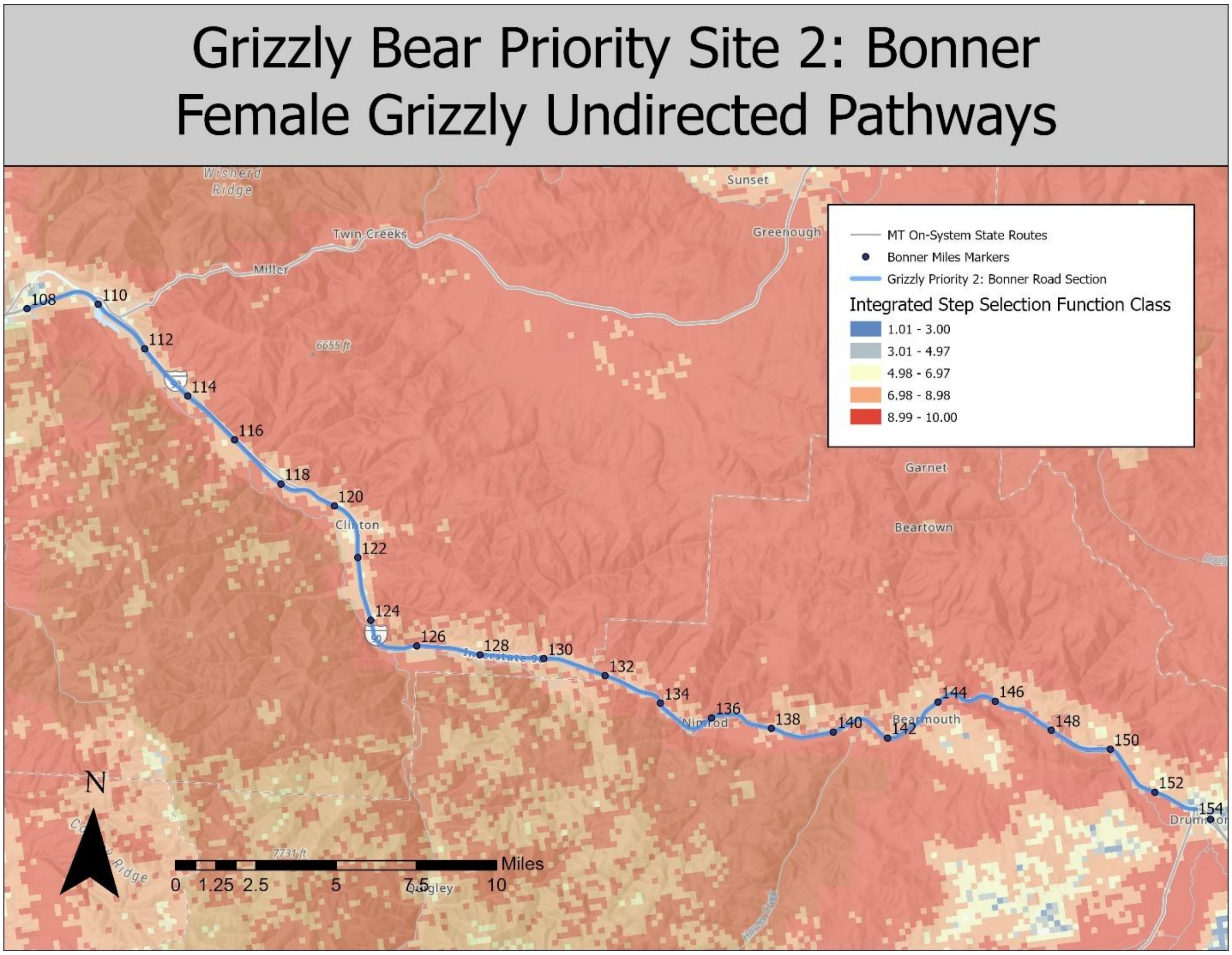


Figure 71: Grizzly bear priority site 2 (Bonner), undirected pathways for female grizzly bears.

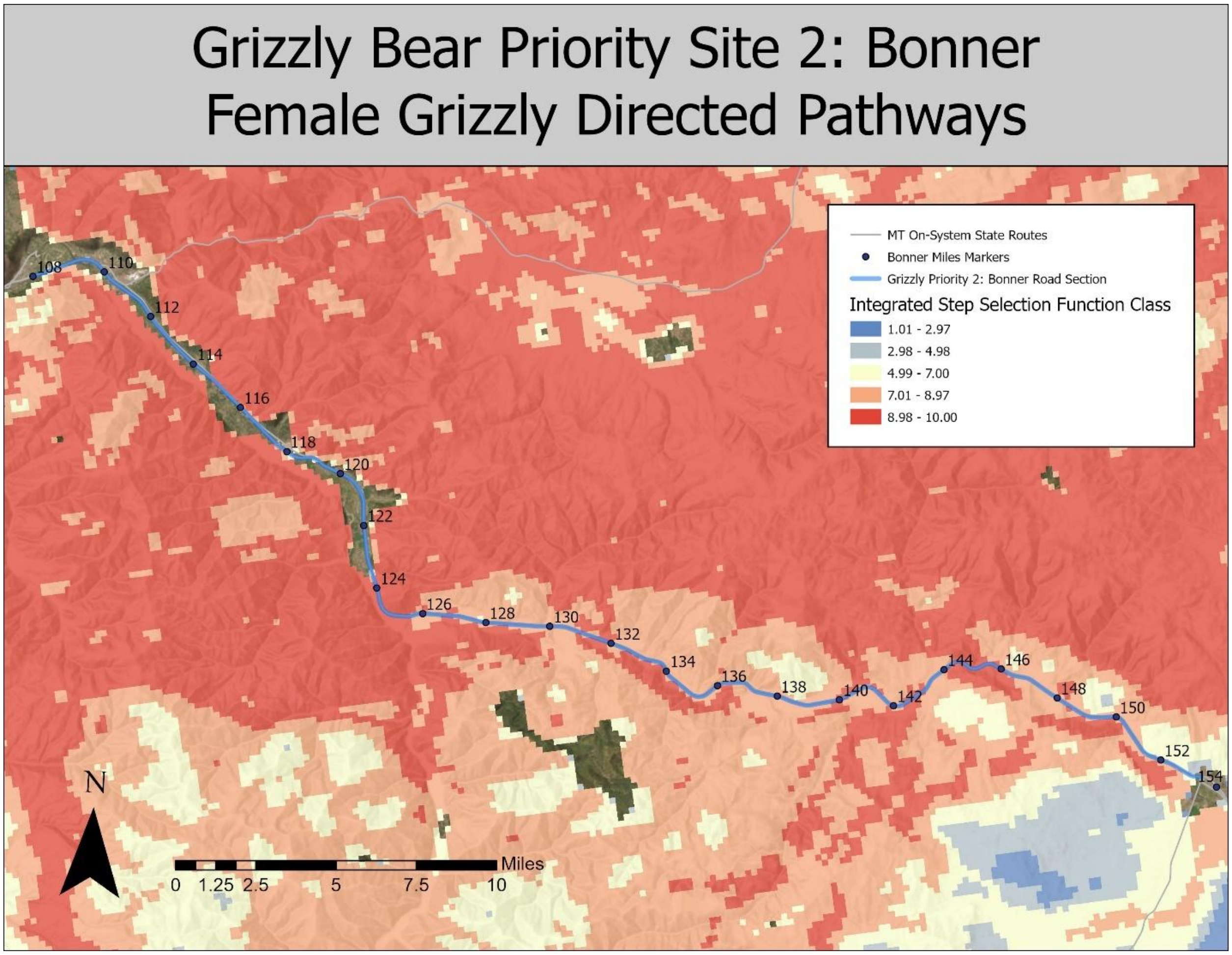


Figure 72: Grizzly bear priority site 2 (Bonner), directed pathways for female grizzly bears.

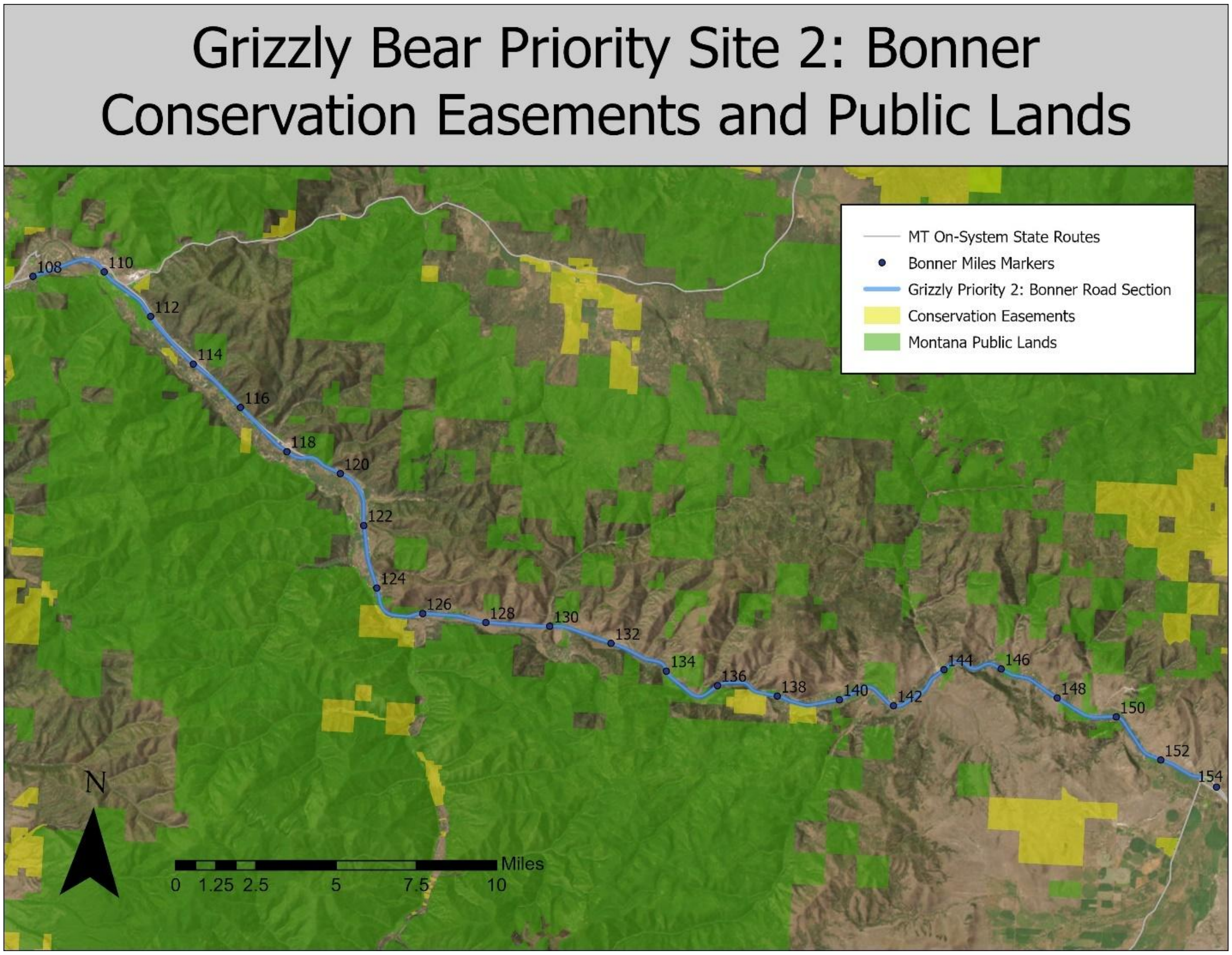


Figure 73: Grizzly bear priority site 2 (Bonner), conservation easements and public lands.

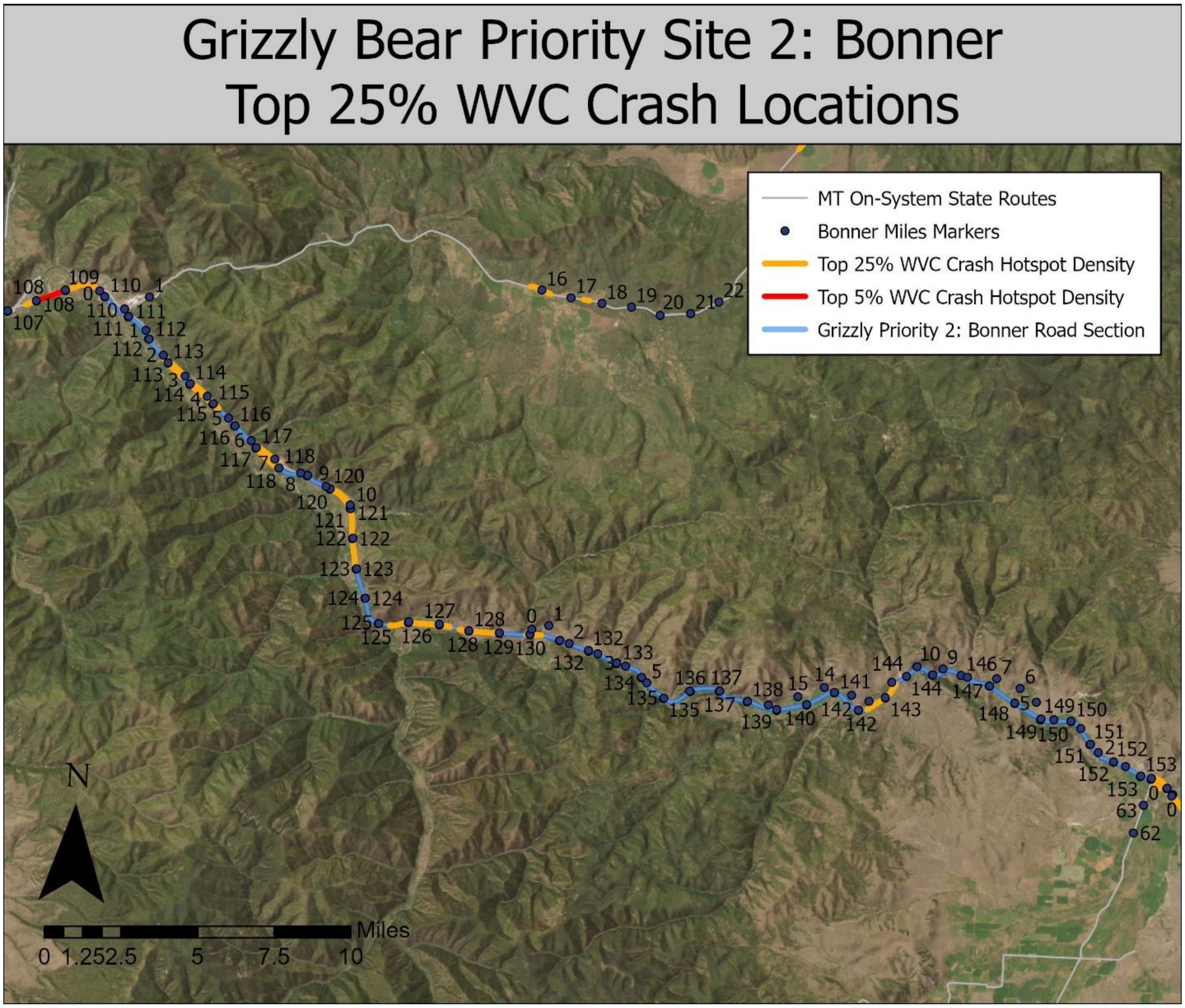


Figure 74: Grizzly bear priority site 2 (Bonner), top 25% crash locations.

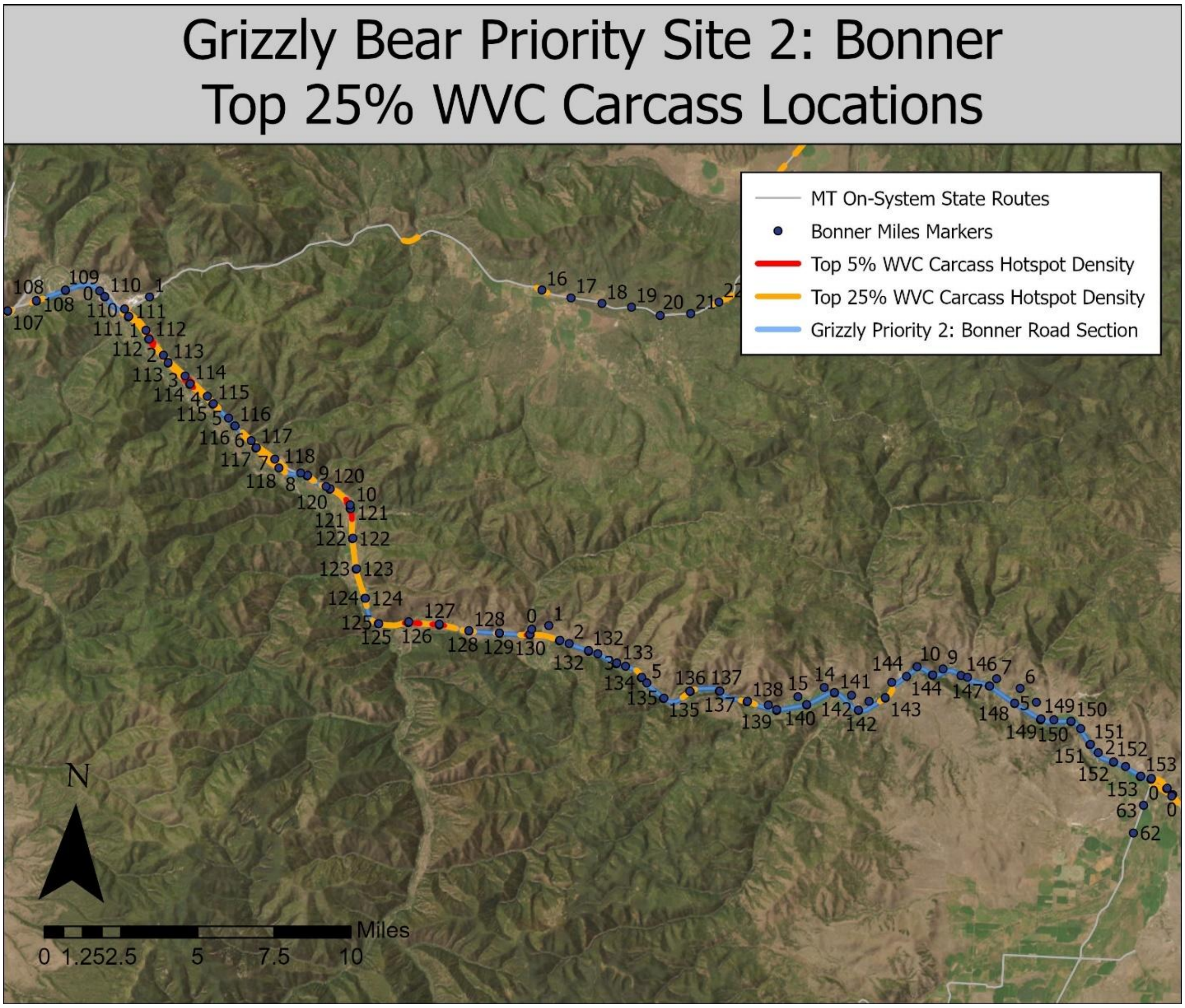


Figure 75: Grizzly bear priority site 2 (Bonner), top 25% carcass locations.

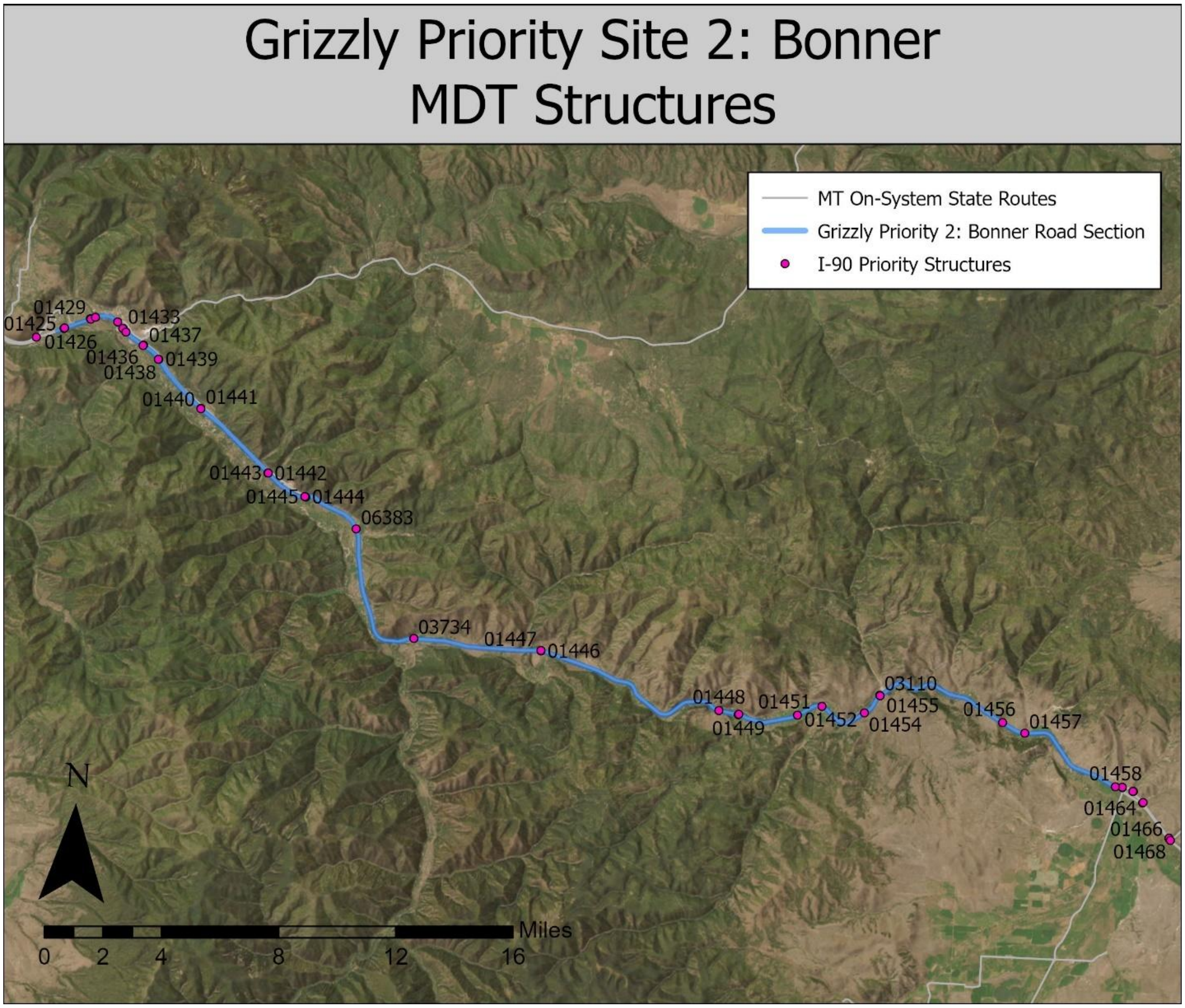


Figure 76: Grizzly bear priority site 2 (Bonner), MDT structures.

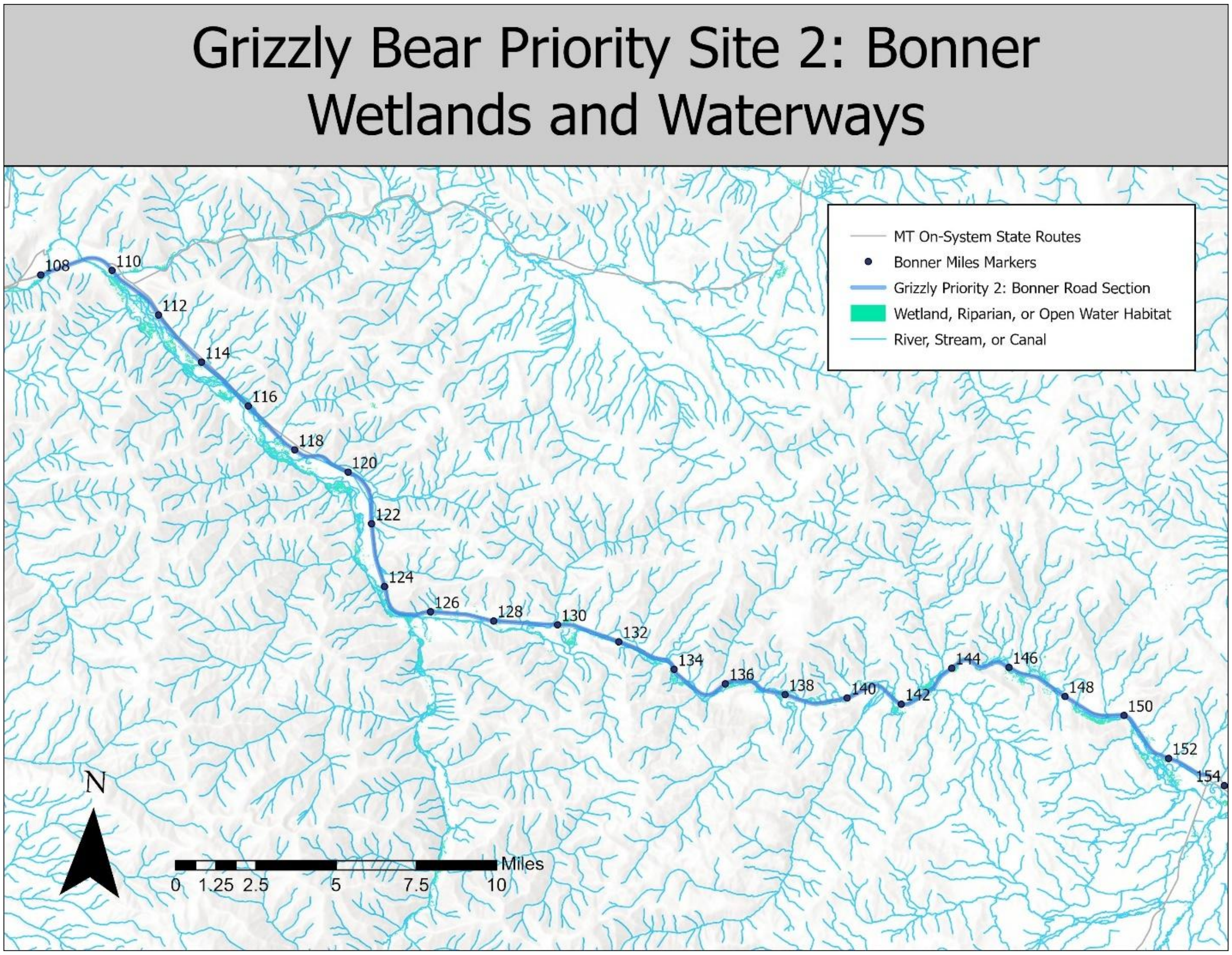


Figure 77: Grizzly bear priority site 2 (Bonner), wetlands and waterways.

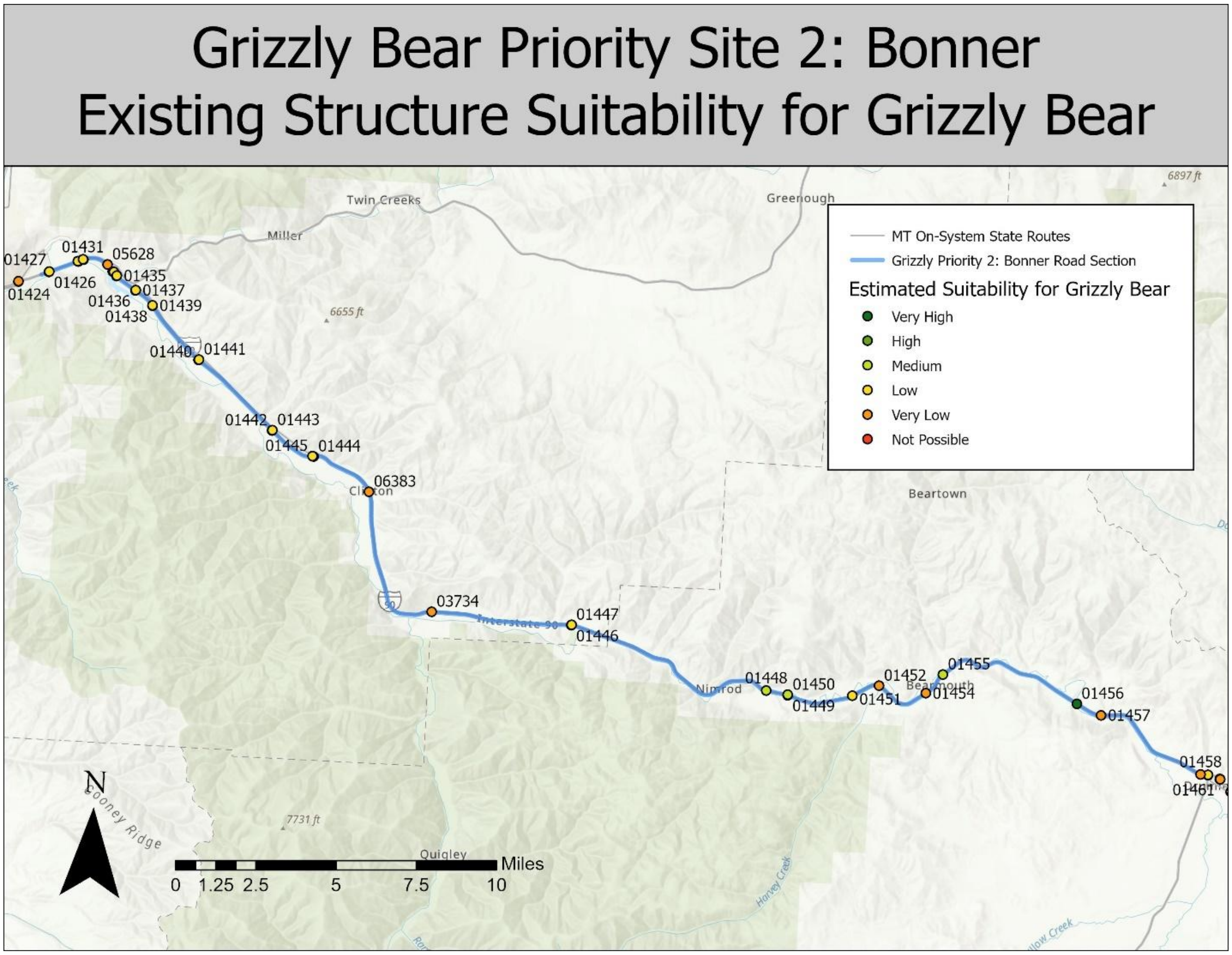


Figure 78: Grizzly bear priority site 2 (Bonner), estimated suitability of existing structures for grizzly bears.

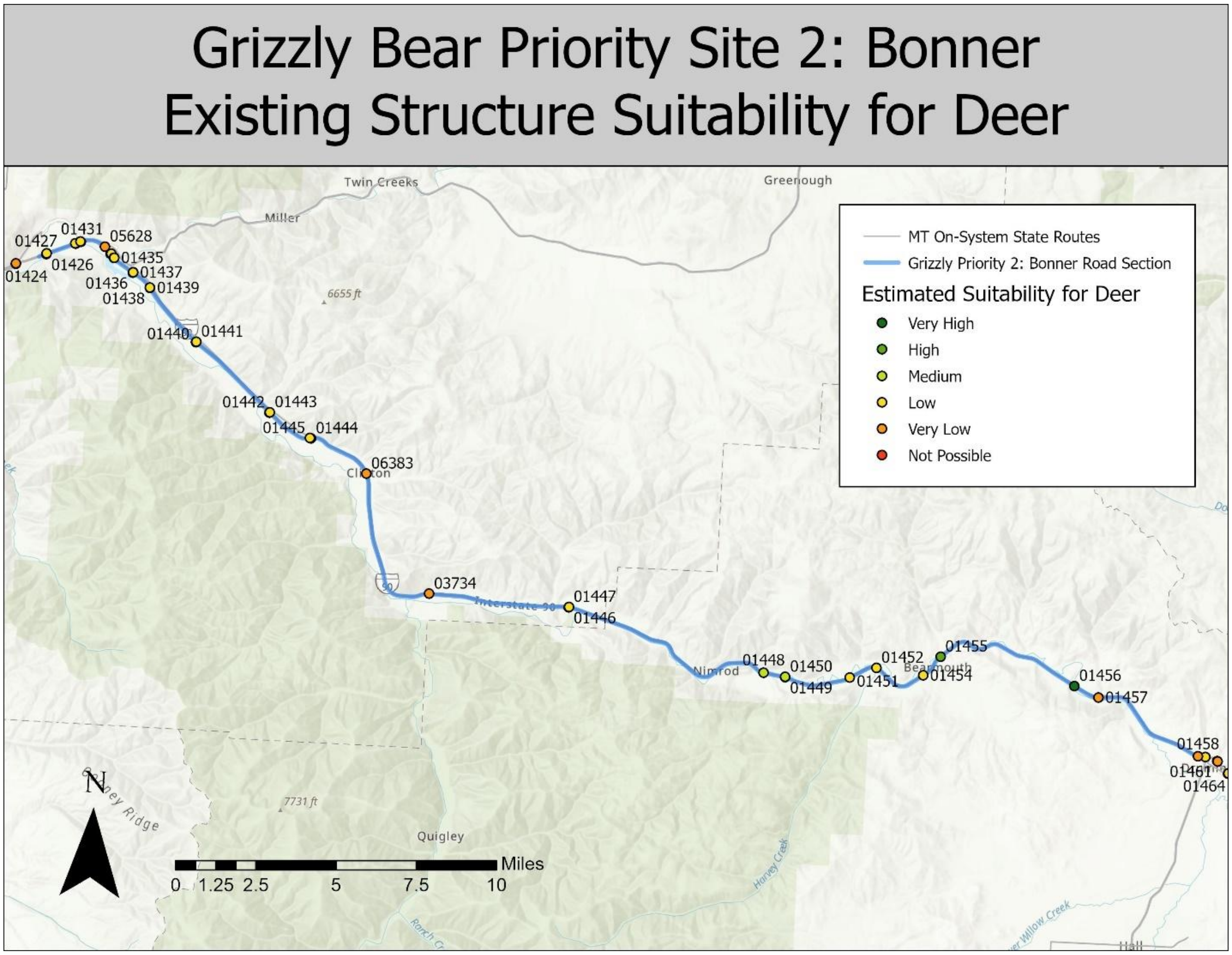


Figure 79: Grizzly bear priority site 2 (Bonner), estimated suitability of existing structures for deer.

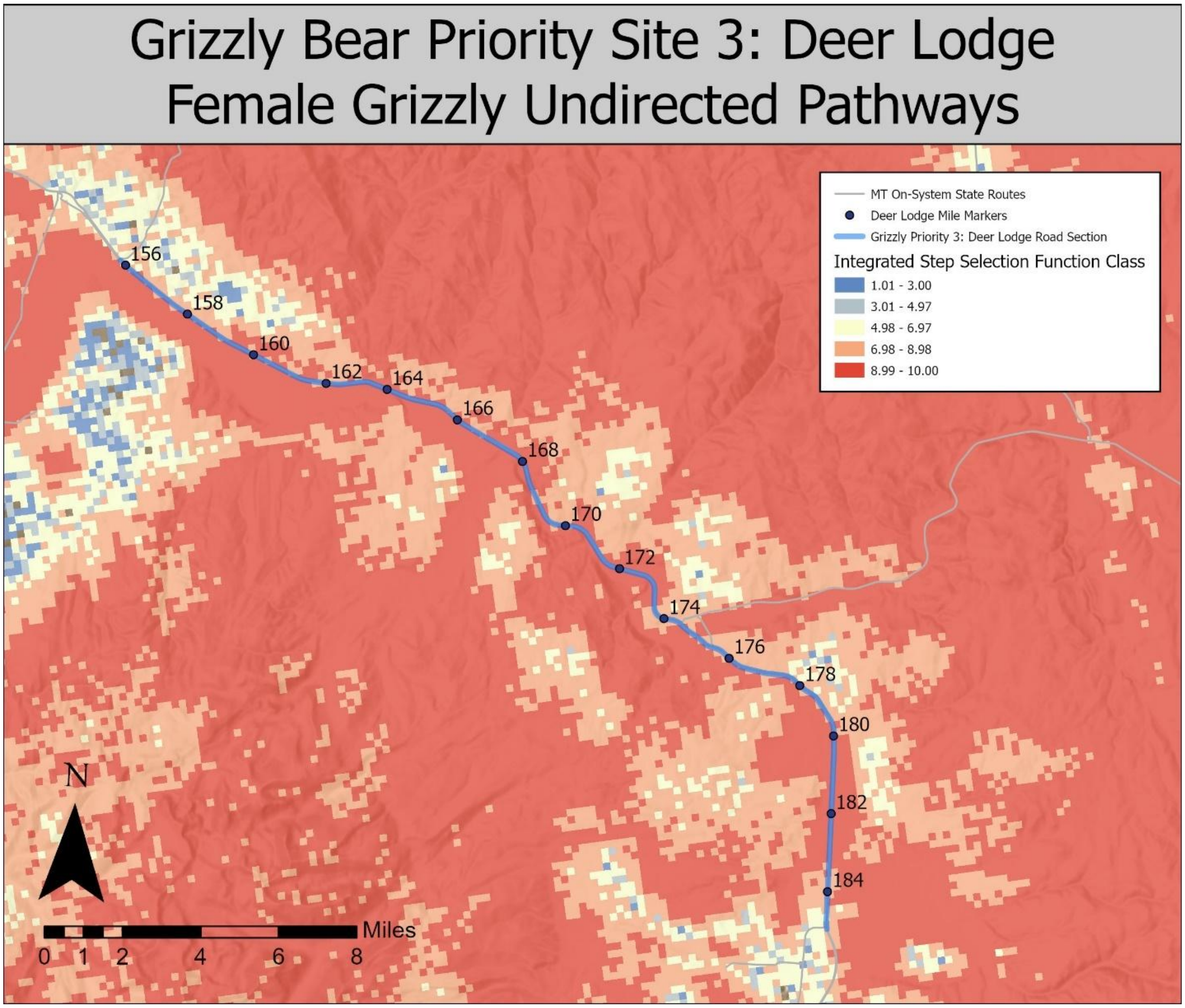


Figure 80: Grizzly bear priority site 3 (Deer Lodge), undirected pathways for female grizzly bears.

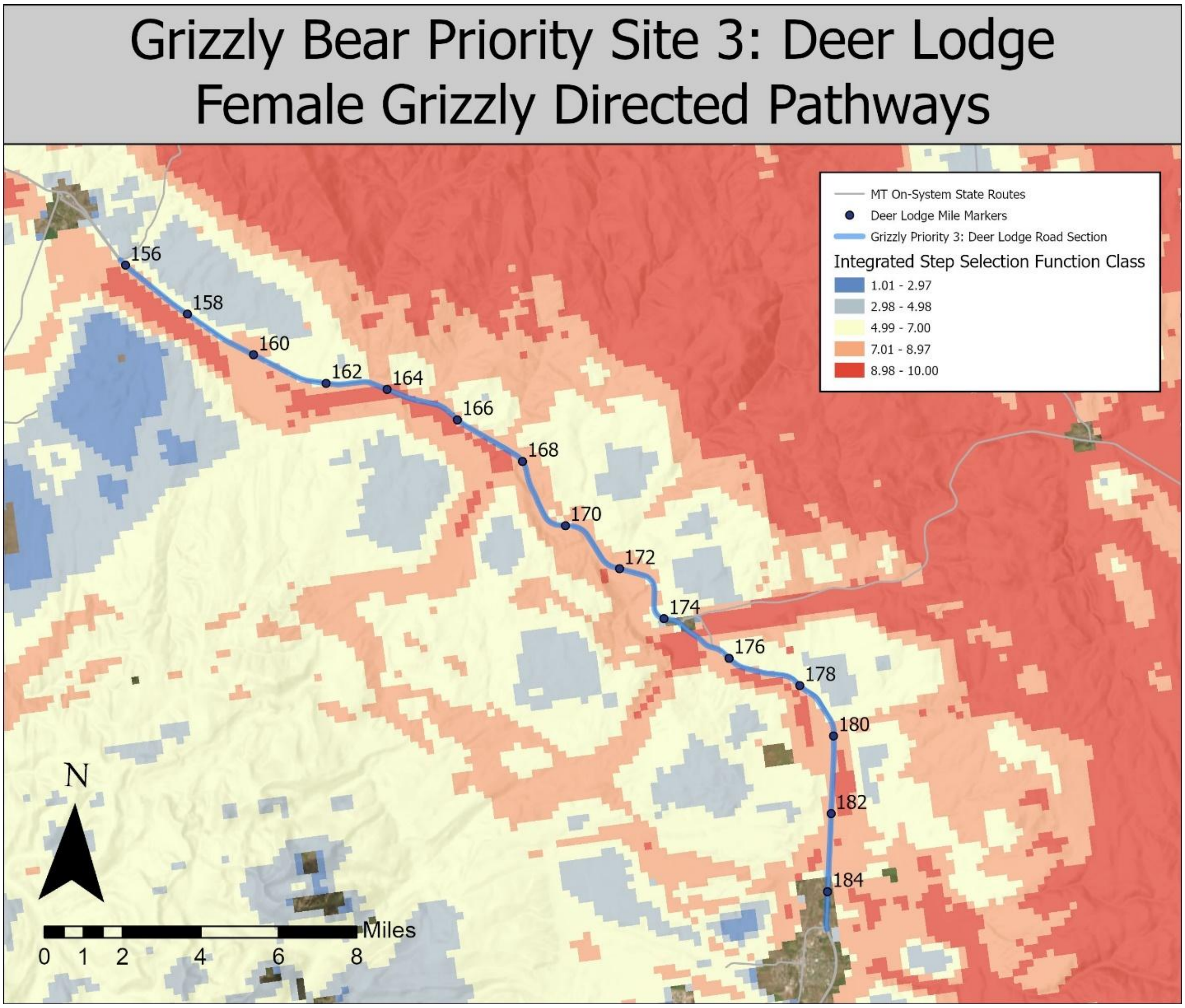


Figure 81: Grizzly bear priority site 3 (Deer Lodge), directed pathways for female grizzly bears.

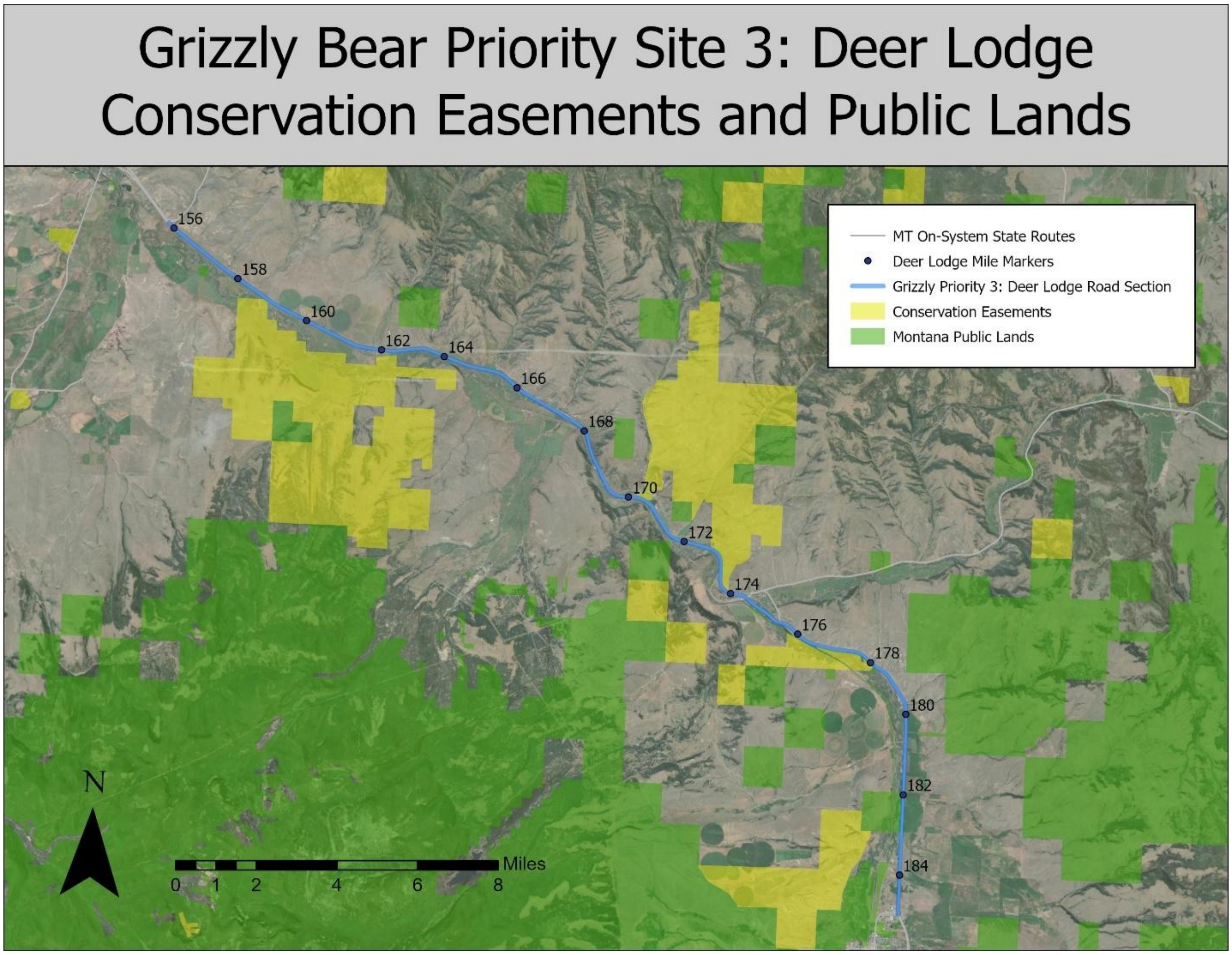


Figure 82: Grizzly bear priority site 3 (Deer Lodge), conservation easements and public lands.

Figure 83: Grizzly bear priority site 3 (Deer Lodge), top 25% crash locations.

Figure 84: Grizzly bear priority site 3 (Deer Lodge), top 25% carcass locations.

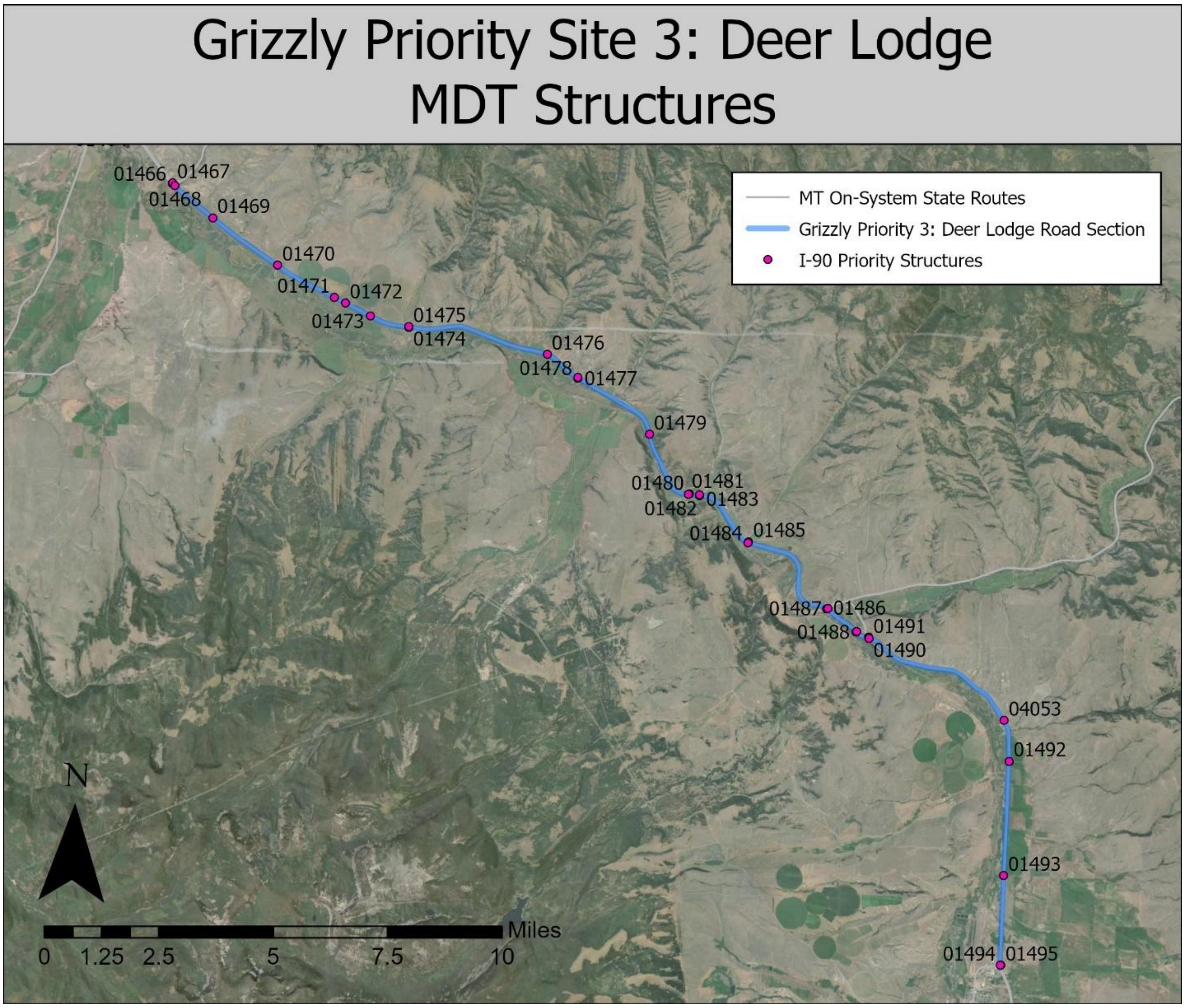


Figure 85: Grizzly bear priority site 3 (Deer Lodge), MDT structures.

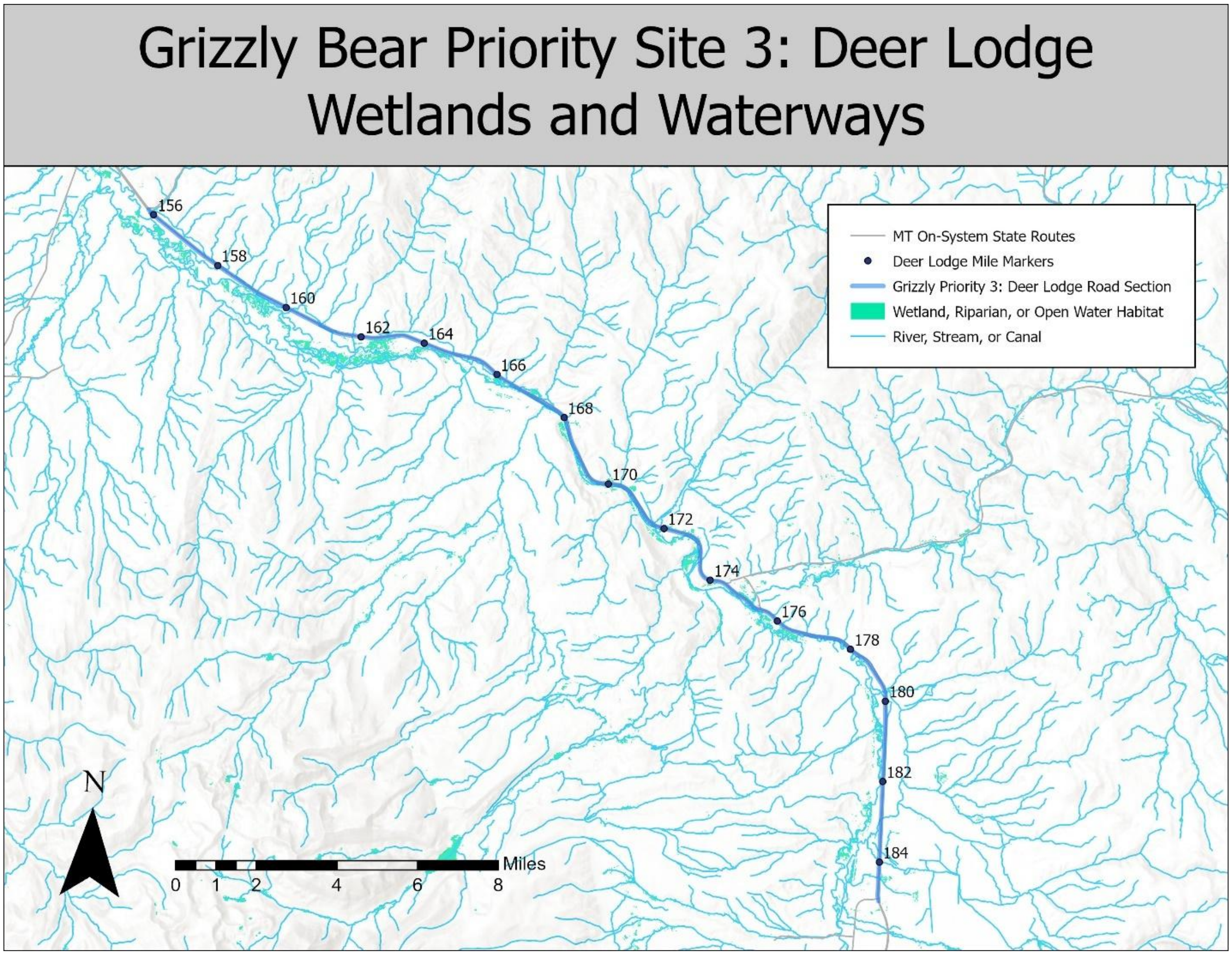


Figure 86: Grizzly bear priority site 3 (Deer Lodge), wetlands and waterways.

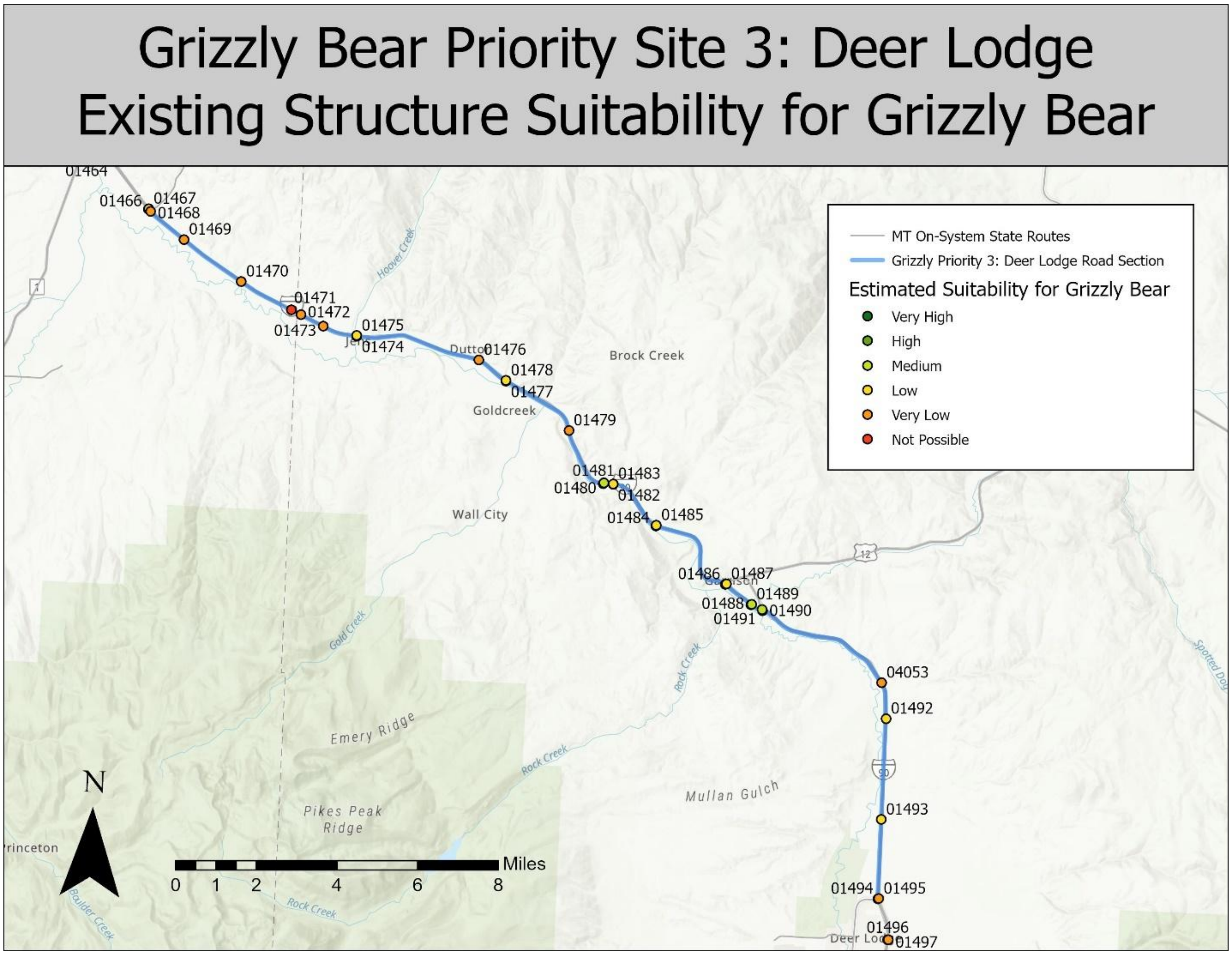


Figure 87: Grizzly bear priority site 3 (Deer Lodge), estimated suitability of existing structures for grizzly bears.

Figure 88: Grizzly bear priority site 3 (Deer Lodge), estimated suitability of existing structures for deer.

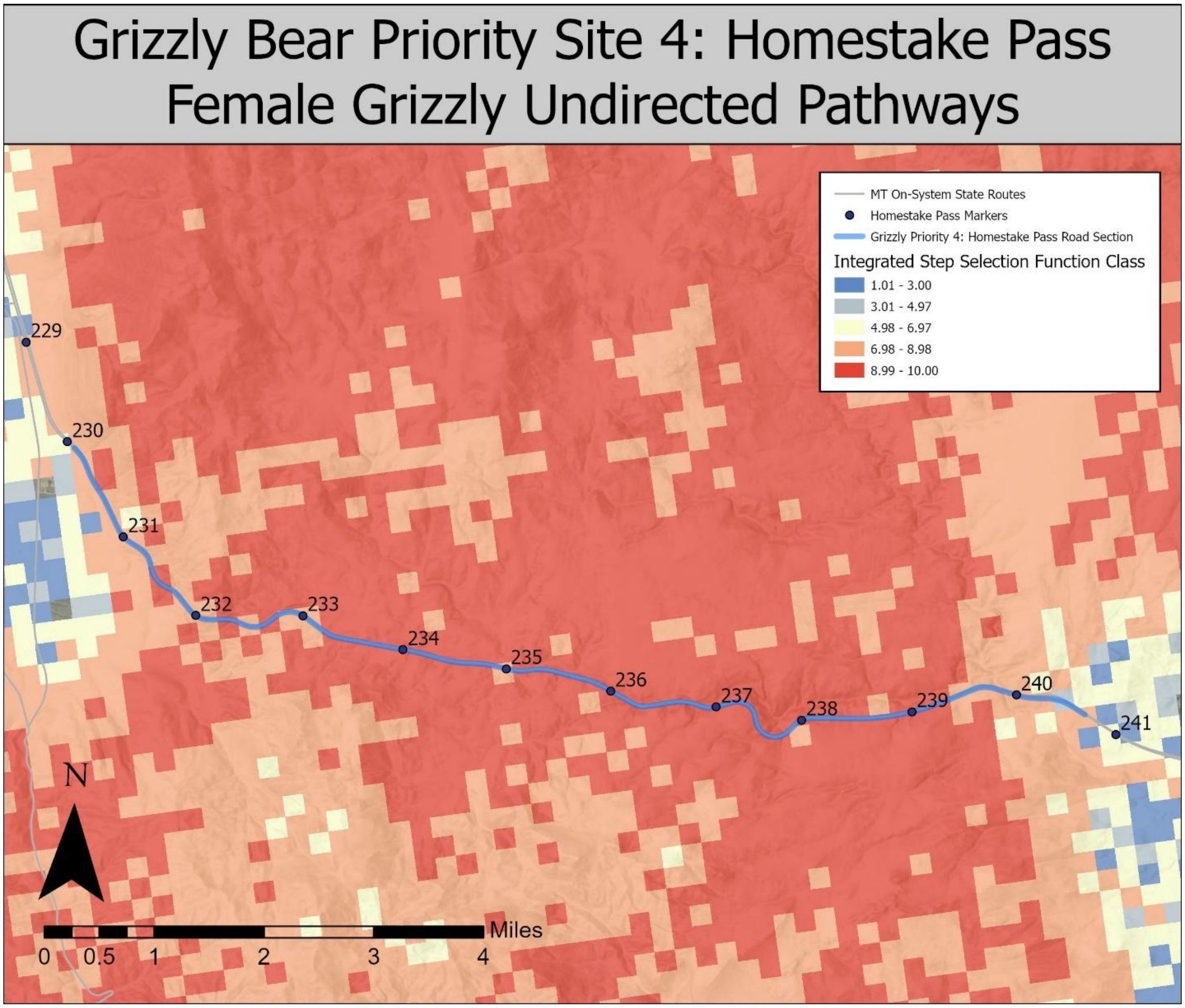


Figure 89: Grizzly bear priority site 4 (Homestake Pass), undirected pathways for female grizzly bears.

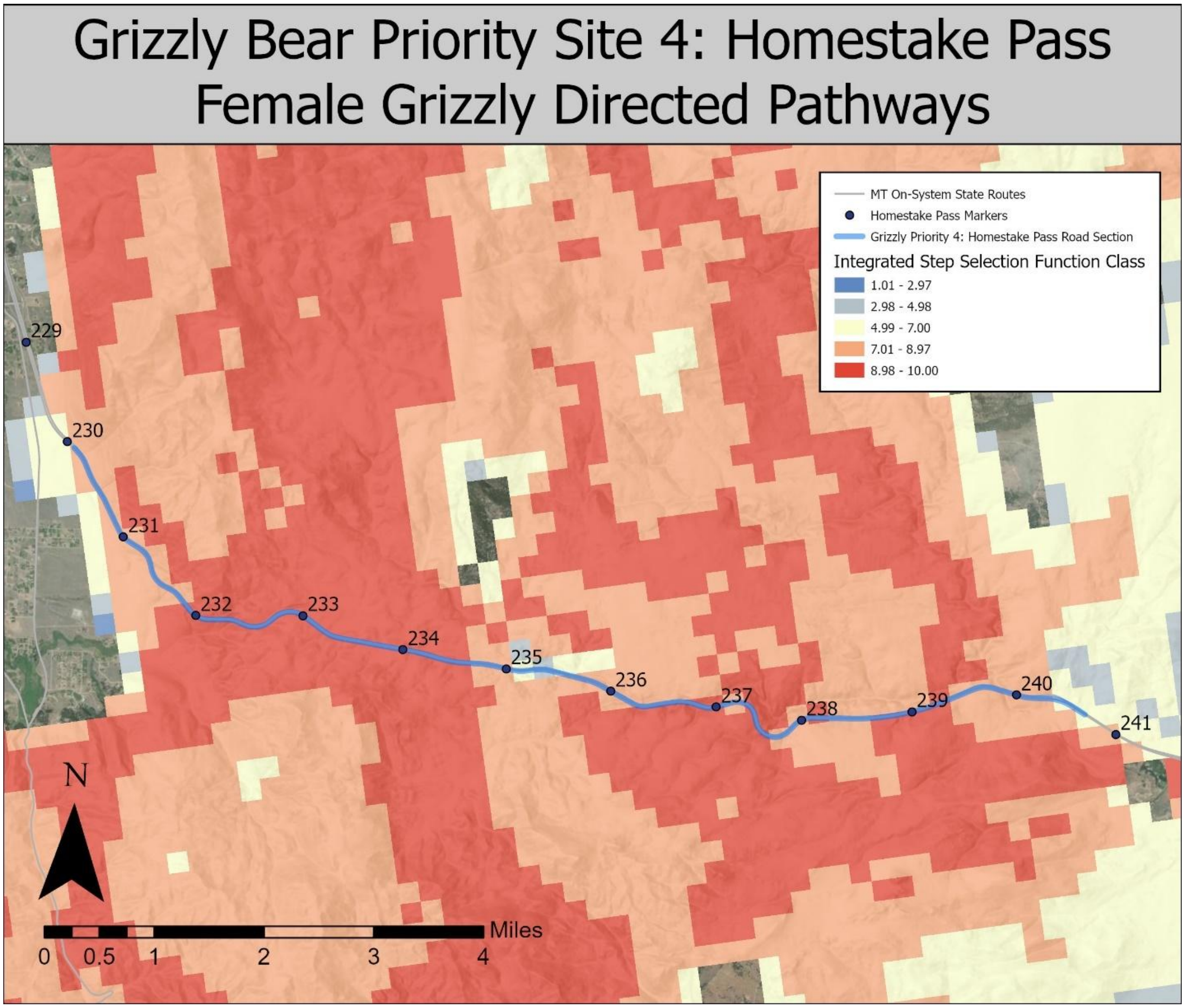


Figure 90: Grizzly bear priority site 4 (Homestake Pass), directed pathways for female grizzly bears.

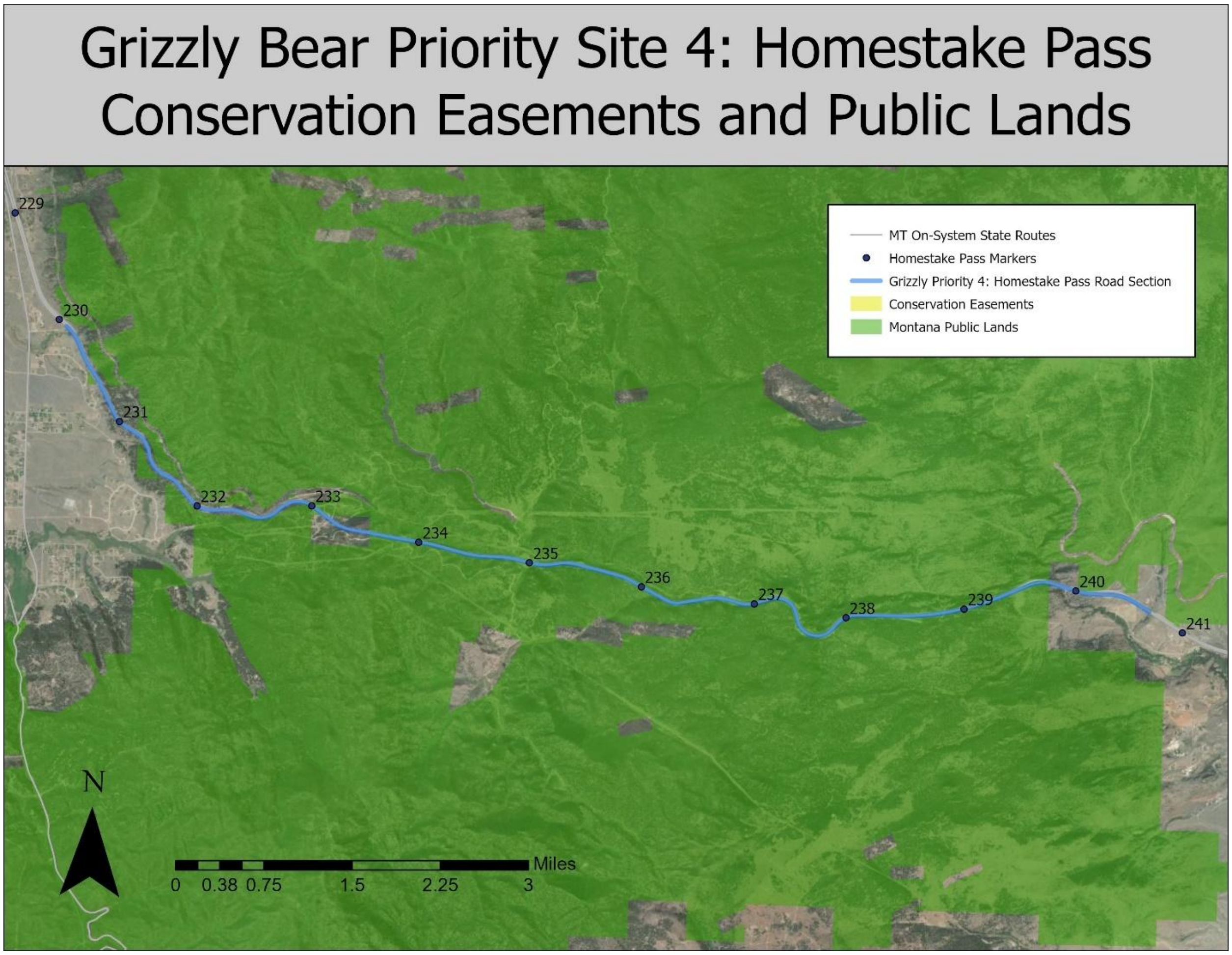


Figure 91: Grizzly bear priority site 4 (Homestake Pass), conservation easements and public lands.

Figure 92: Grizzly bear priority site 4 (Homestake Pass), top 25% crash locations.

Figure 93: Grizzly bear priority site 4 (Homestake Pass), top 25% carcass locations.

Figure 94: Grizzly bear priority site 4 (Homestake Pass), MDT structures.

Figure 95: Grizzly bear priority site 4 (Homestake Pass), wetlands and waterways.

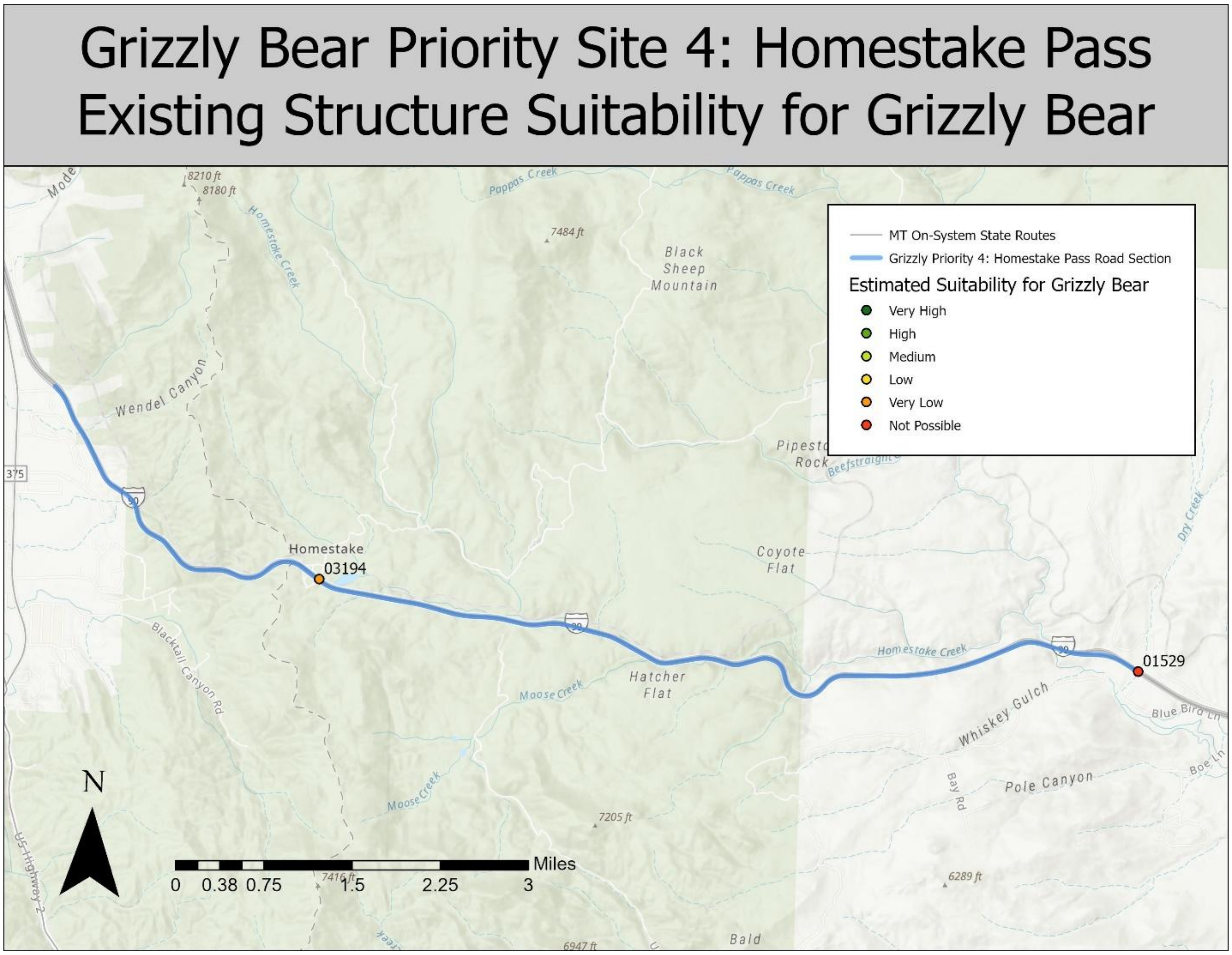


Figure 96: Grizzly bear priority site 4 (Homestake Pass), estimated suitability of existing structures for grizzly bears.

Figure 97: Grizzly bear priority site 4 (Homestake Pass), estimated suitability of existing structures for deer.

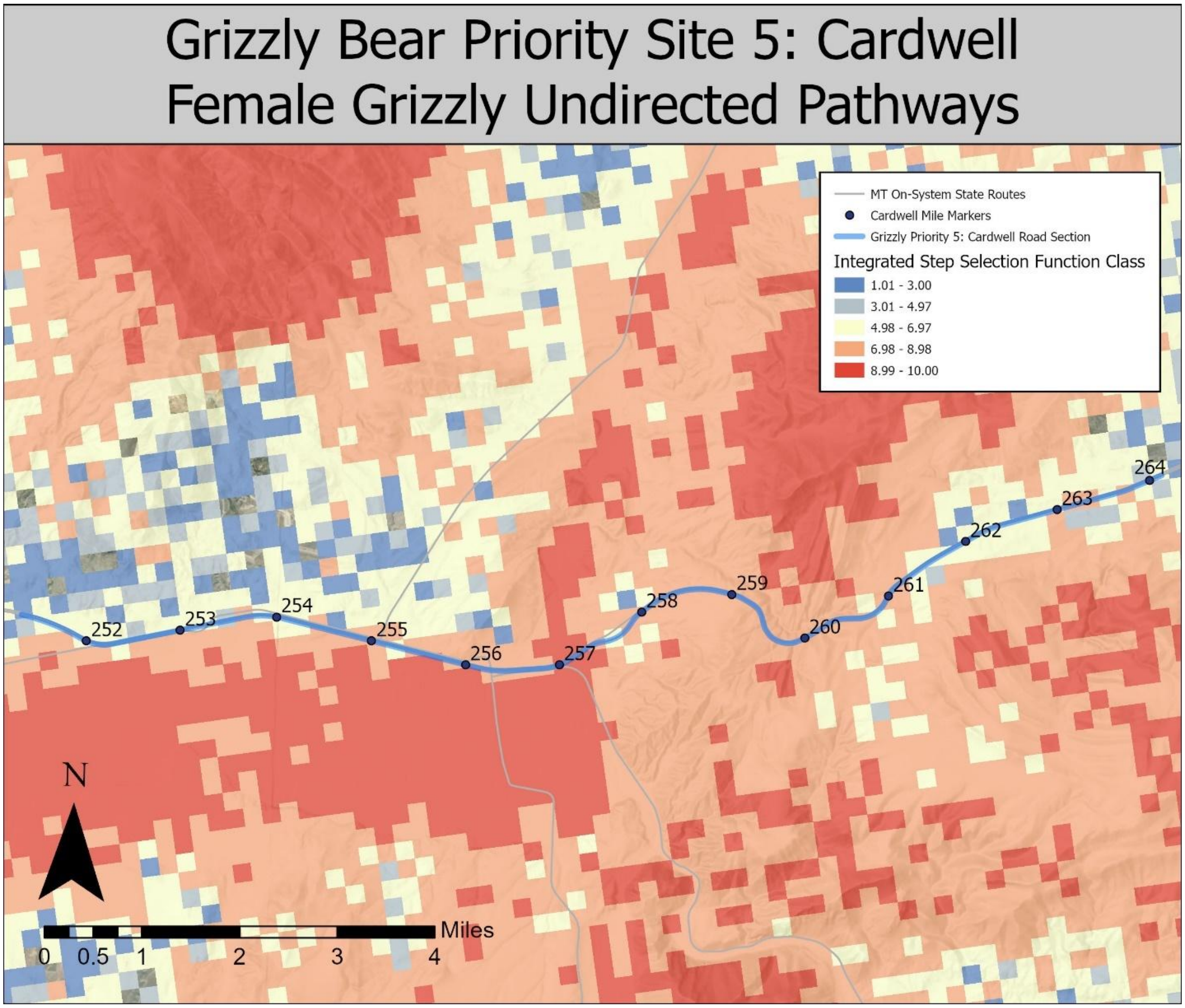


Figure 98: Grizzly bear priority site 5 (Cardwell), undirected pathways for female grizzly bears.

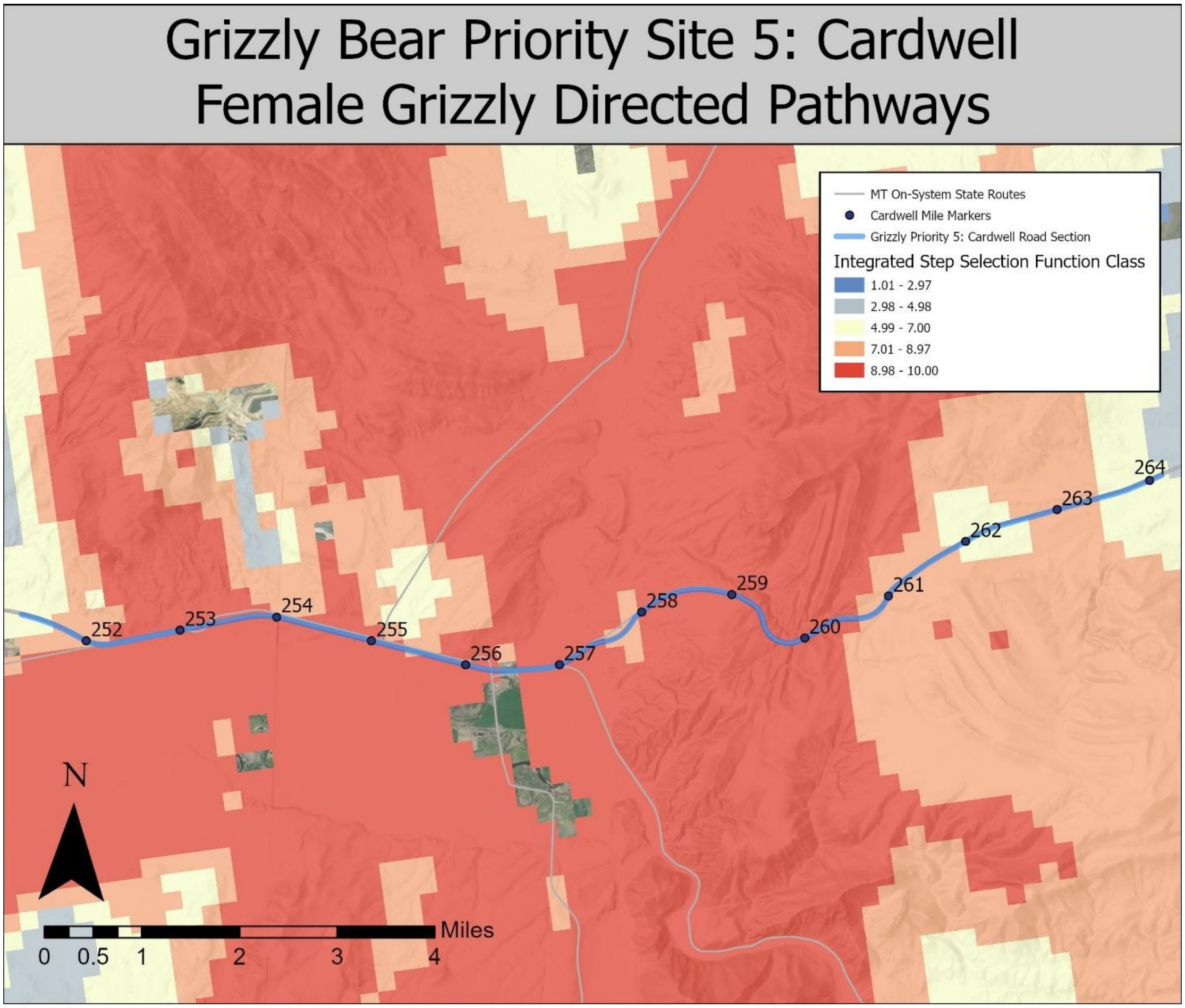


Figure 99: Grizzly bear priority site 5 (Cardwell), directed pathways for female grizzly bears.

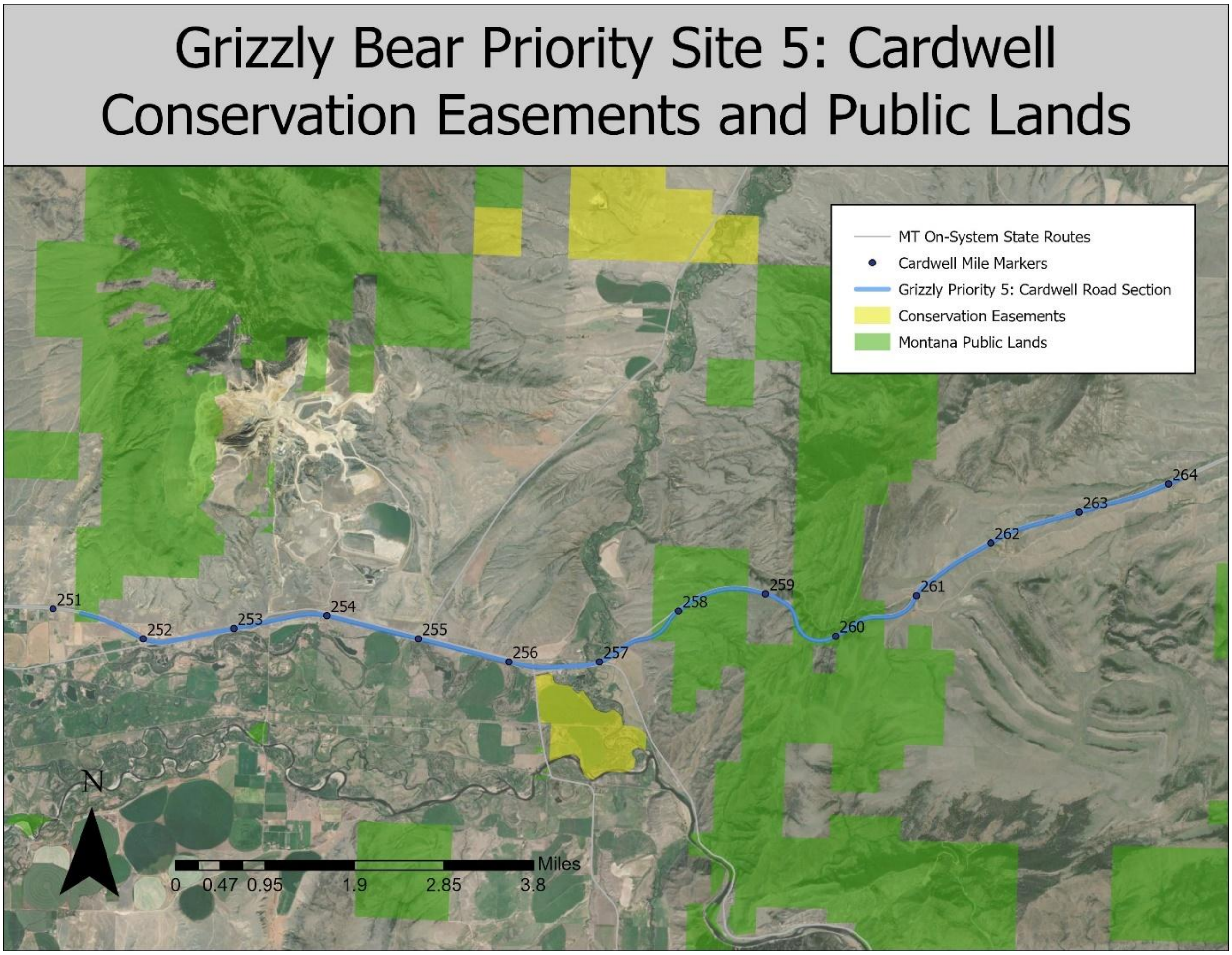


Figure 100: Grizzly bear priority site 5 (Cardwell), conservation easements and public lands.

Figure 101: Grizzly bear priority site 5 (Cardwell), top 25% crash locations.

Figure 102: Grizzly bear priority site 5 (Cardwell), top 25% carcass locations.

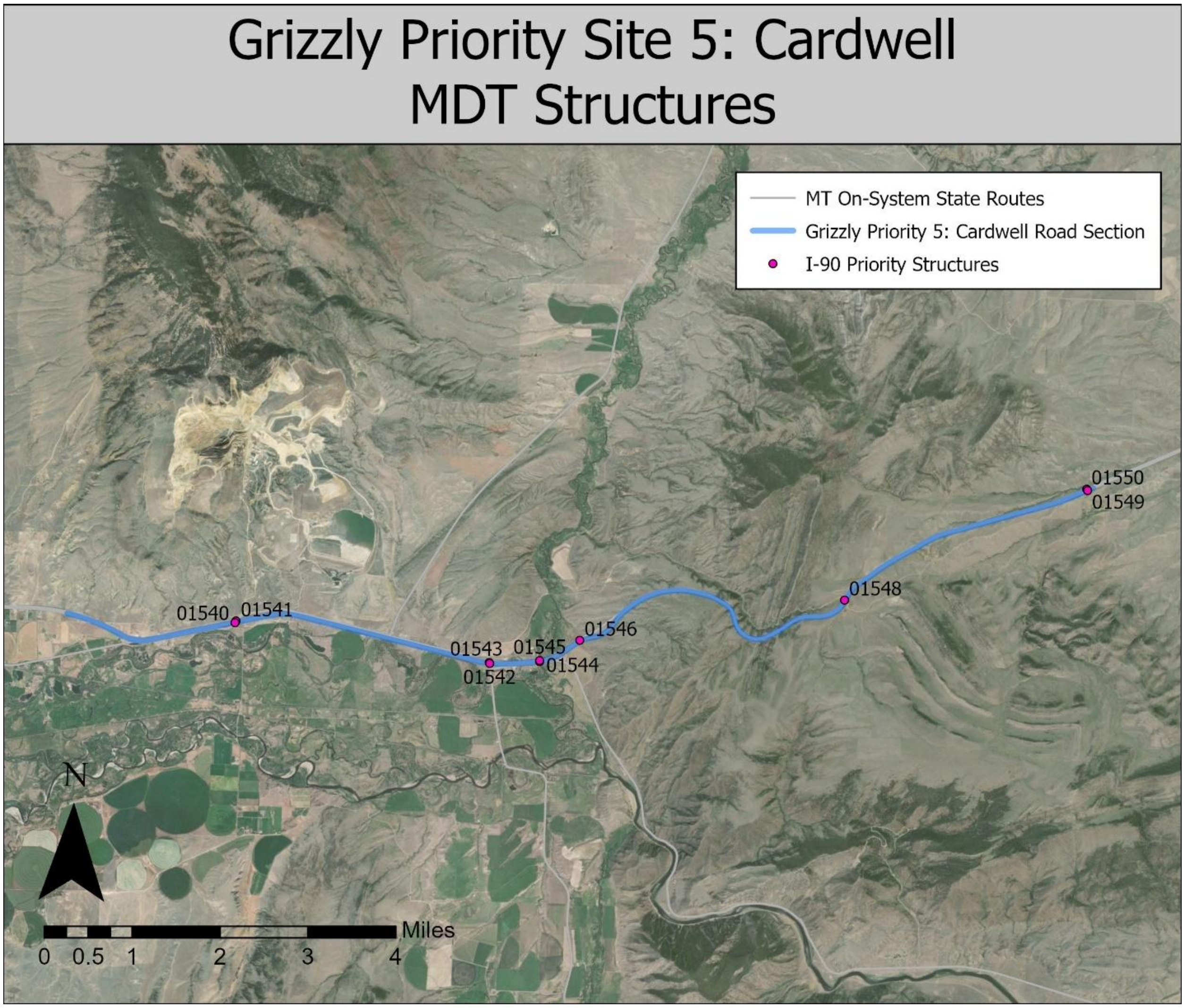


Figure 103: Grizzly bear priority site 5 (Cardwell), MDT structures.

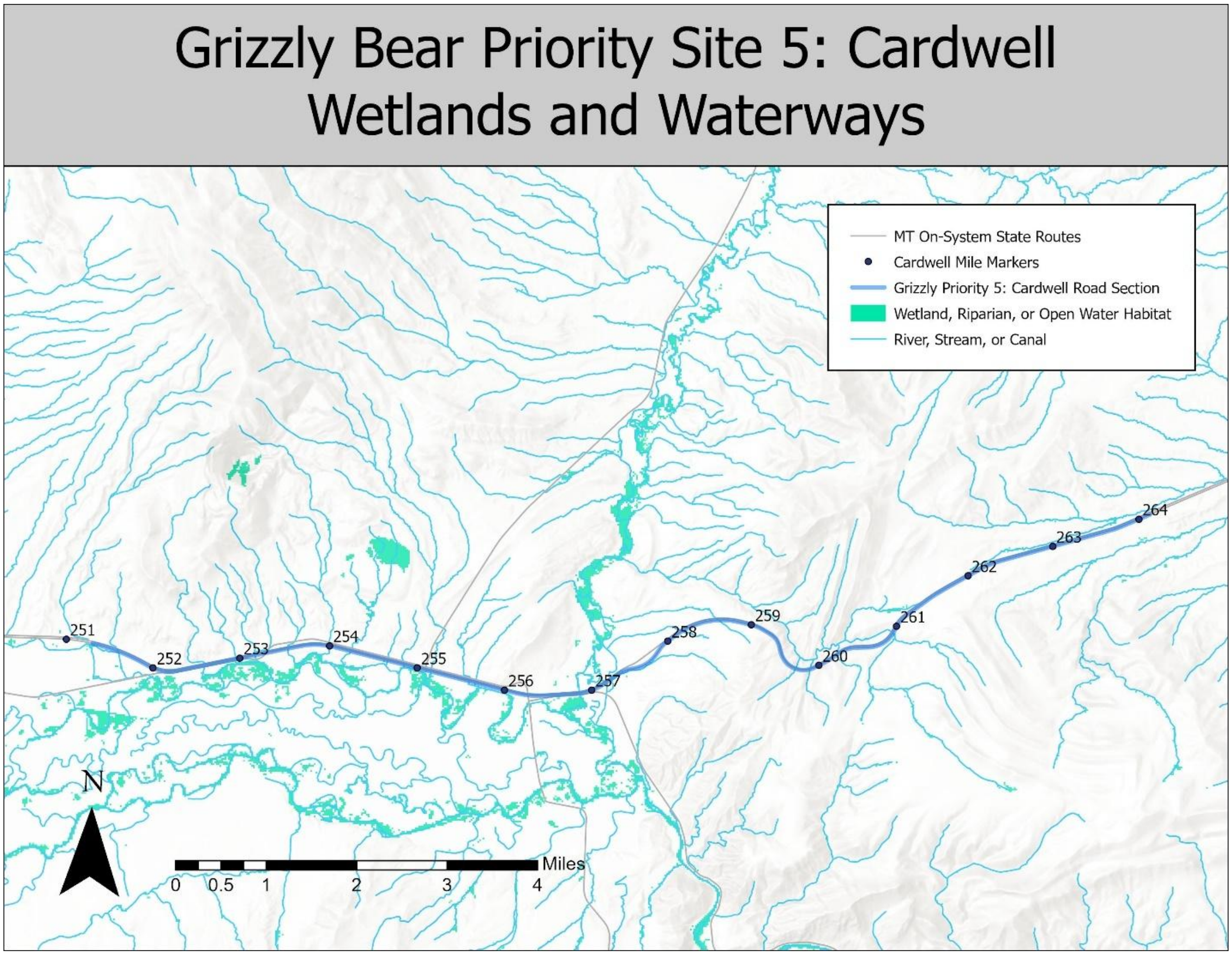


Figure 104: Grizzly bear priority site 5 (Cardwell), wetlands and waterways.

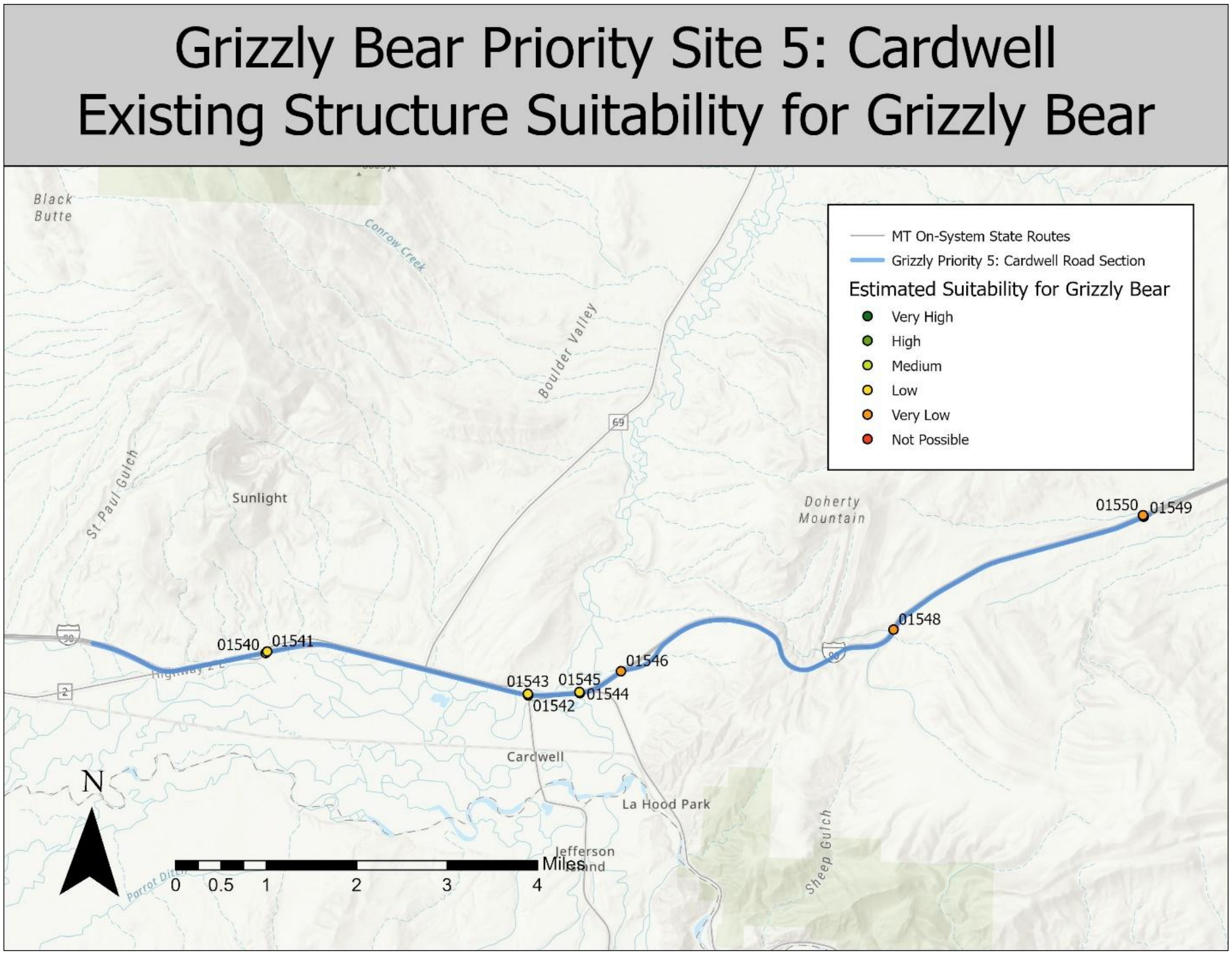


Figure 105: Grizzly bear priority site 5 (Cardwell), estimated suitability of existing structures for grizzly bears.

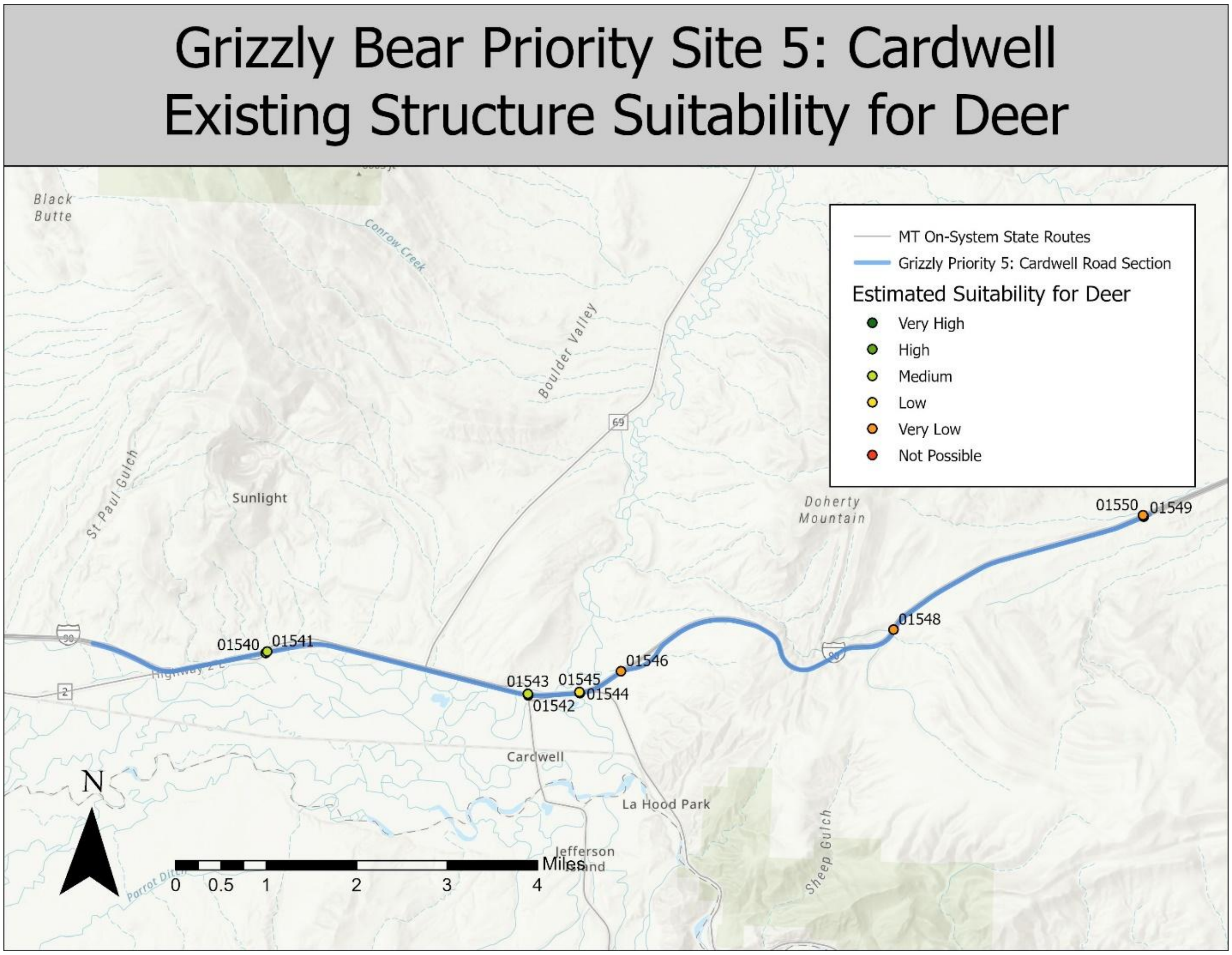


Figure 106: Grizzly bear priority site 5 (Cardwell), estimated suitability of existing structures for deer.

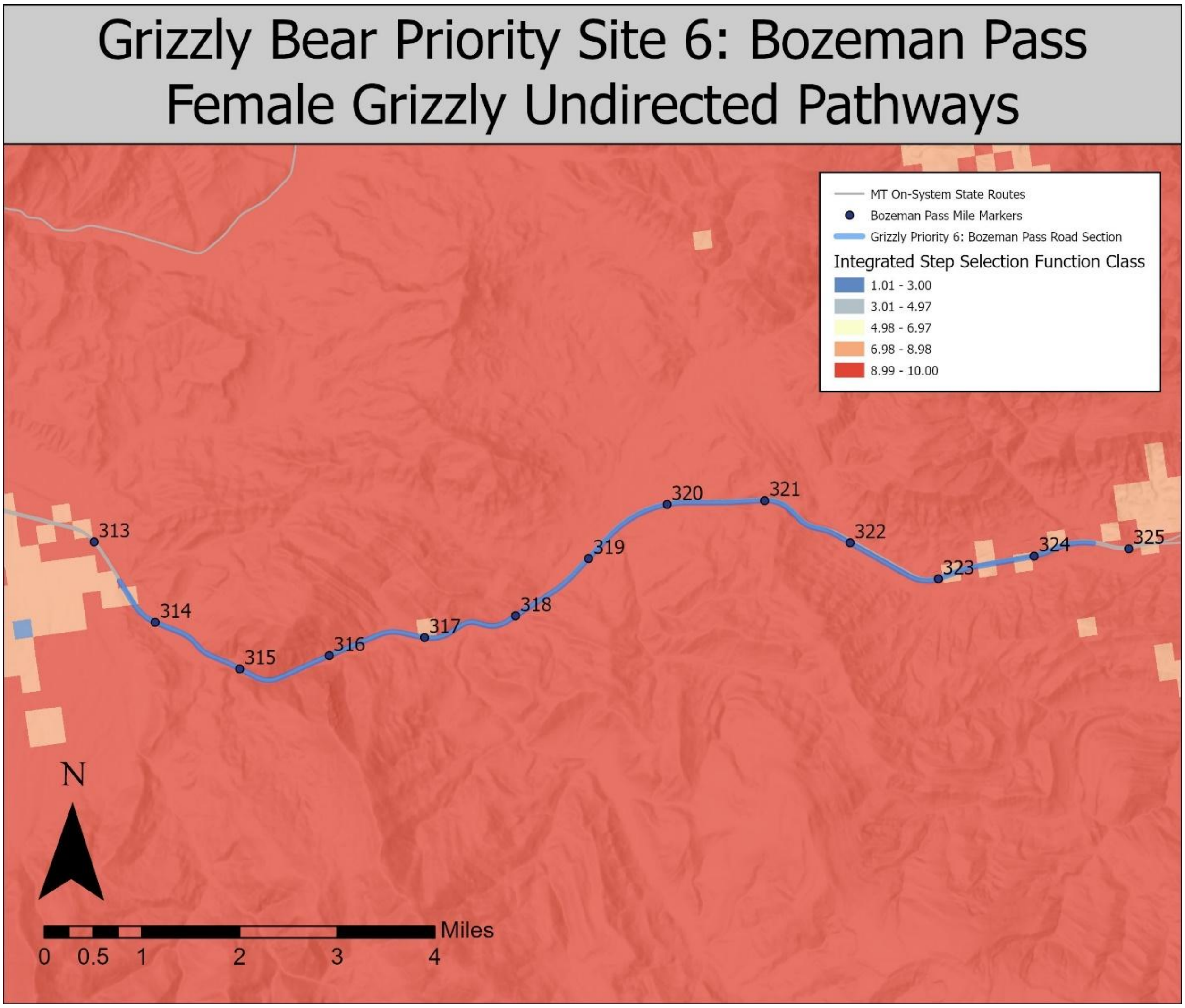


Figure 107: Grizzly bear priority site 6 (Bozeman Pass), undirected pathways for female grizzly bears.

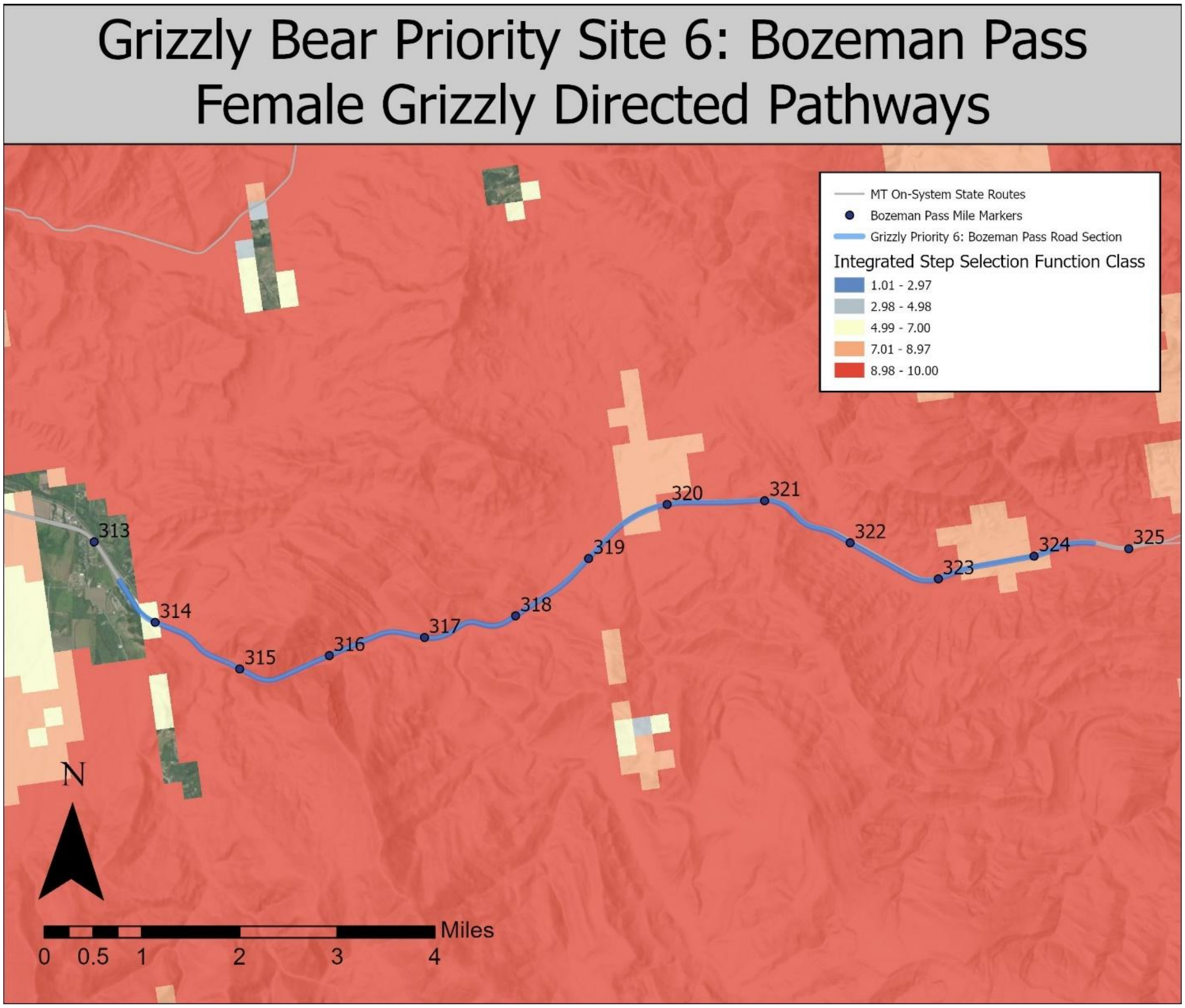


Figure 108: Grizzly bear priority site 6 (Bozeman Pass), directed pathways for female grizzly bears.

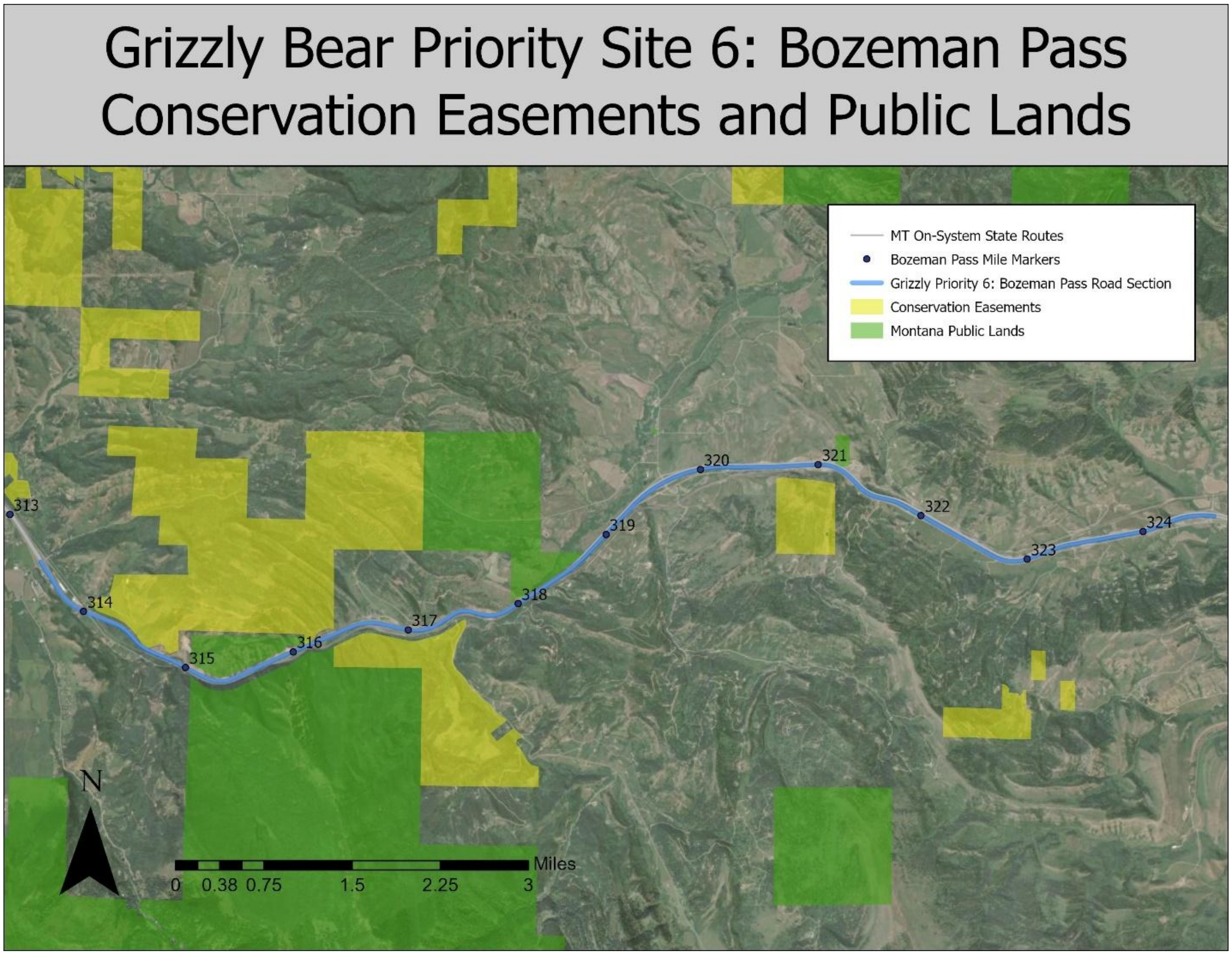


Figure 109: Grizzly bear priority site 6 (Bozeman Pass), conservation easements and public lands.

Figure 110: Grizzly bear priority site 6 (Bozeman Pass), top 25% crash locations.

Figure 111: Grizzly bear priority site 6 (Bozeman Pass), top 25% carcass locations.

Figure 112: Grizzly bear priority site 6 (Bozeman Pass), MDT structures.

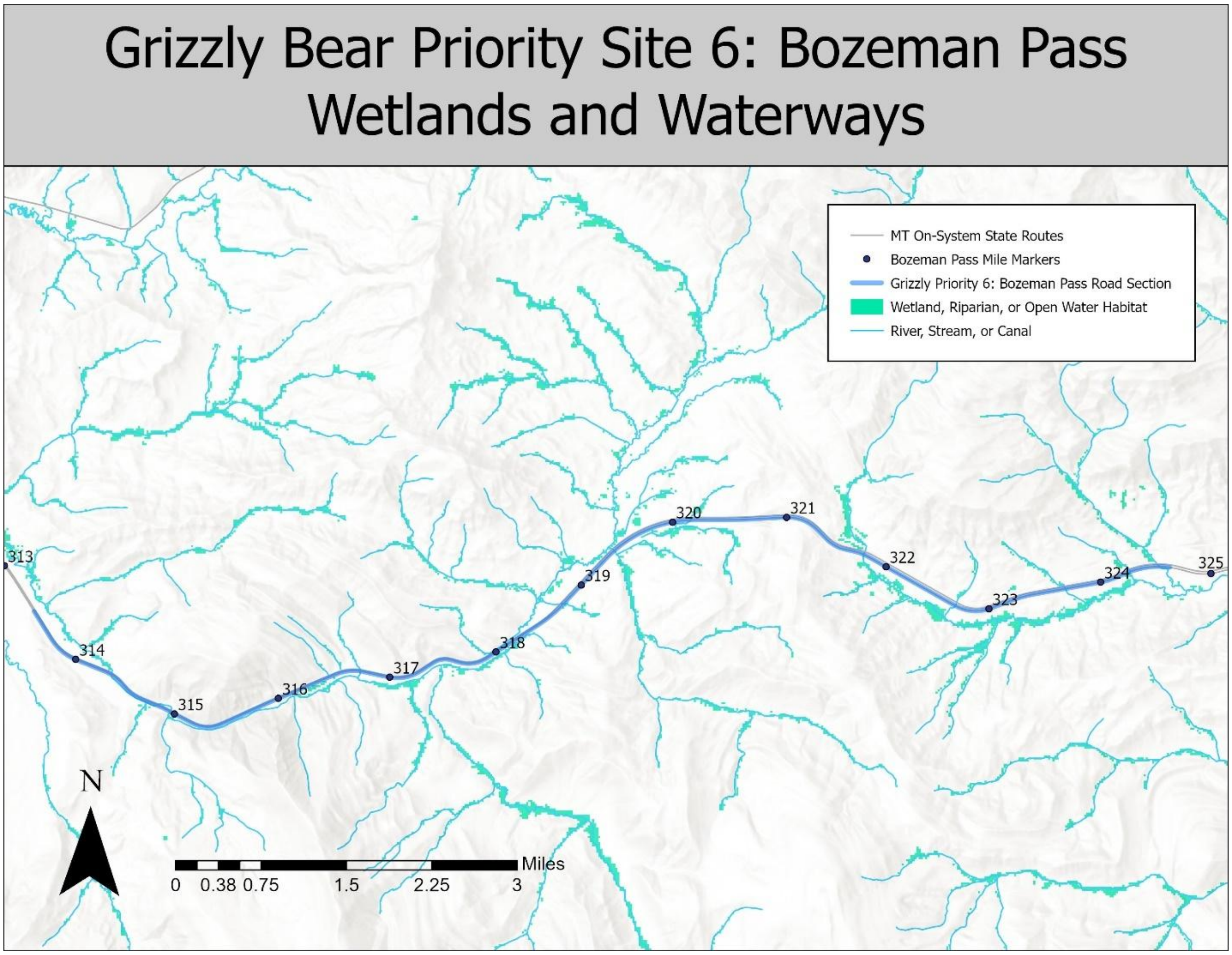


Figure 113: Grizzly bear priority site 6 (Bozeman Pass), wetlands and waterways.

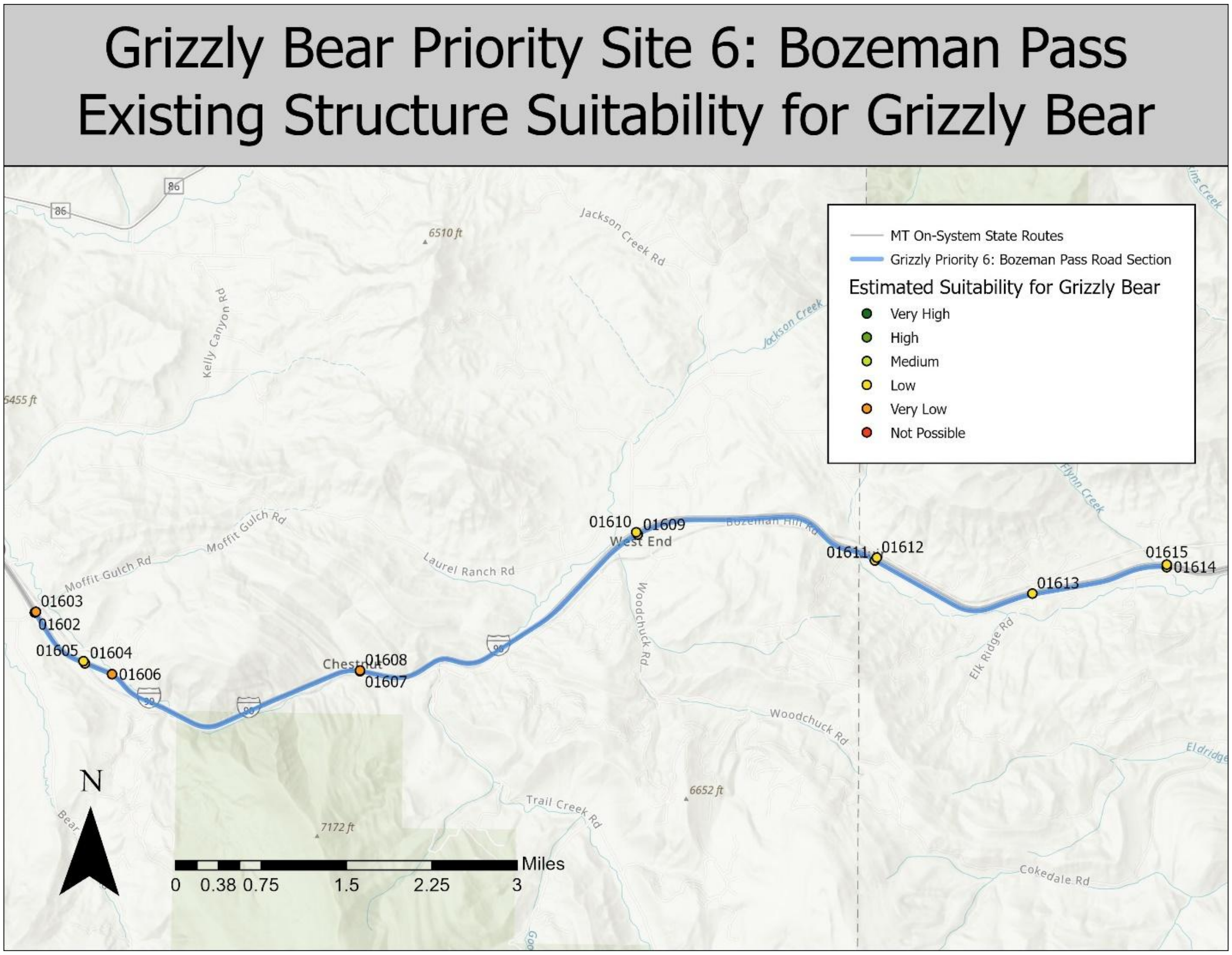


Figure 114: Grizzly bear priority site 6 (Bozeman Pass), estimated suitability of existing structures for grizzly bears.

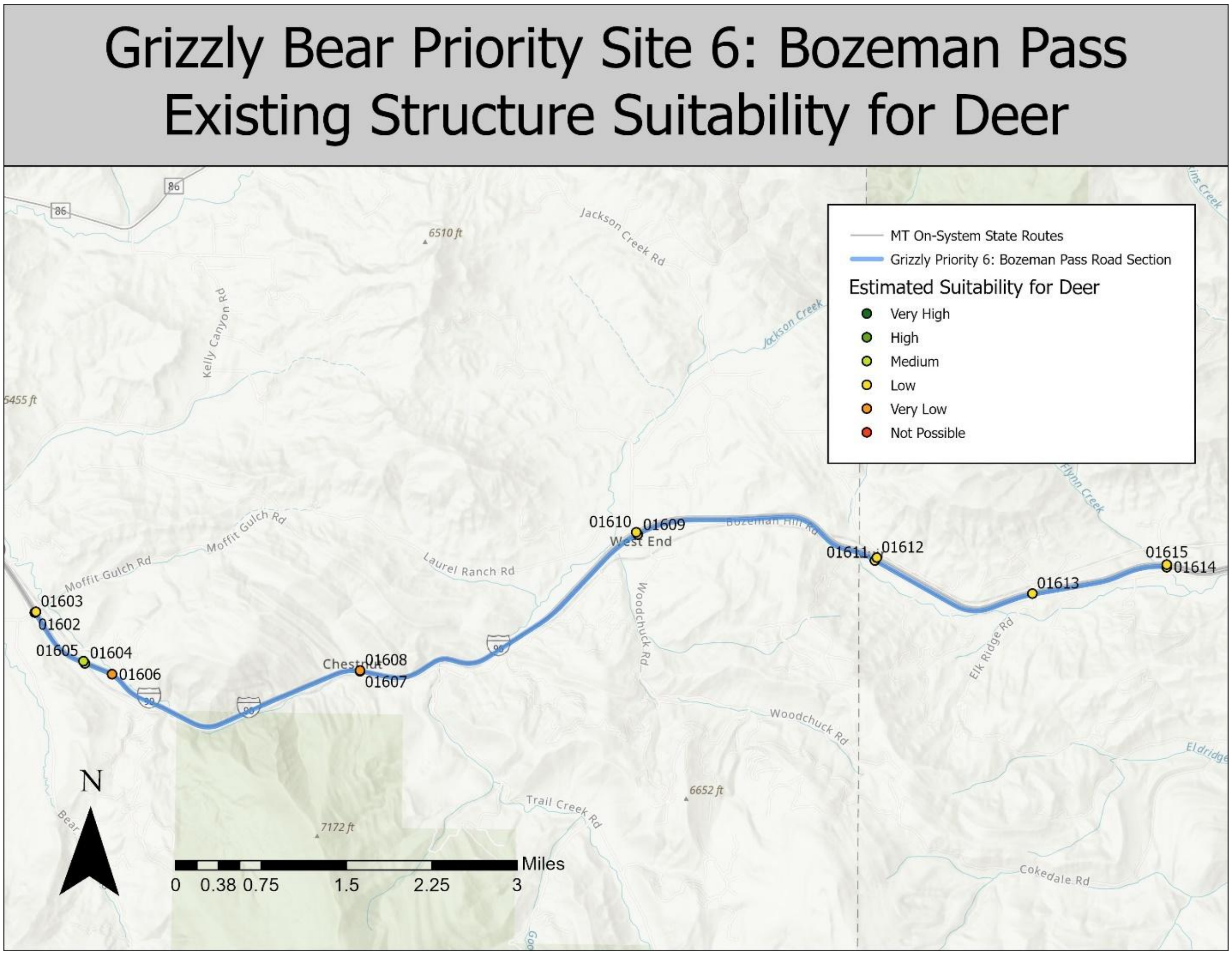


Figure 115: Grizzly bear priority site 6 (Bozeman Pass), estimated suitability of existing structures for deer.

15 Appendix B: detailed maps zones collisions with large wild mammals

Safety priority site 1 (Riverbend) maps are in Figure 116, Figure 117, Figure 118, Figure 119, Figure 120, Figure 121, Figure 122, Figure 123, Figure 124
Safety priority site 2 (East Missoula) maps are in Figure 125, Figure 126, Figure 127, Figure 128, Figure 129, Figure 130, Figure 131, Figure 132, Figure 133
Safety priority site 3 (Drummond) maps are in Figure 134, Figure 135, Figure 136, Figure 137, Figure 138, Figure 139, Figure 140, Figure 141, Figure 142
Safety priority site 4 (Bozeman) maps are in Figure 143, Figure 144, Figure 145, Figure 146, Figure 147, Figure 148, Figure 149, Figure 150, Figure 151
Safety priority site 5 (Livingston) maps are in Figure 152, Figure 153, Figure 154, Figure 155, Figure 156, Figure 157, Figure 158, Figure 159, Figure 160

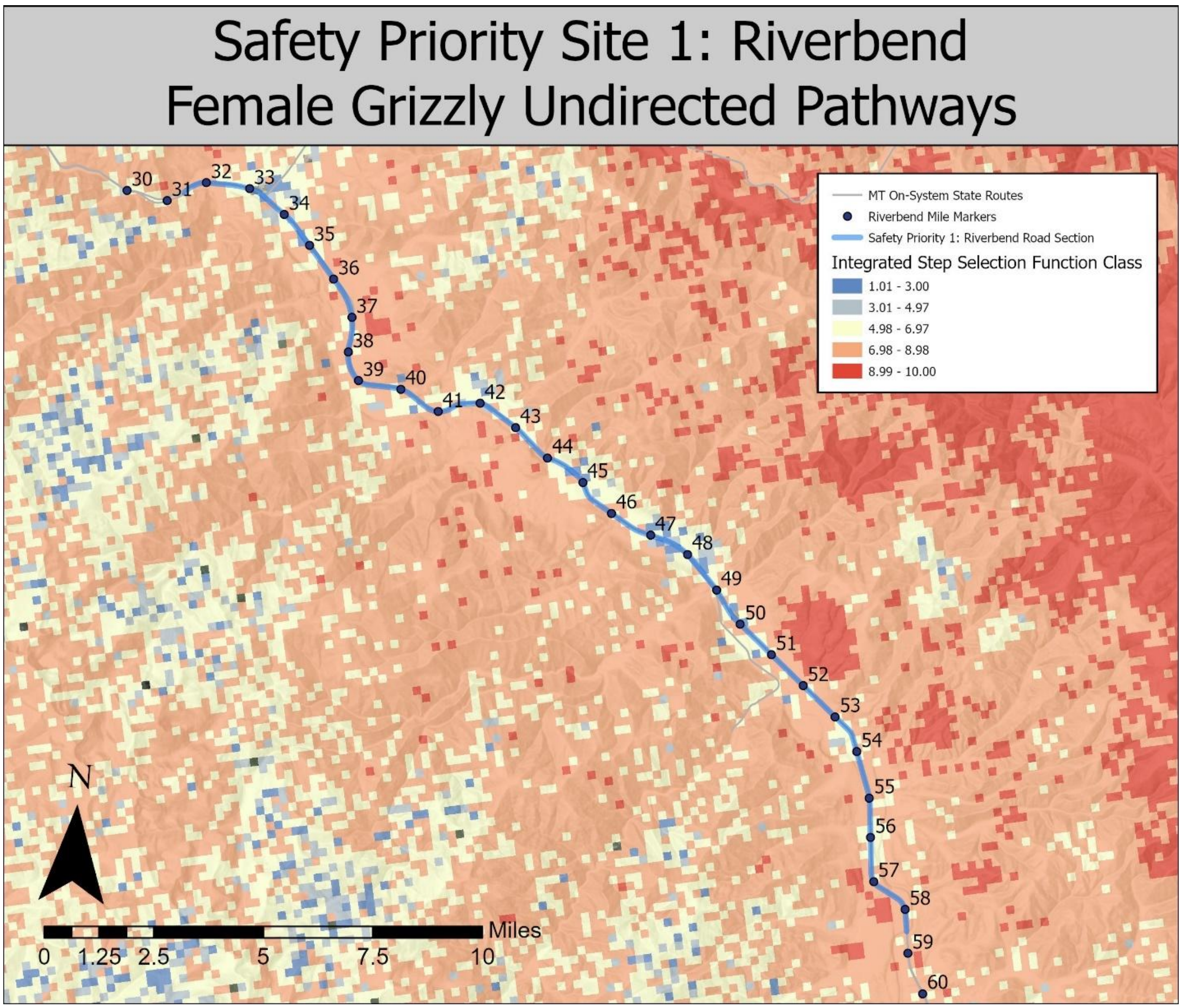


Figure 116: Safety priority site 1 (Riverbend), undirected pathways for female grizzly bears.

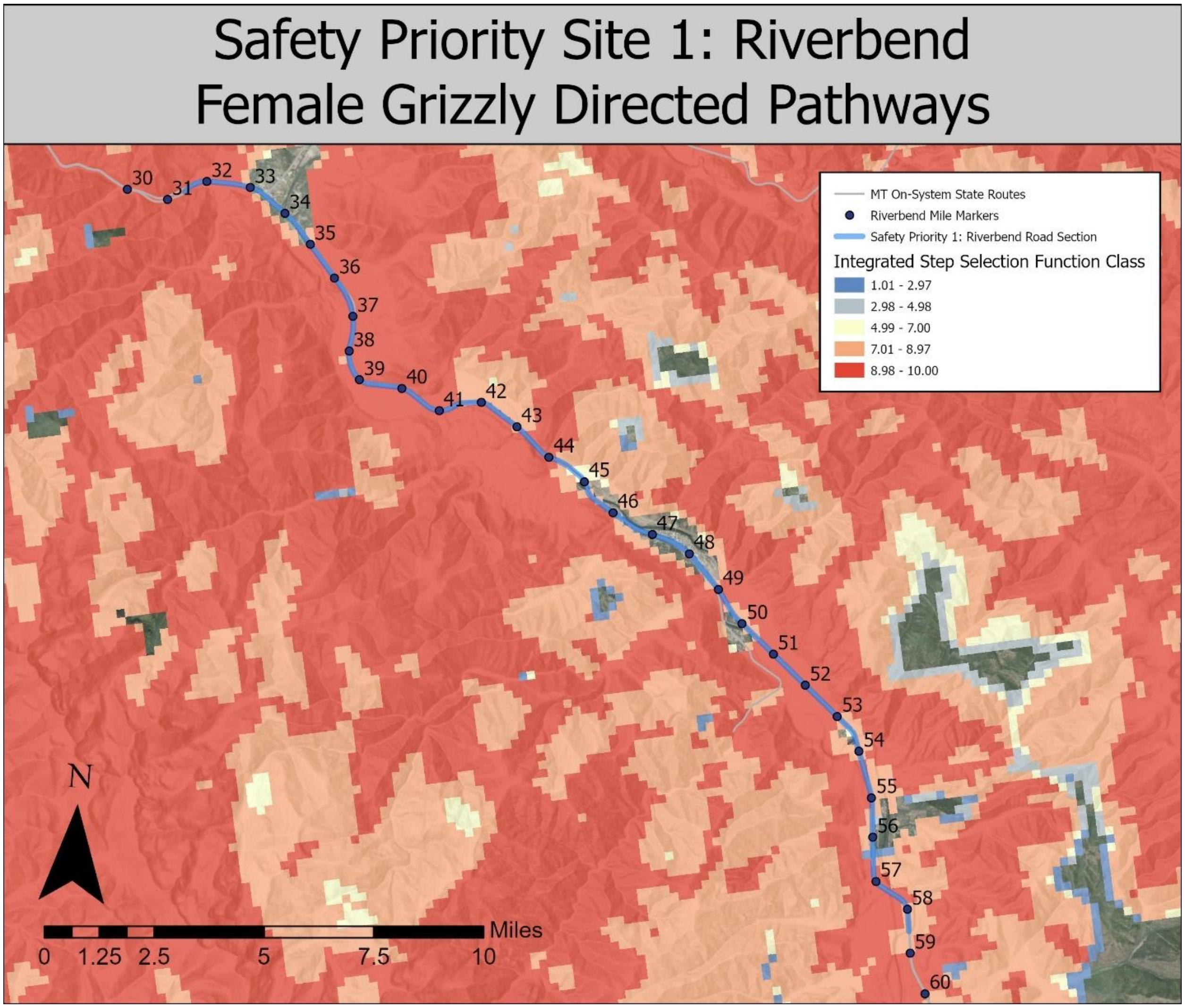


Figure 117: Safety priority site 1 (Riverbend), directed pathways for female grizzly bears.

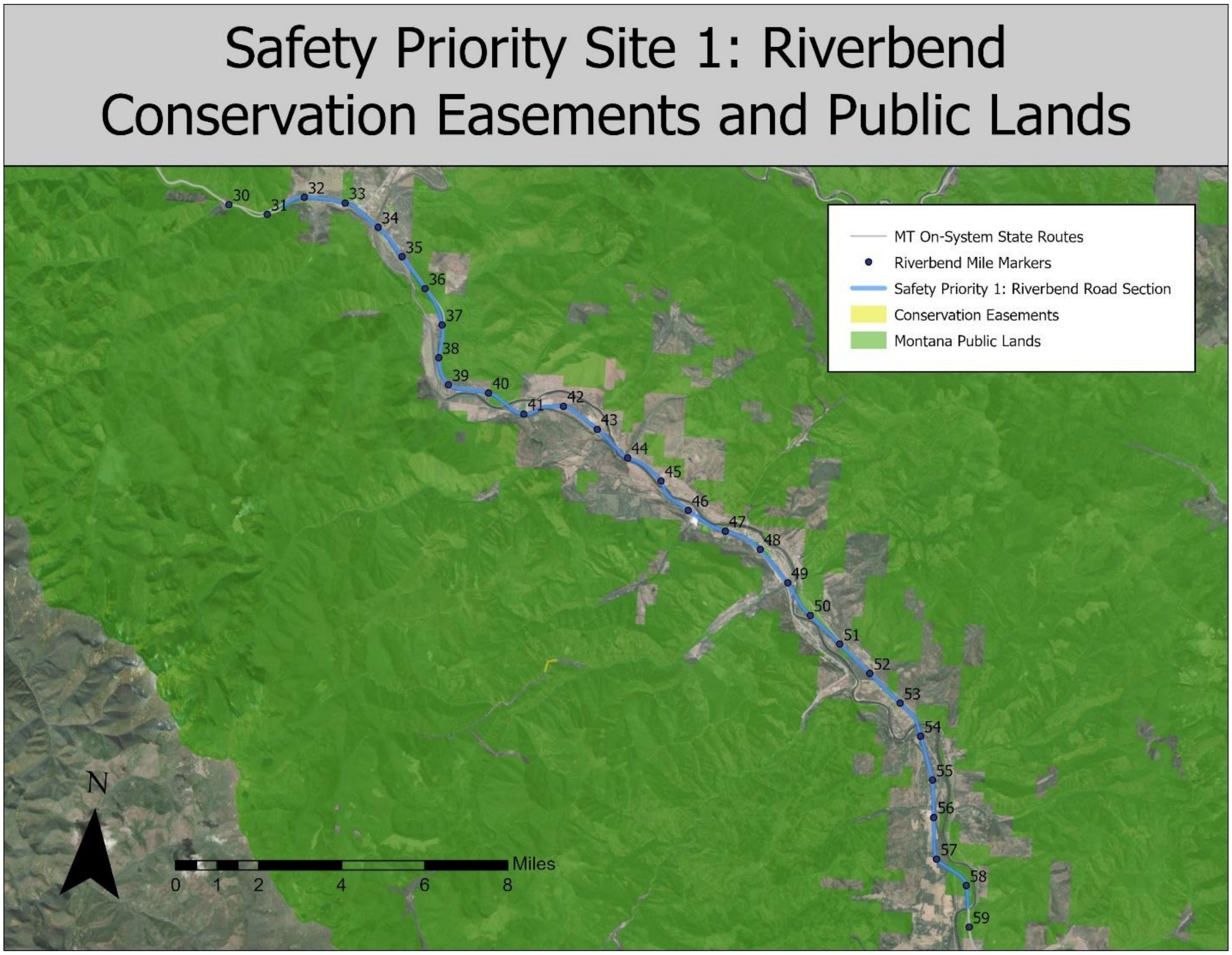


Figure 118: Safety priority site 1 (Riverbend), conservation easements and public lands.

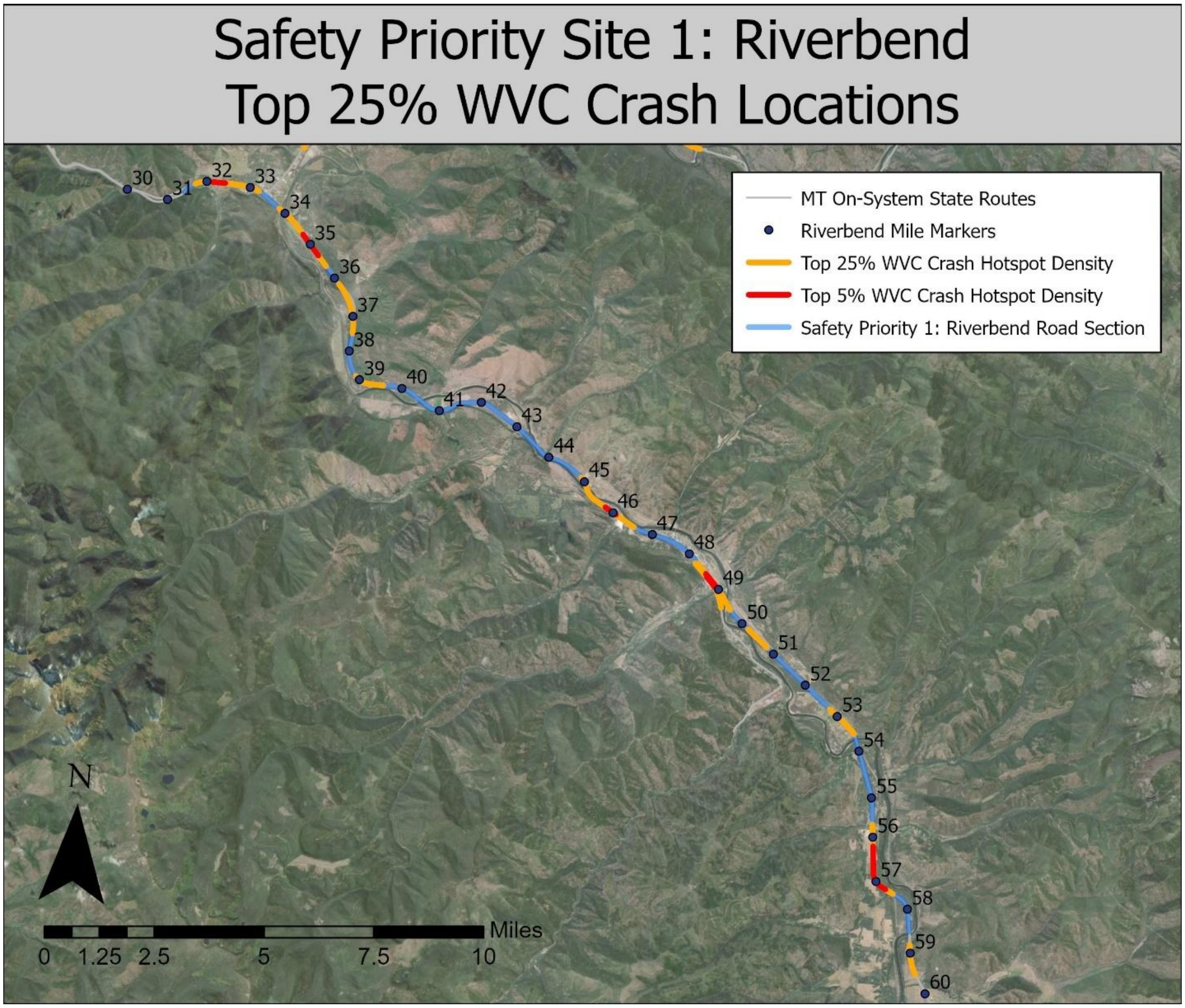


Figure 119: Safety priority site 1 (Riverbend), top 25% crash locations.

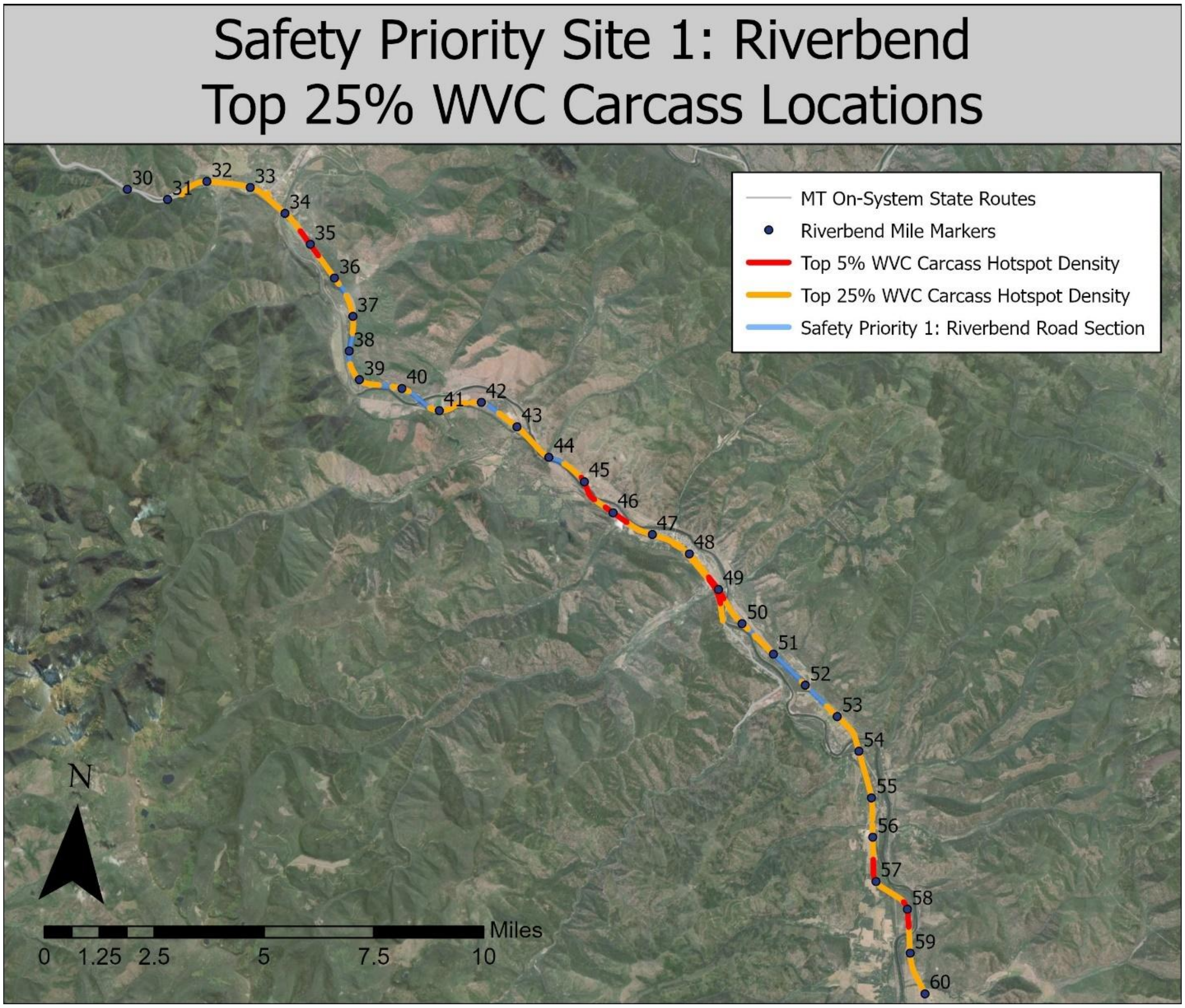


Figure 120: Safety priority site 1 (Riverbend), top 25% carcass locations.

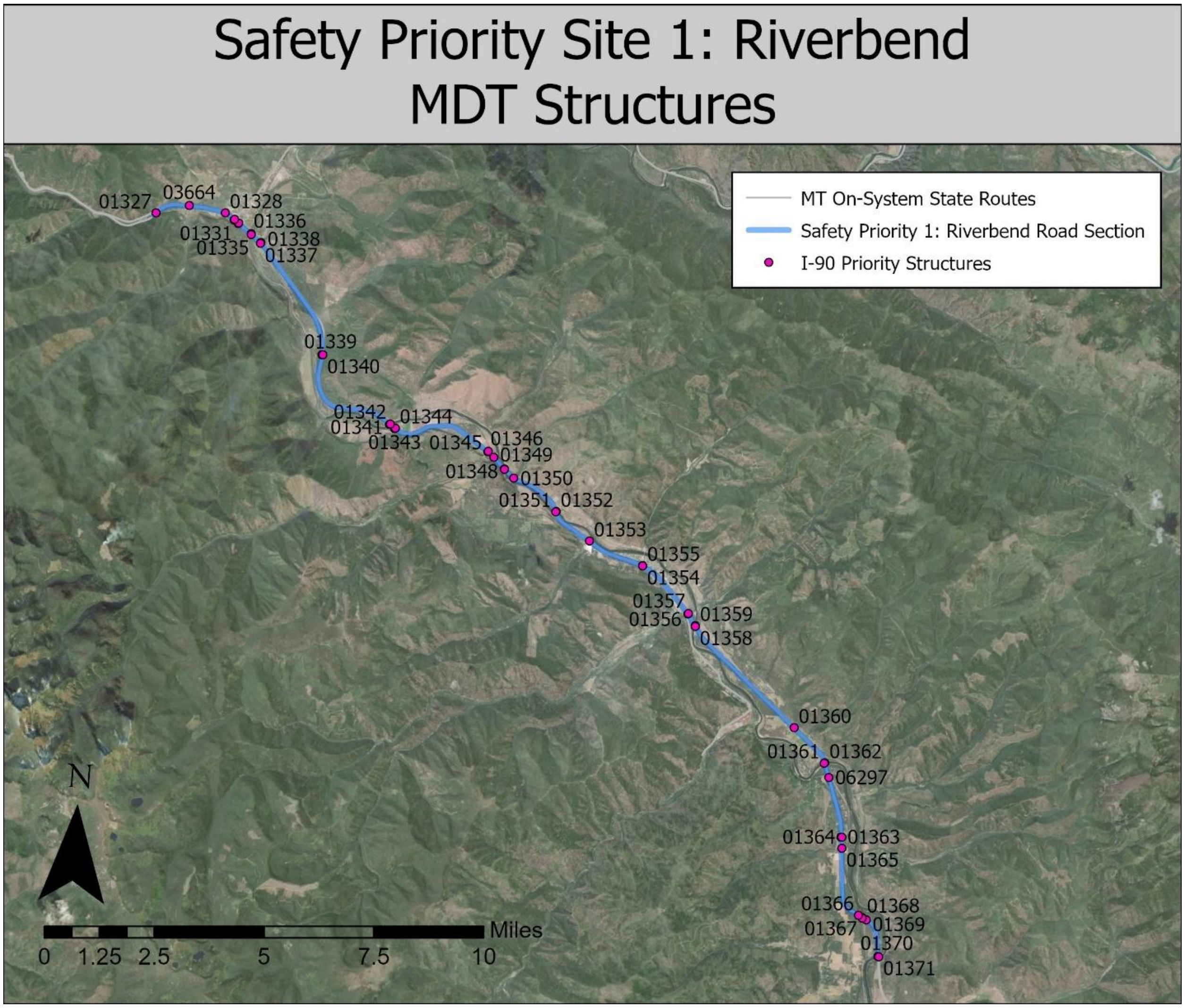


Figure 121: Safety priority site 1 (Riverbend), MDT structures.

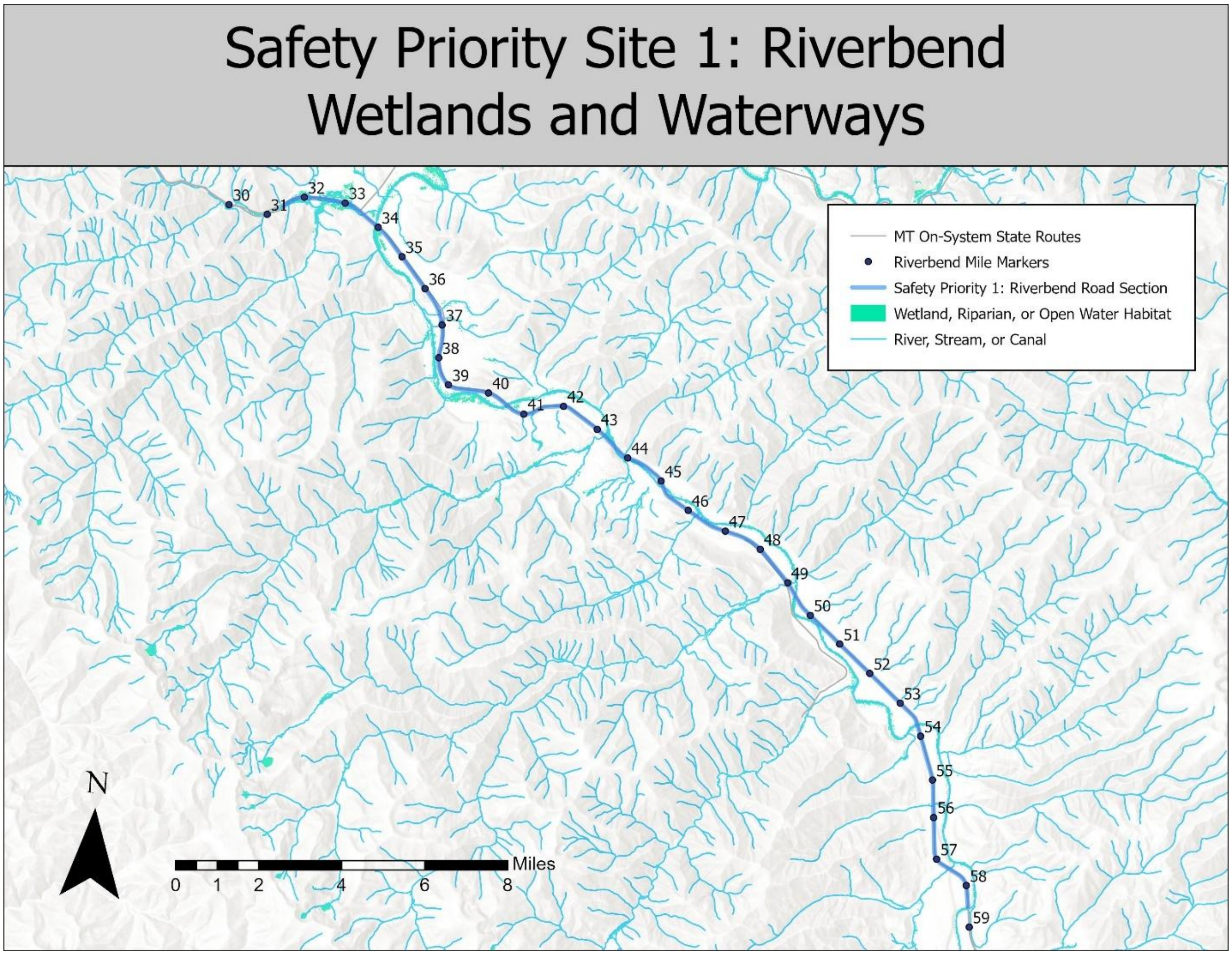


Figure 122: Safety priority site 1 (Riverbend), wetlands and waterways.

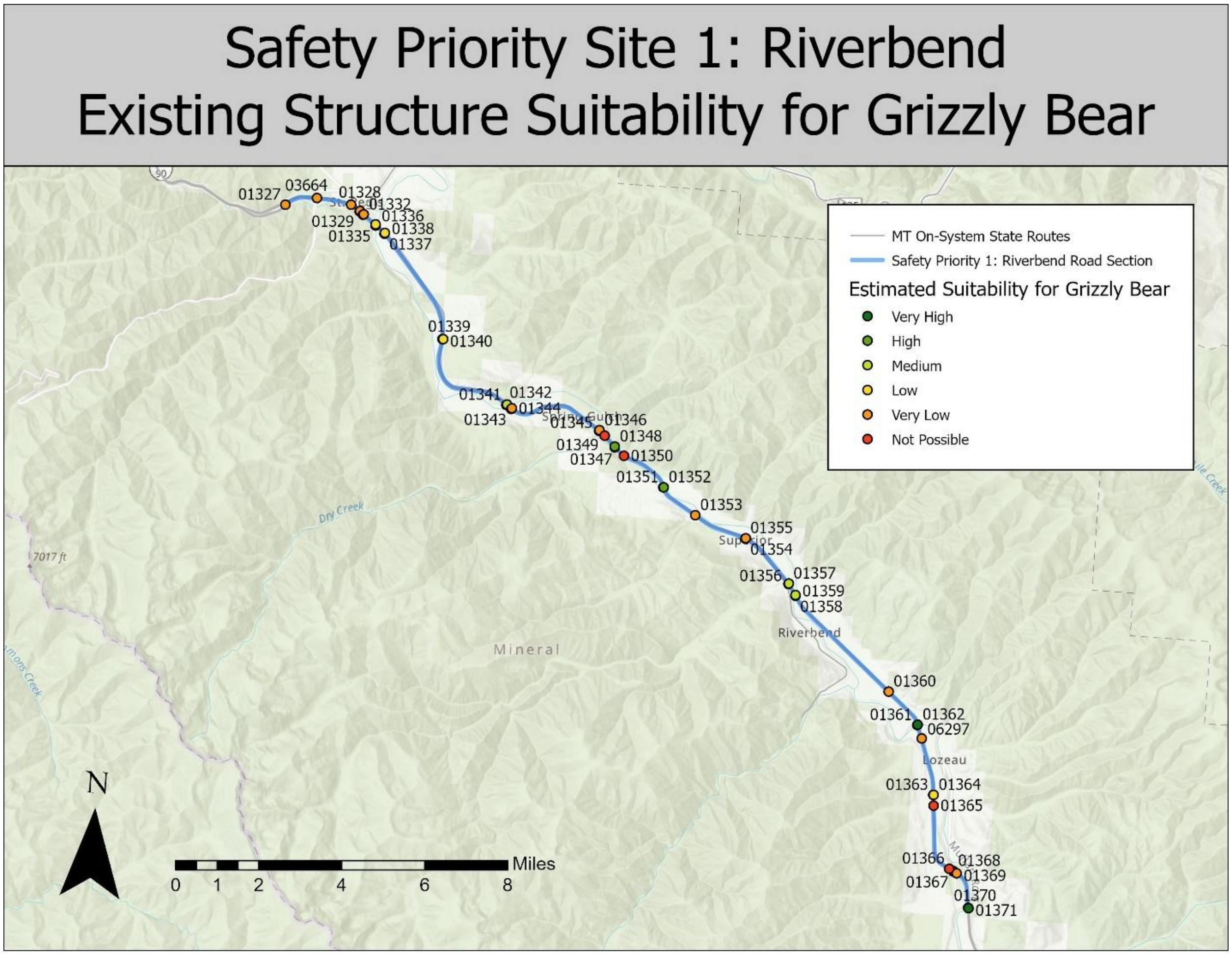


Figure 123: Safety priority site 1 (Riverbend), estimated suitability of existing structures for grizzly bears.

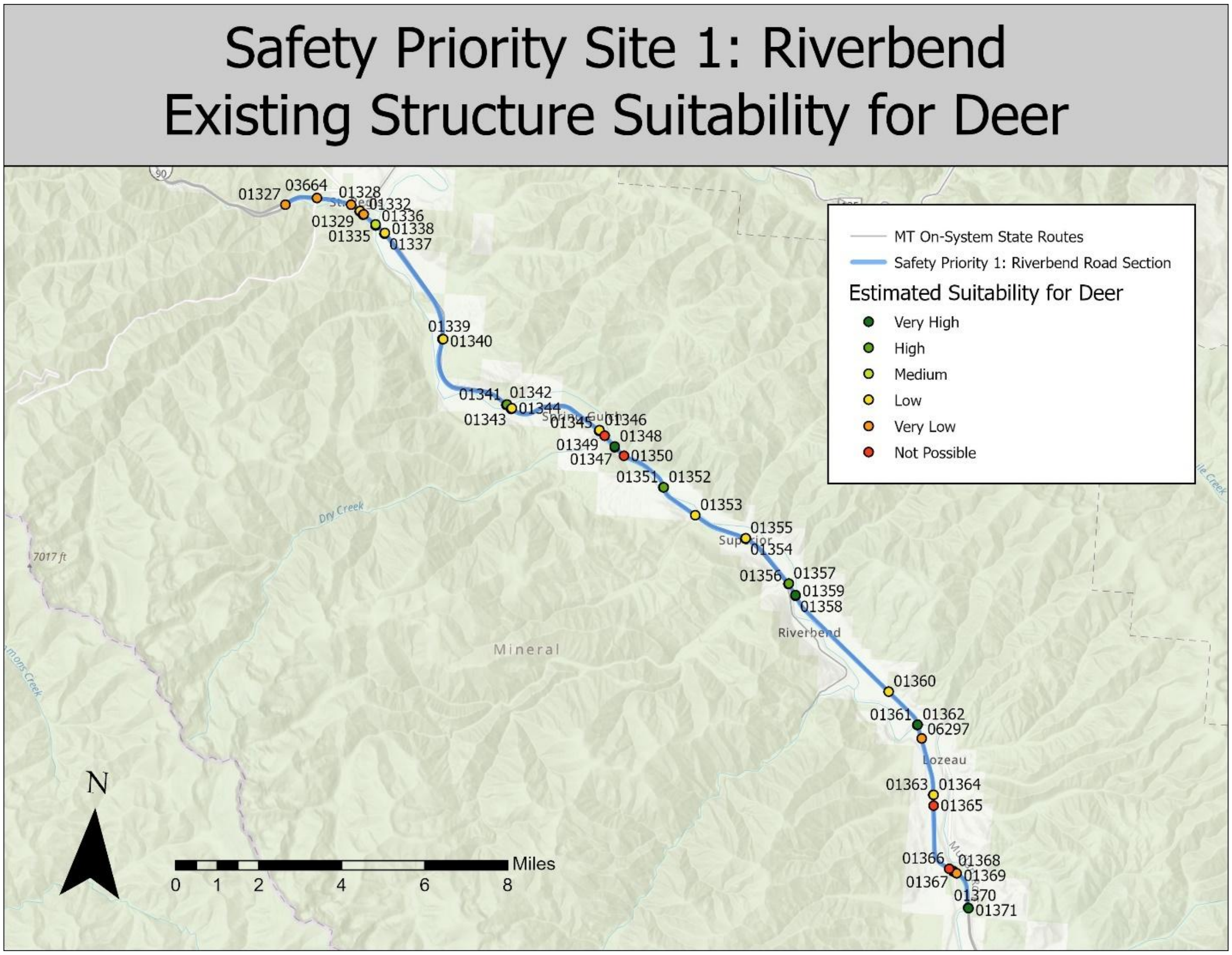


Figure 124: Safety priority site 1 (Riverbend), estimated suitability of existing structures for deer.

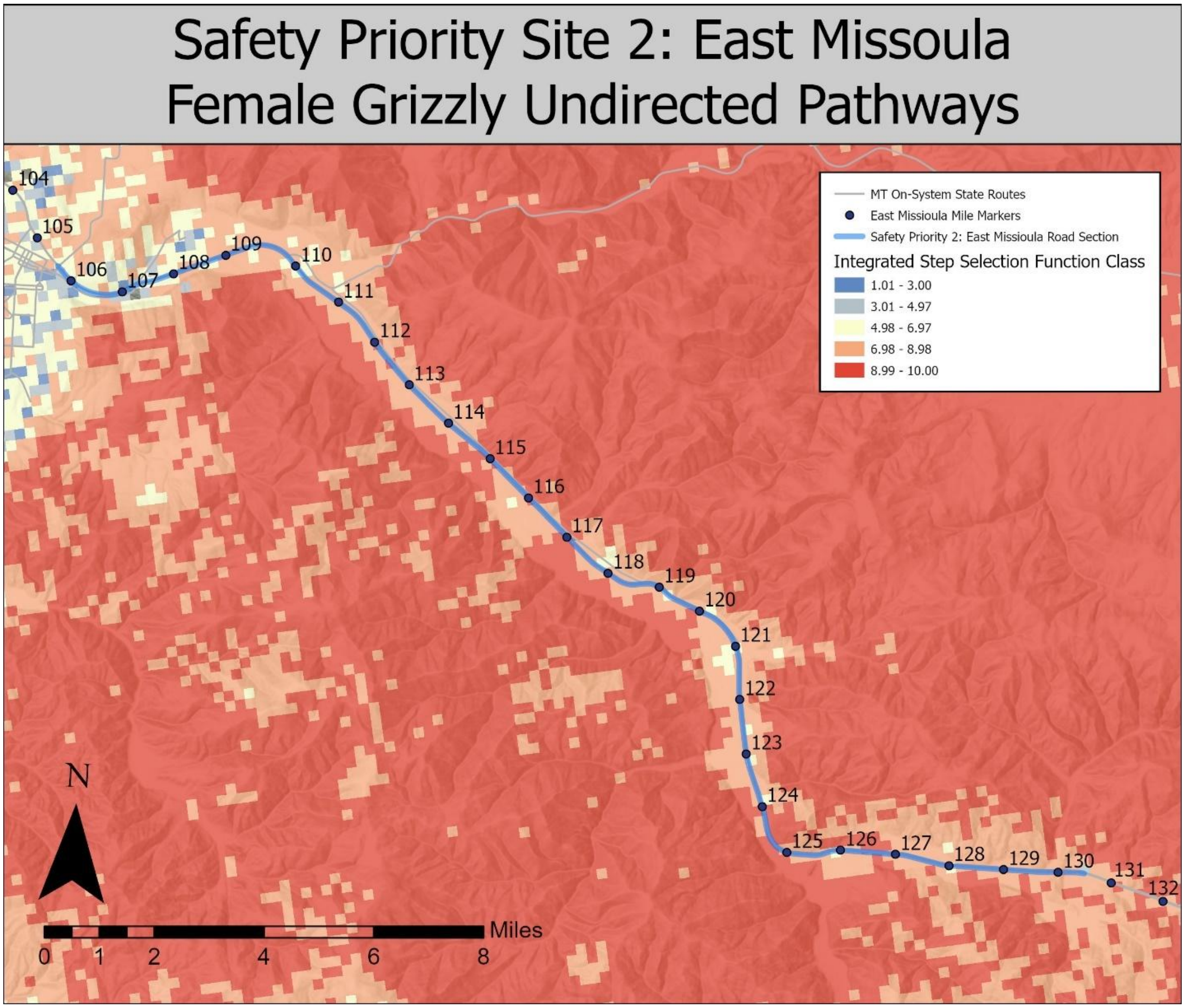


Figure 125: Safety priority site 2 (East Missoula), undirected pathways for female grizzly bears.

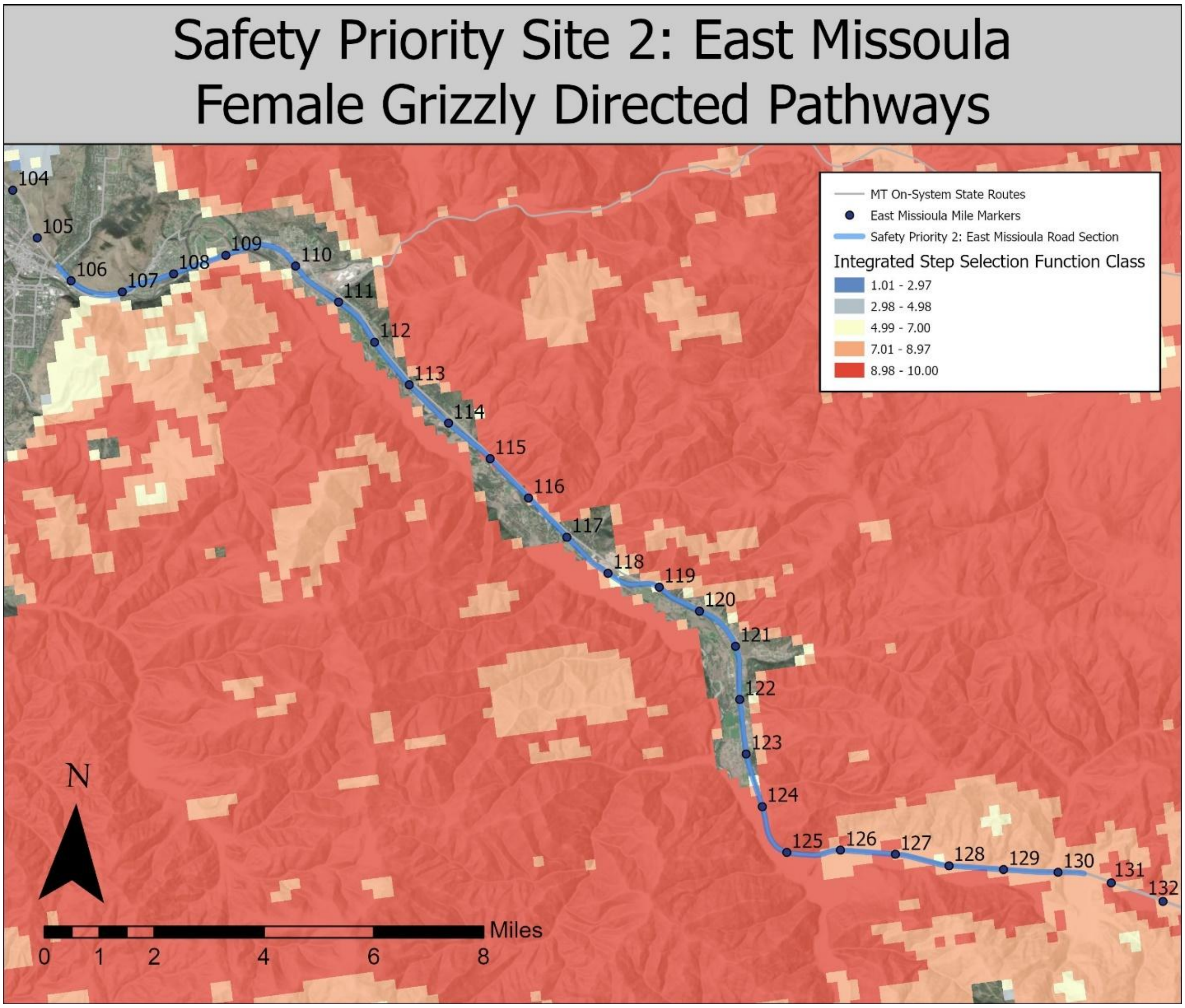


Figure 126: Safety priority site 2 (East Missoula), directed pathways for female grizzly bears.

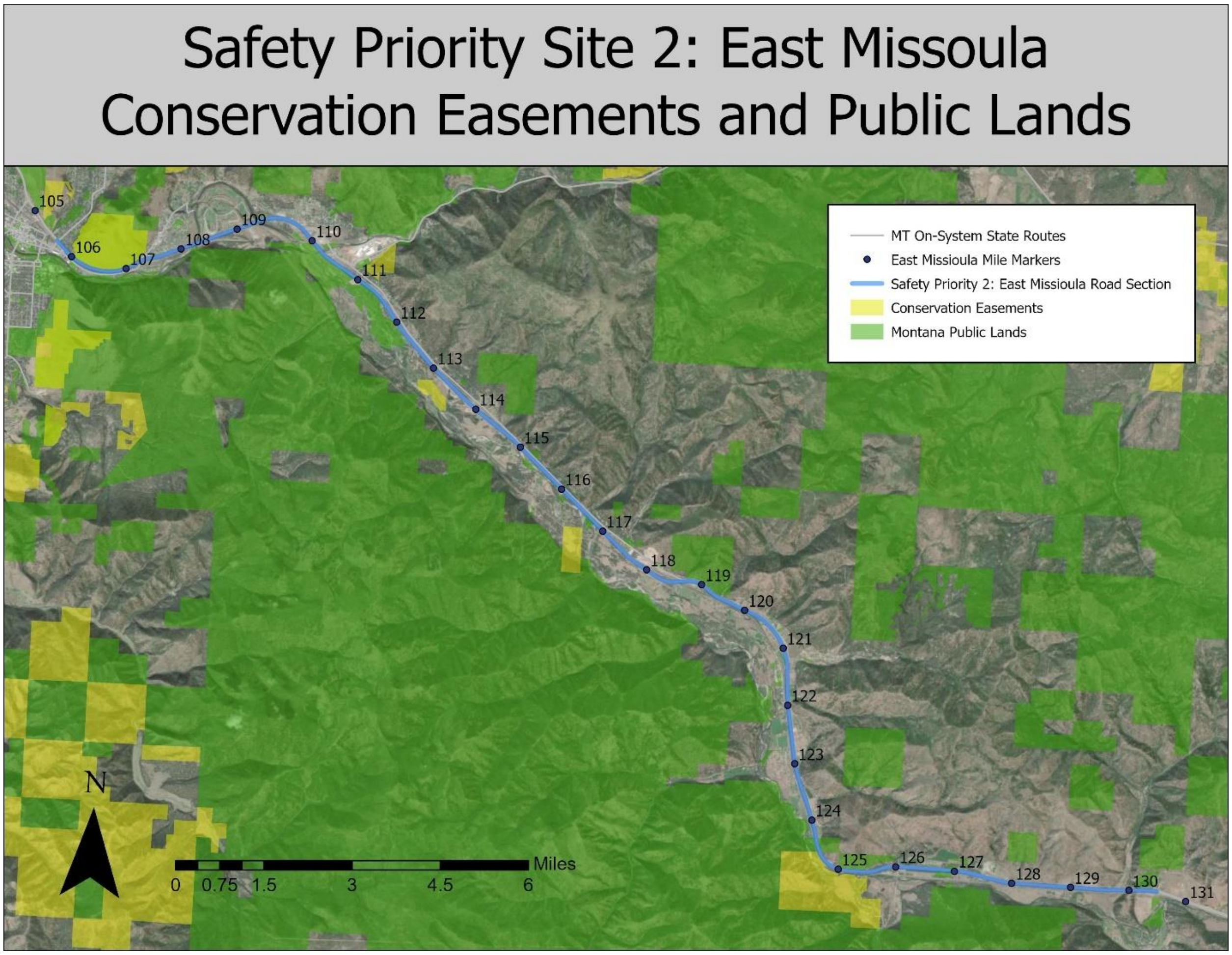


Figure 127: Safety priority site 2 (East Missoula), conservation easements and public lands.

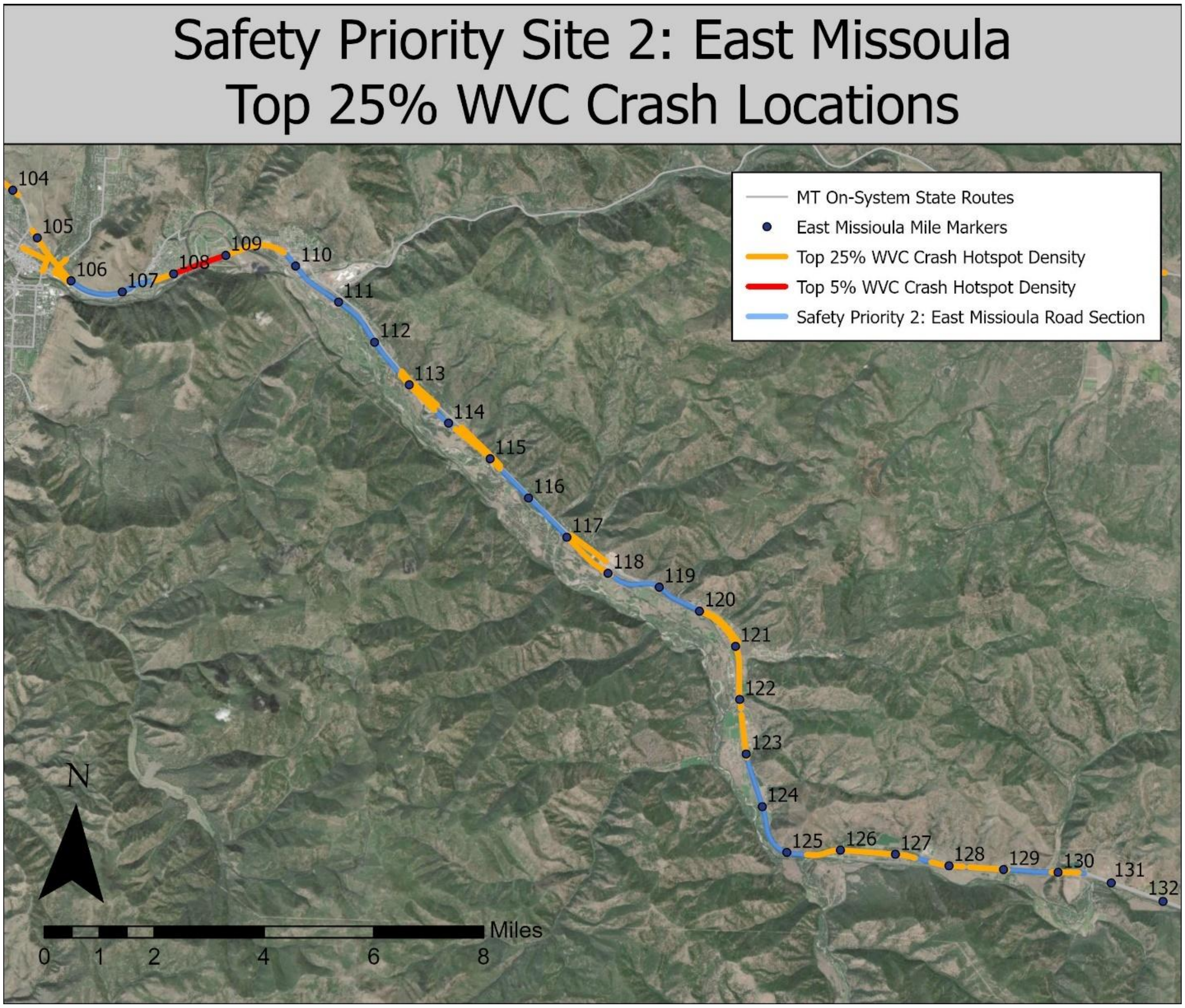


Figure 128: Safety priority site 2 (East Missoula), top 25% crash locations.

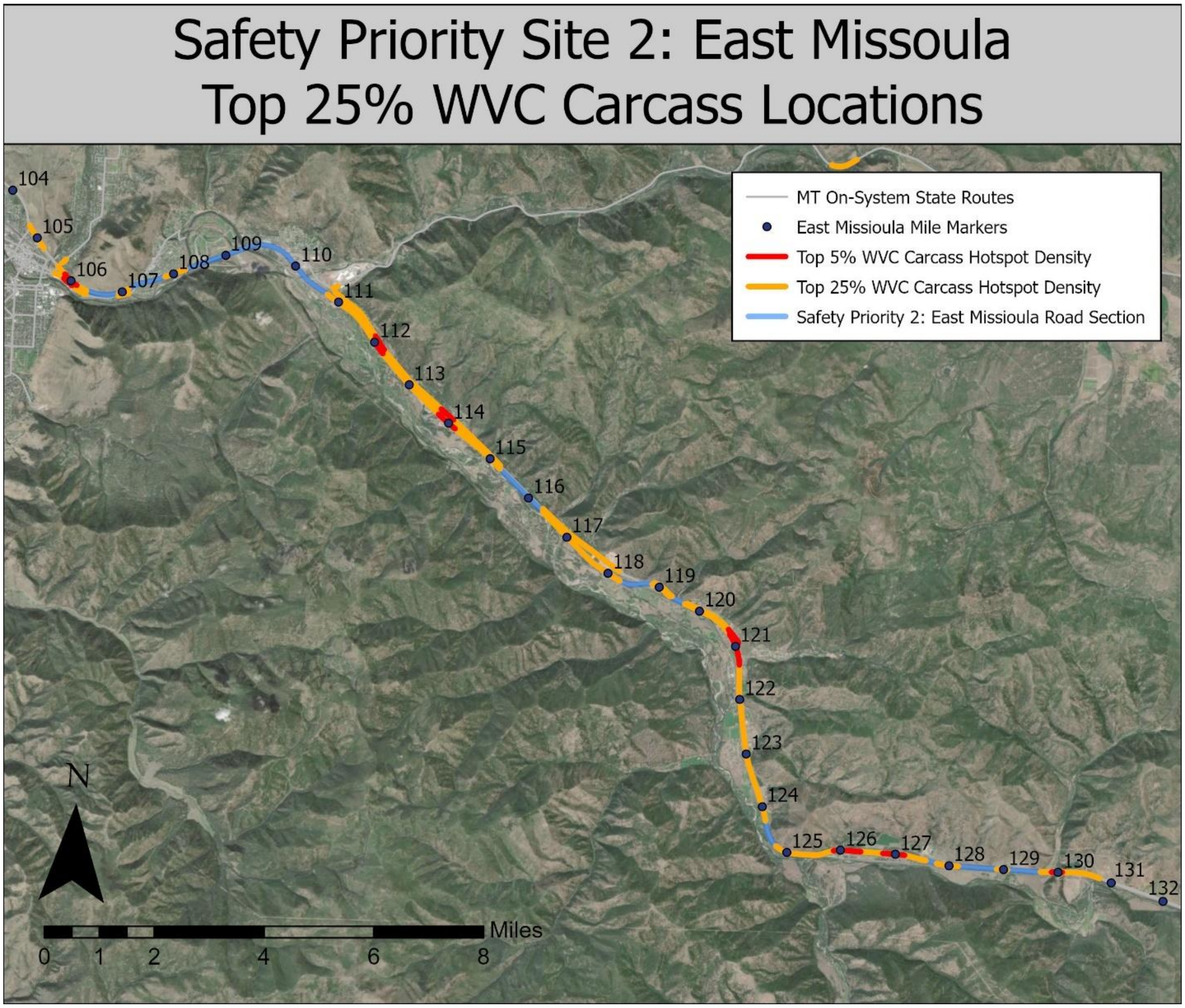


Figure 129: Safety priority site 2 (East Missoula), top 25% carcass locations.

Figure 130: Safety priority site 2 (East Missoula), MDT structures.

Figure 131: Safety priority site 2 (East Missoula), wetlands and waterways.

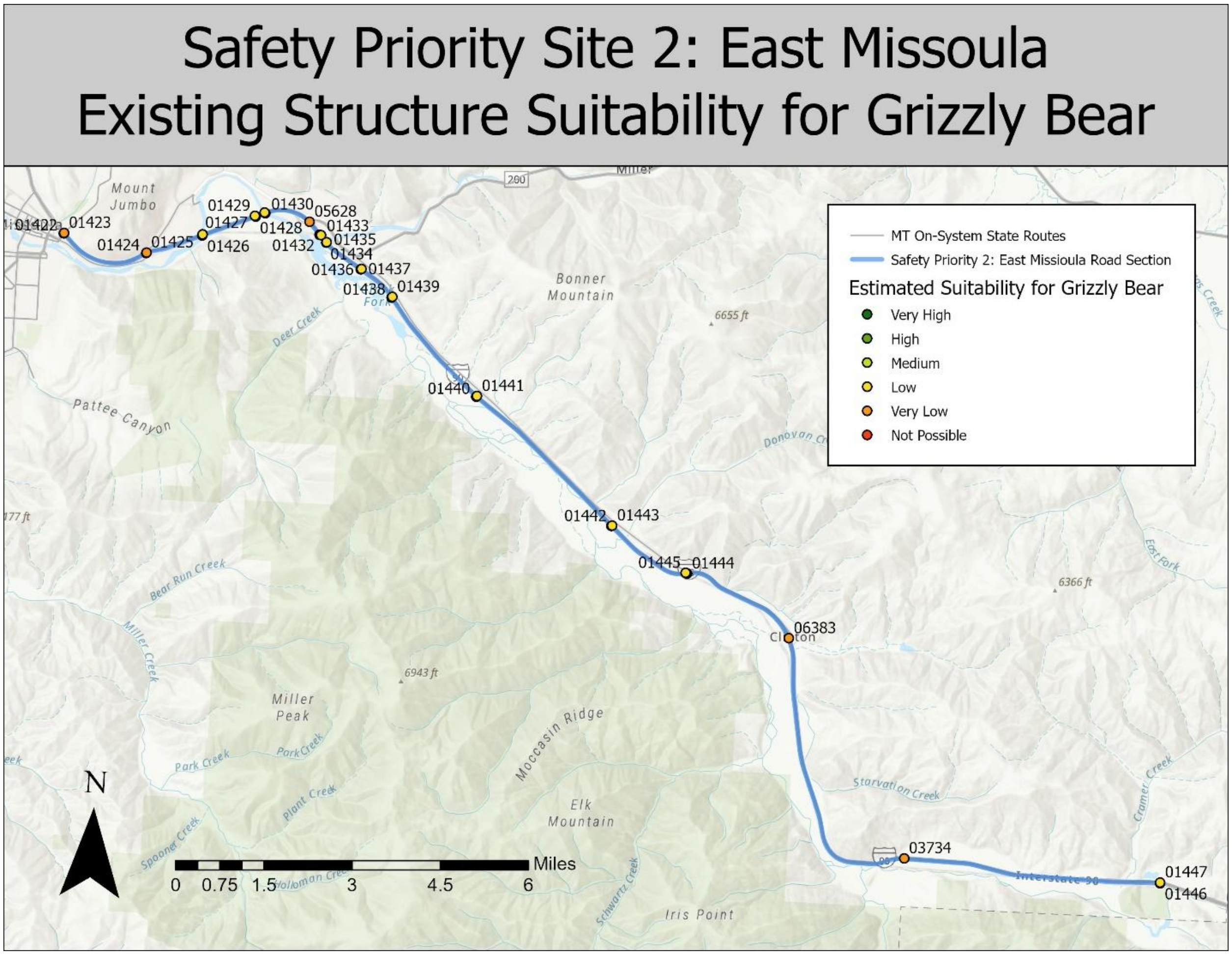


Figure 132: Safety priority site 2 (East Missoula), estimated suitability of existing structures for grizzly bears.

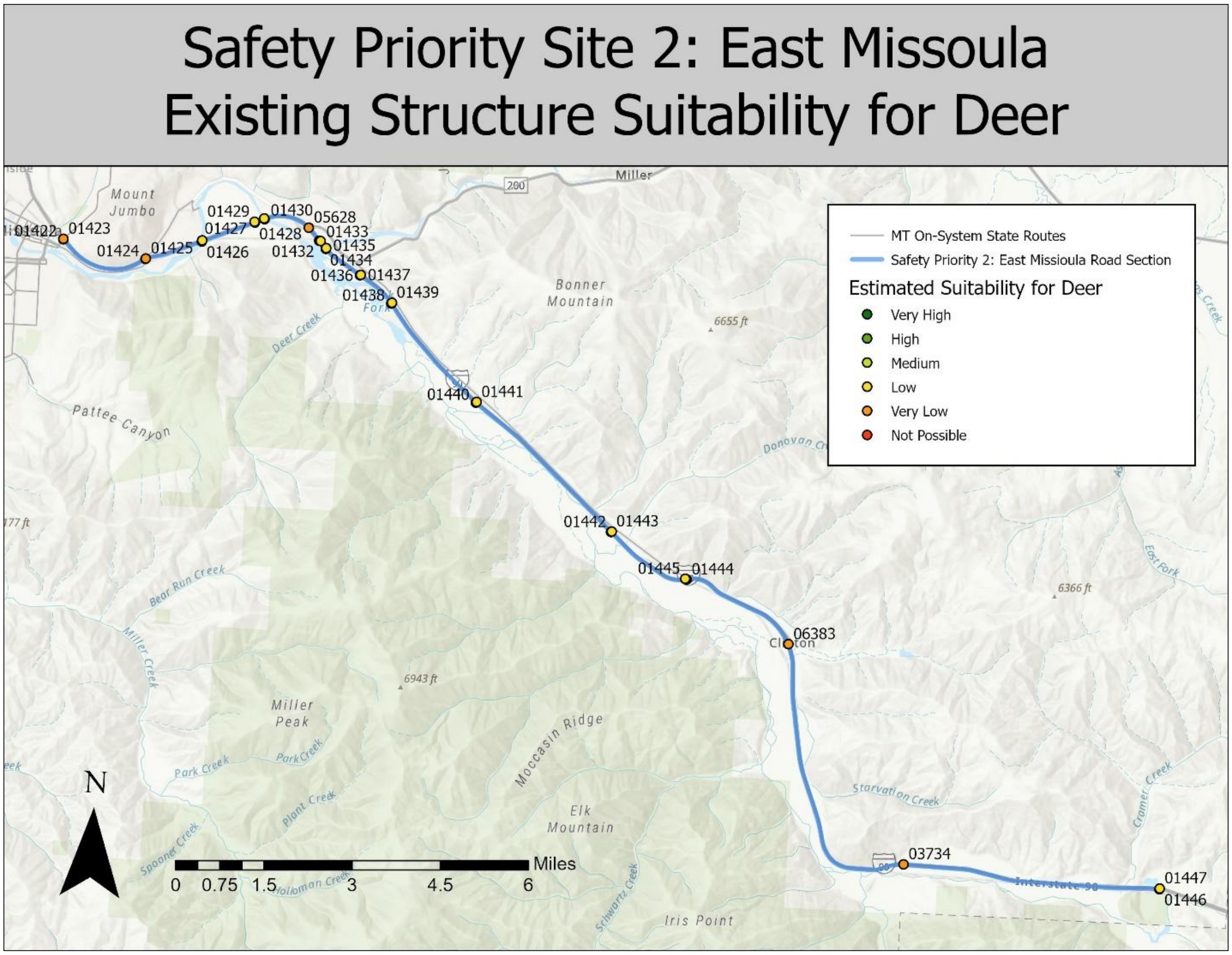


Figure 133: Safety priority site 2 (East Missoula), estimated suitability of existing structures for deer.

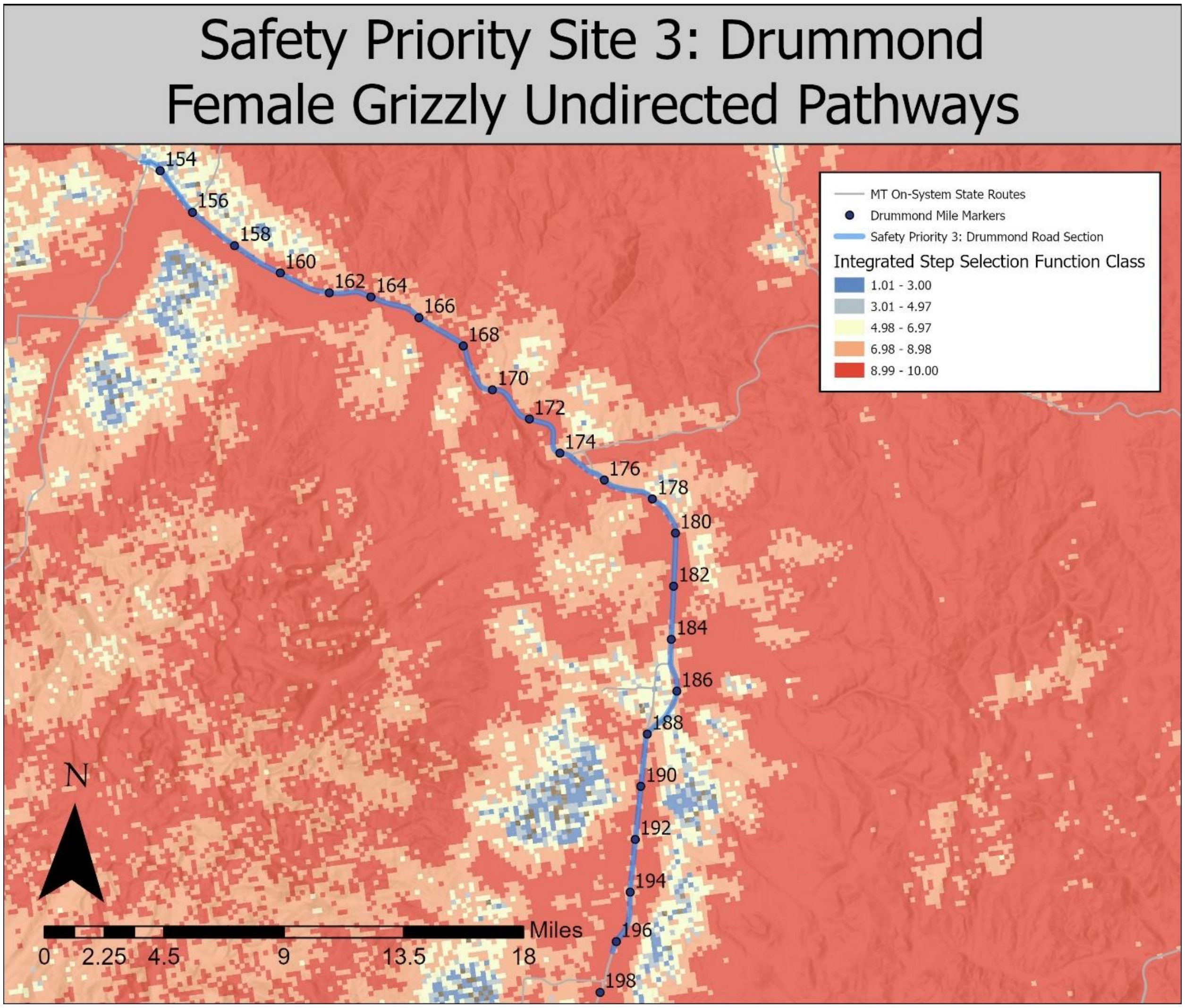


Figure 134: Safety priority site 3 (Drummond), undirected pathways for female grizzly bears.

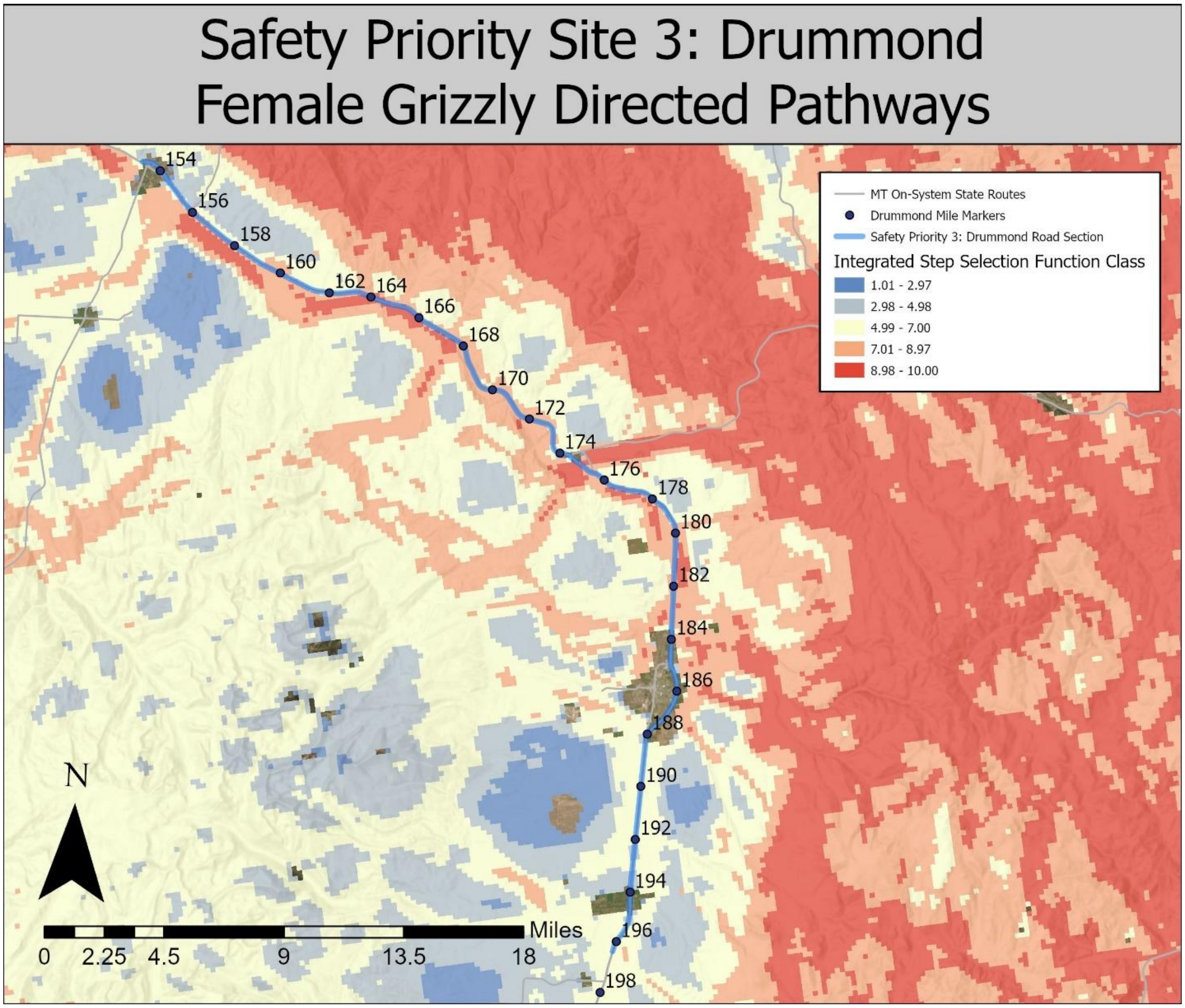


Figure 135: Safety priority site 3 (Drummond), directed pathways for female grizzly bears.

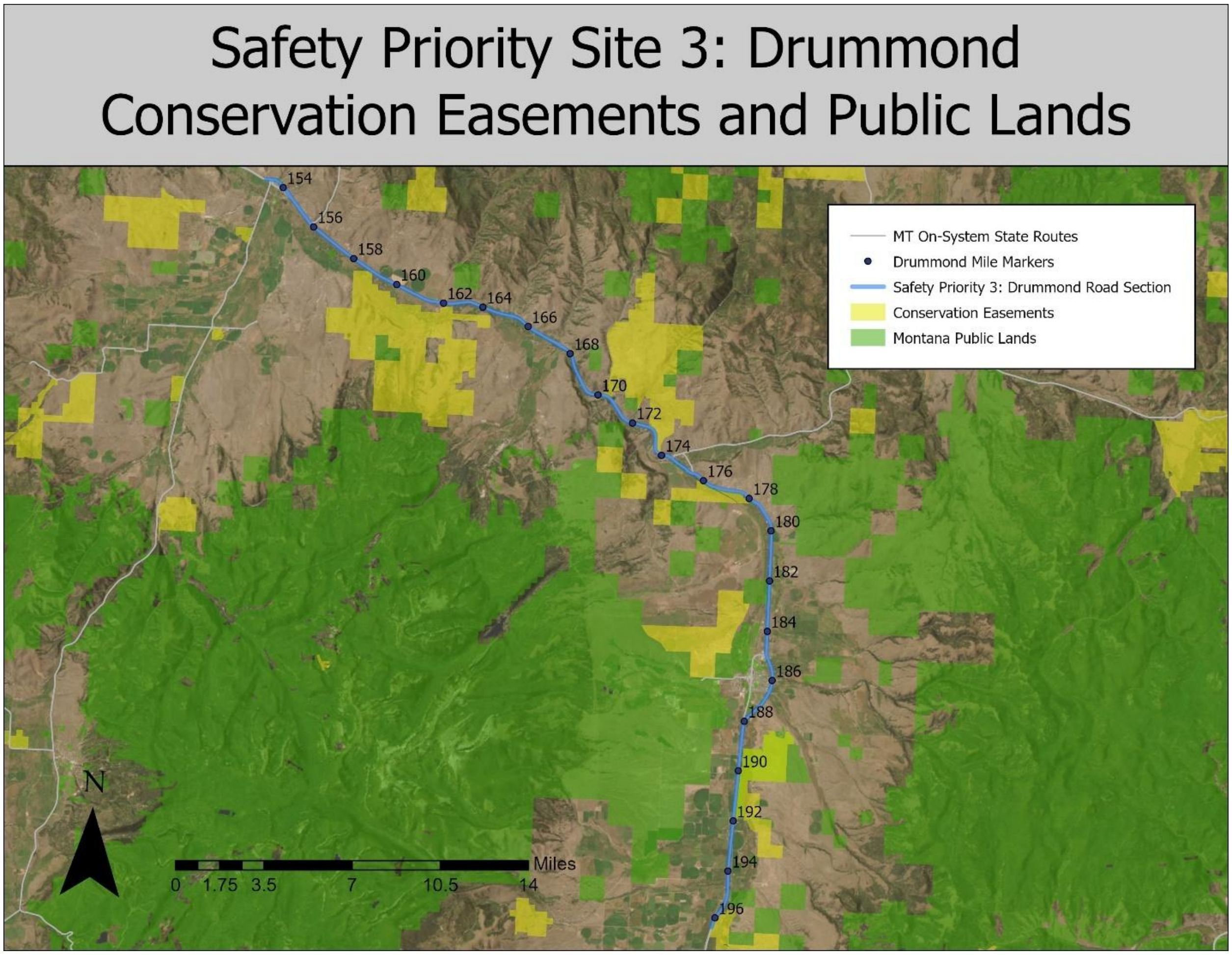


Figure 136: Safety priority site 3 (Drummond), conservation easements and public lands.

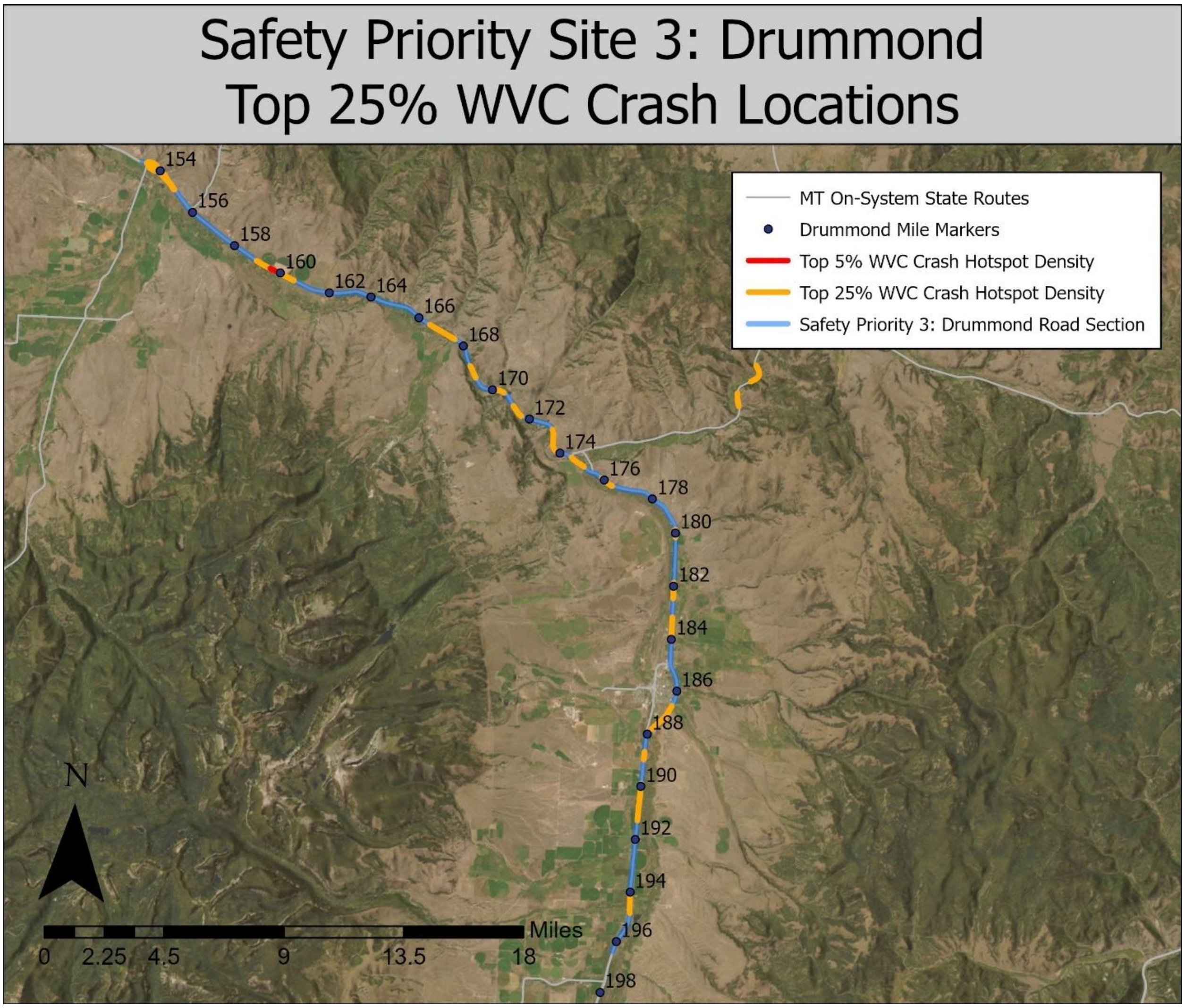


Figure 137: Safety priority site 3 (Drummond), top 25% crash locations.

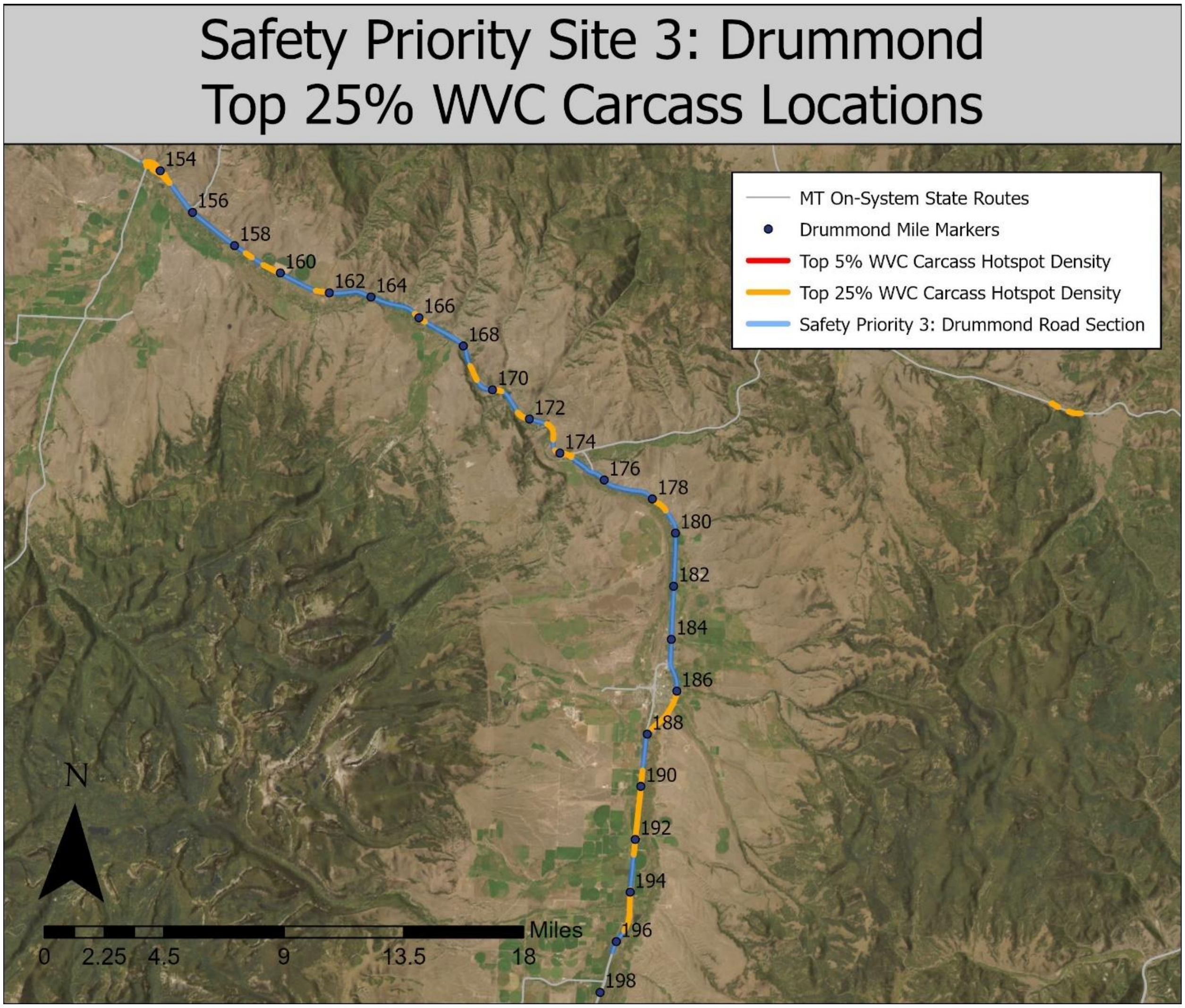


Figure 138: Safety priority site 3 (Drummond), top 25% carcass locations.

Figure 139: Safety priority site 3 (Drummond), MDT structures.

Figure 140: Safety priority site 3 (Drummond), wetlands and waterways.

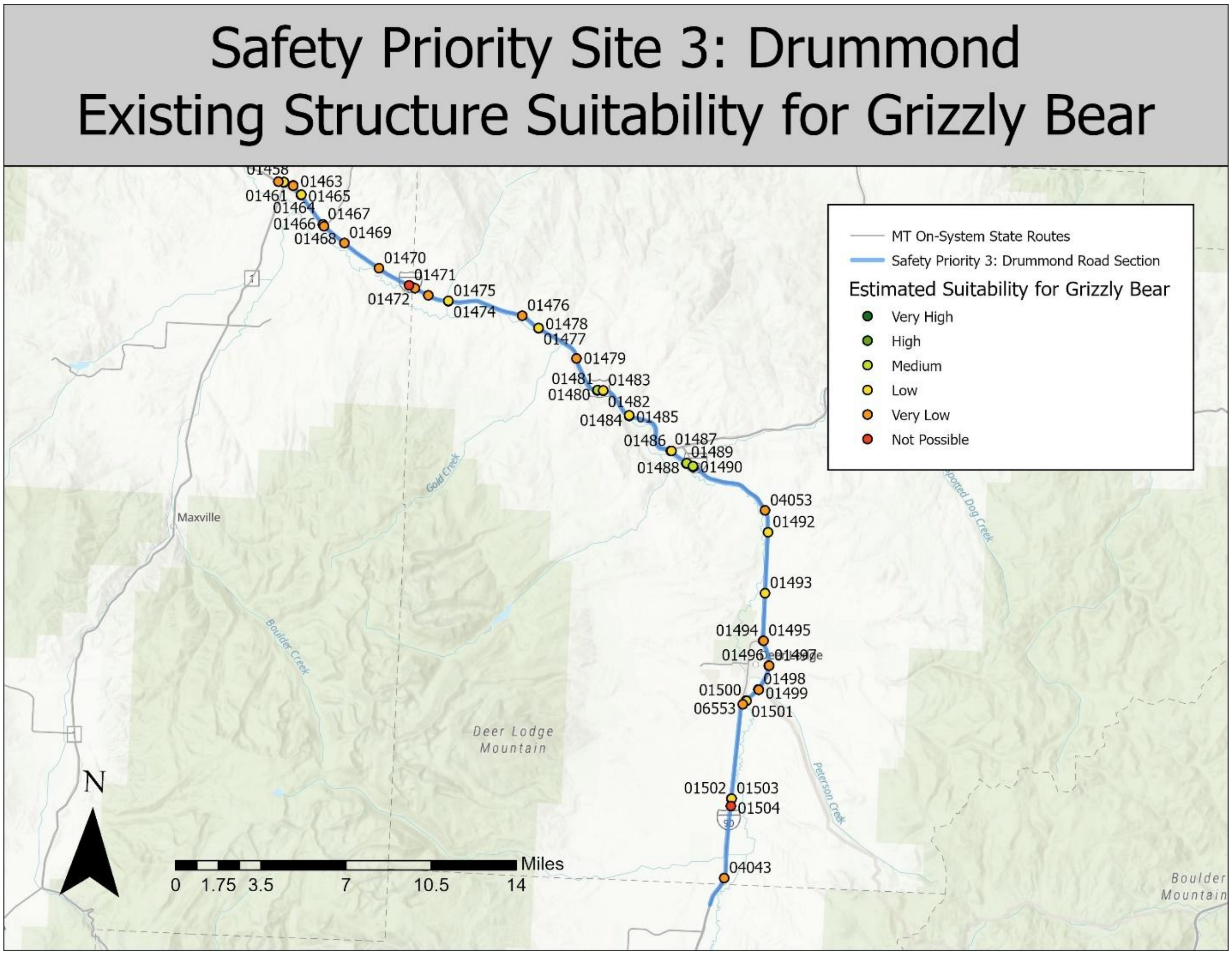


Figure 141: Safety priority site 3 (Drummond), estimated suitability of existing structures for grizzly bears.

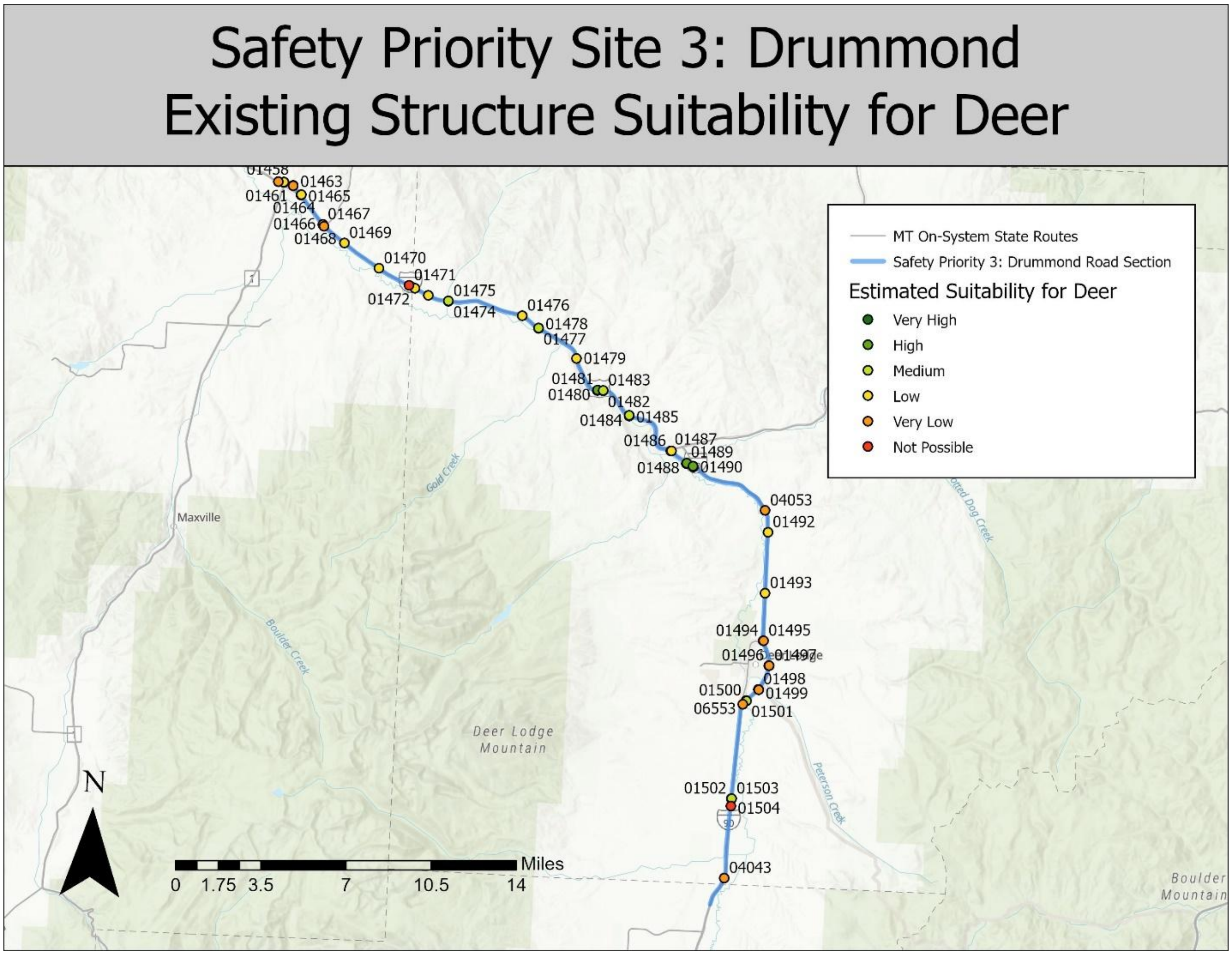


Figure 142: Safety priority site 3 (Drummond), estimated suitability of existing structures for deer.

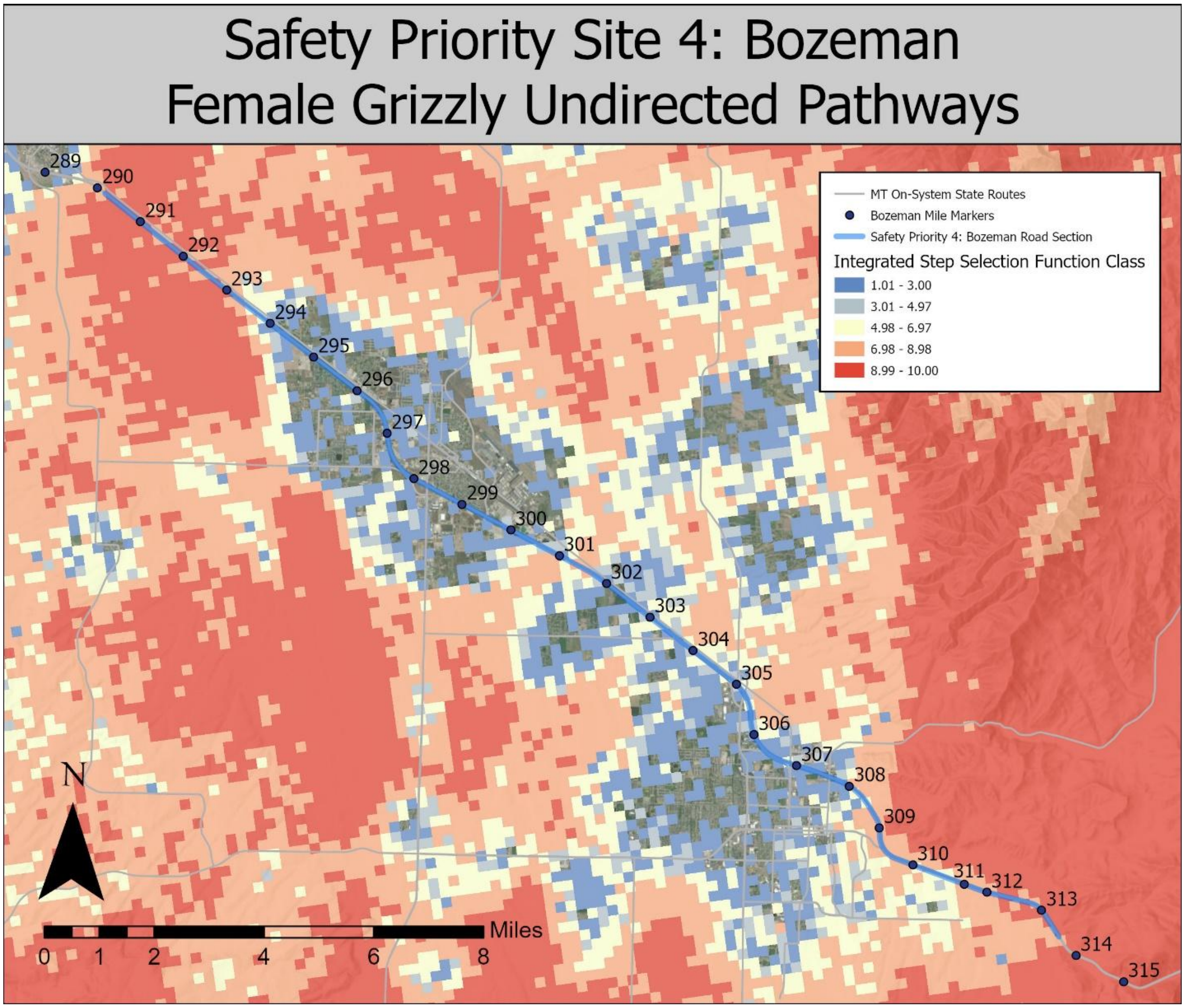


Figure 143: Safety priority site 4 (Bozeman), undirected pathways for female grizzly bears.

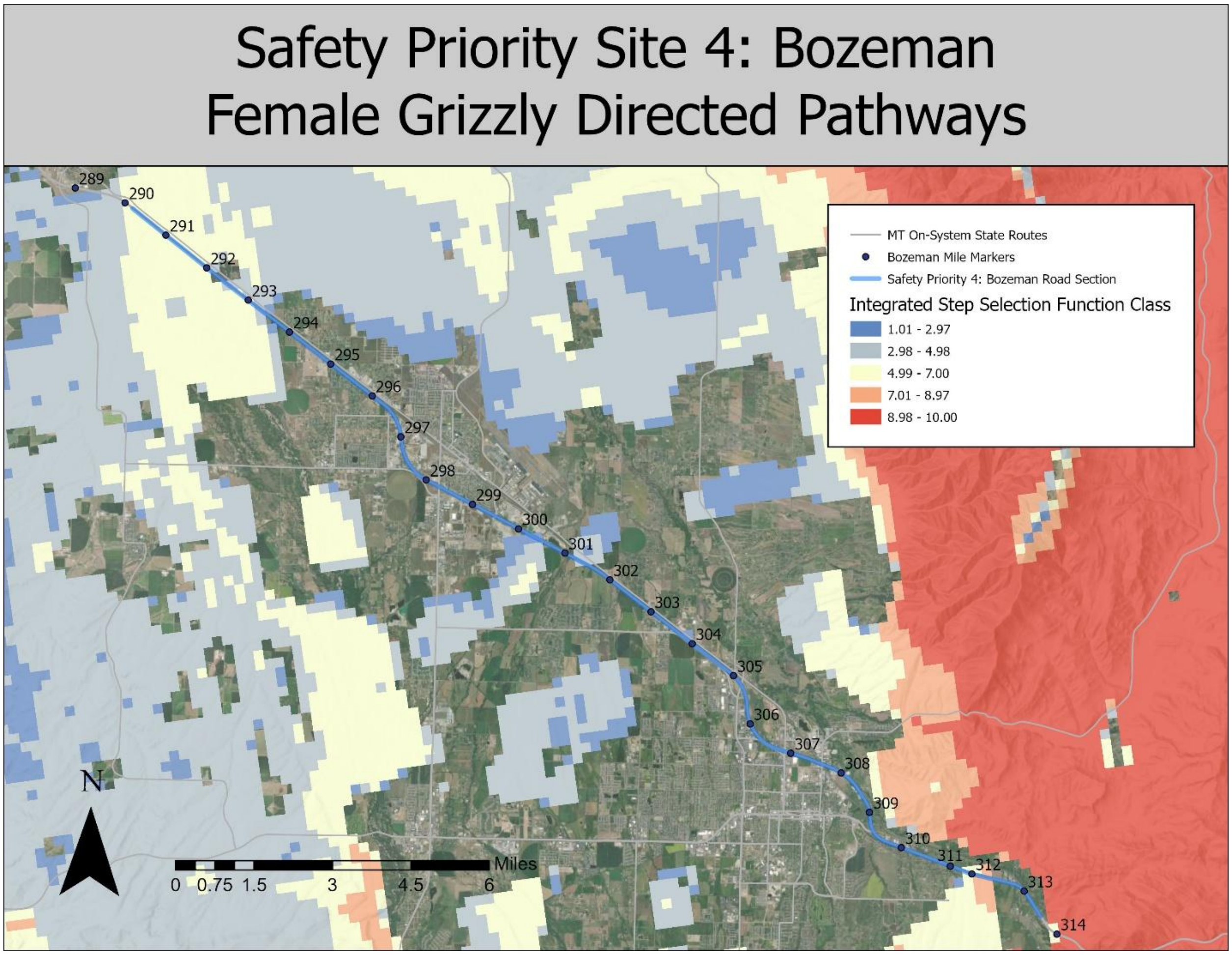


Figure 144: Safety priority site 4 (Bozeman), directed pathways for female grizzly bears.

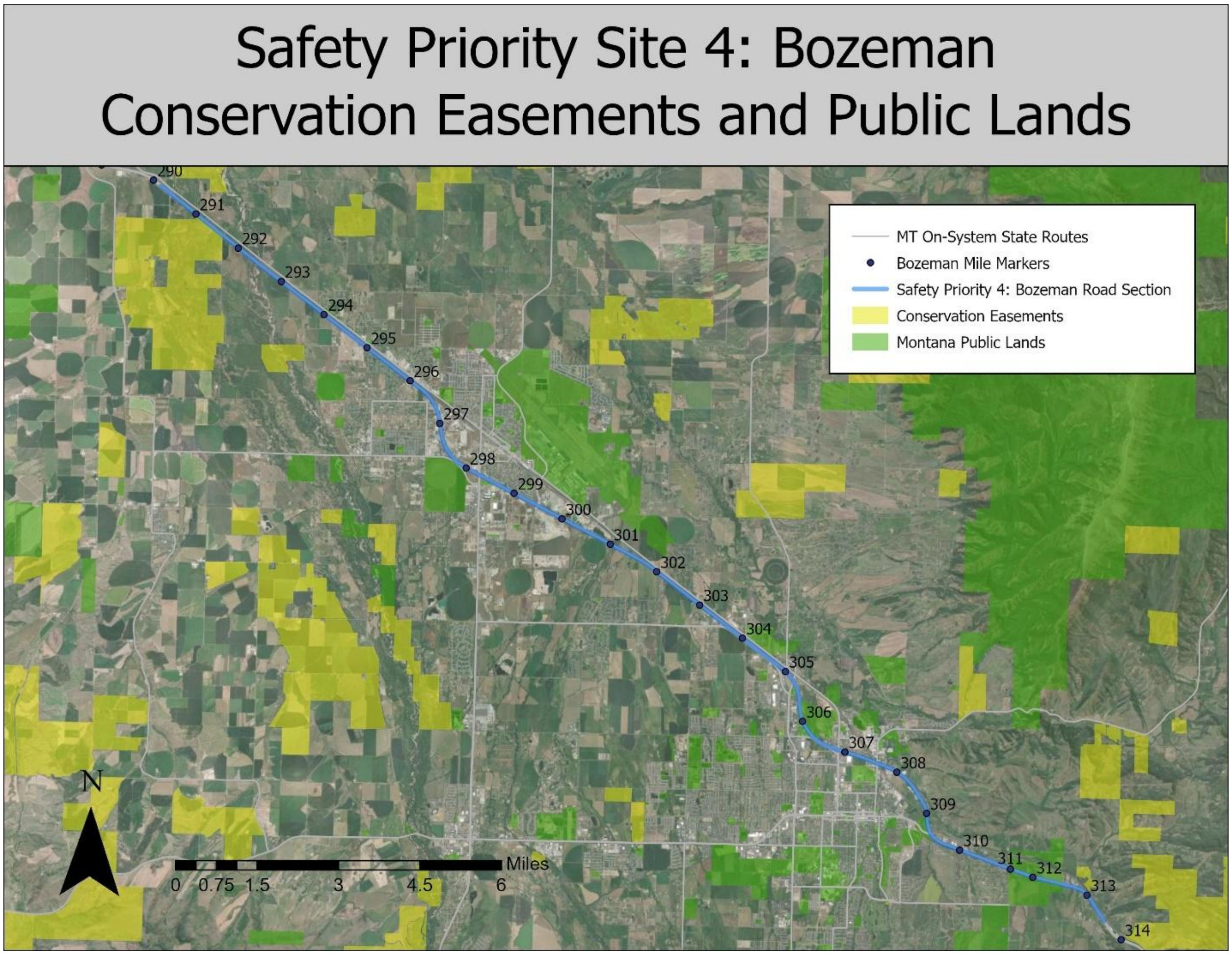


Figure 145: Safety priority site 4 (Bozeman), conservation easements and public lands.

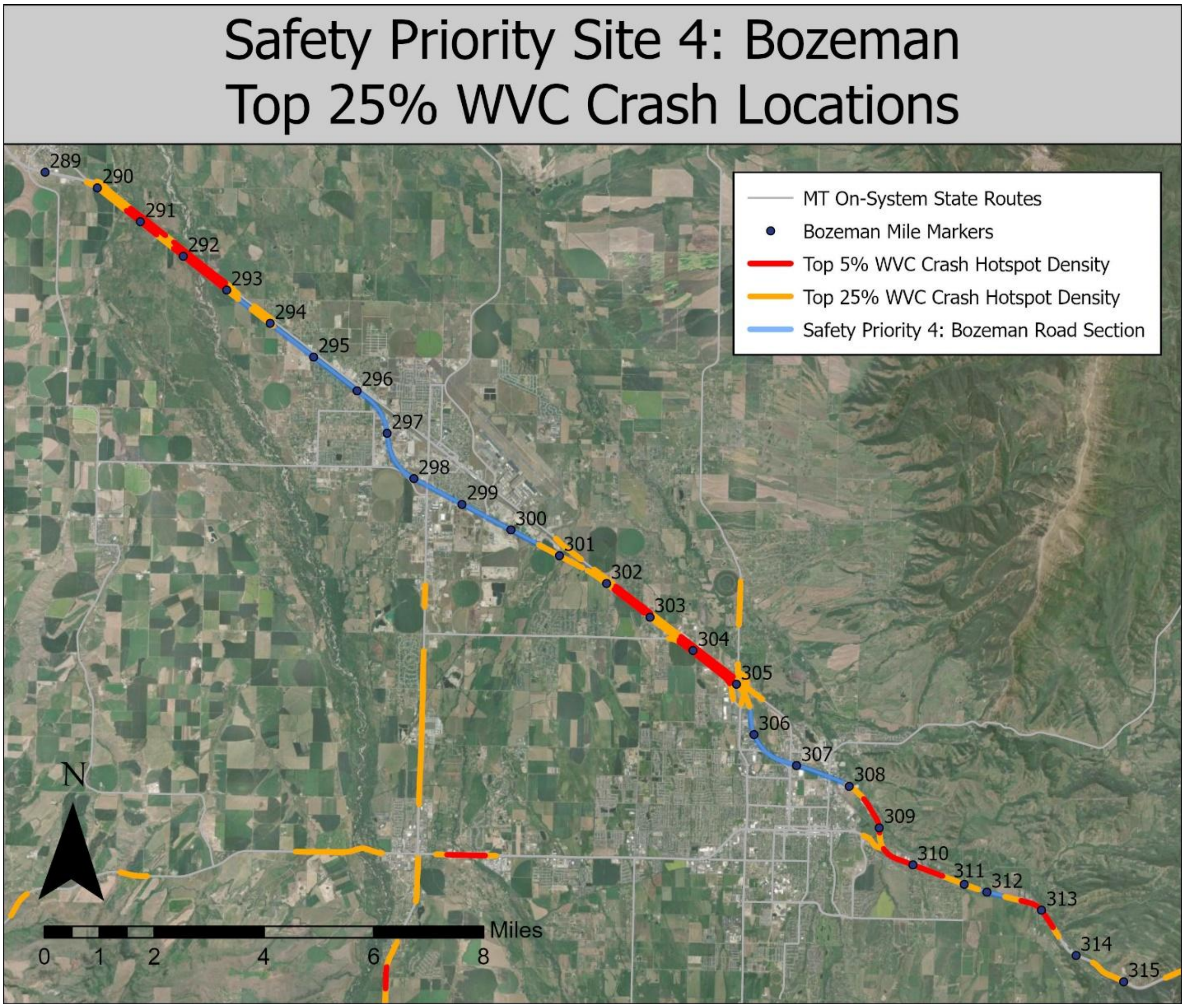


Figure 146: Safety priority site 4 (Bozeman), top 25% crash locations.

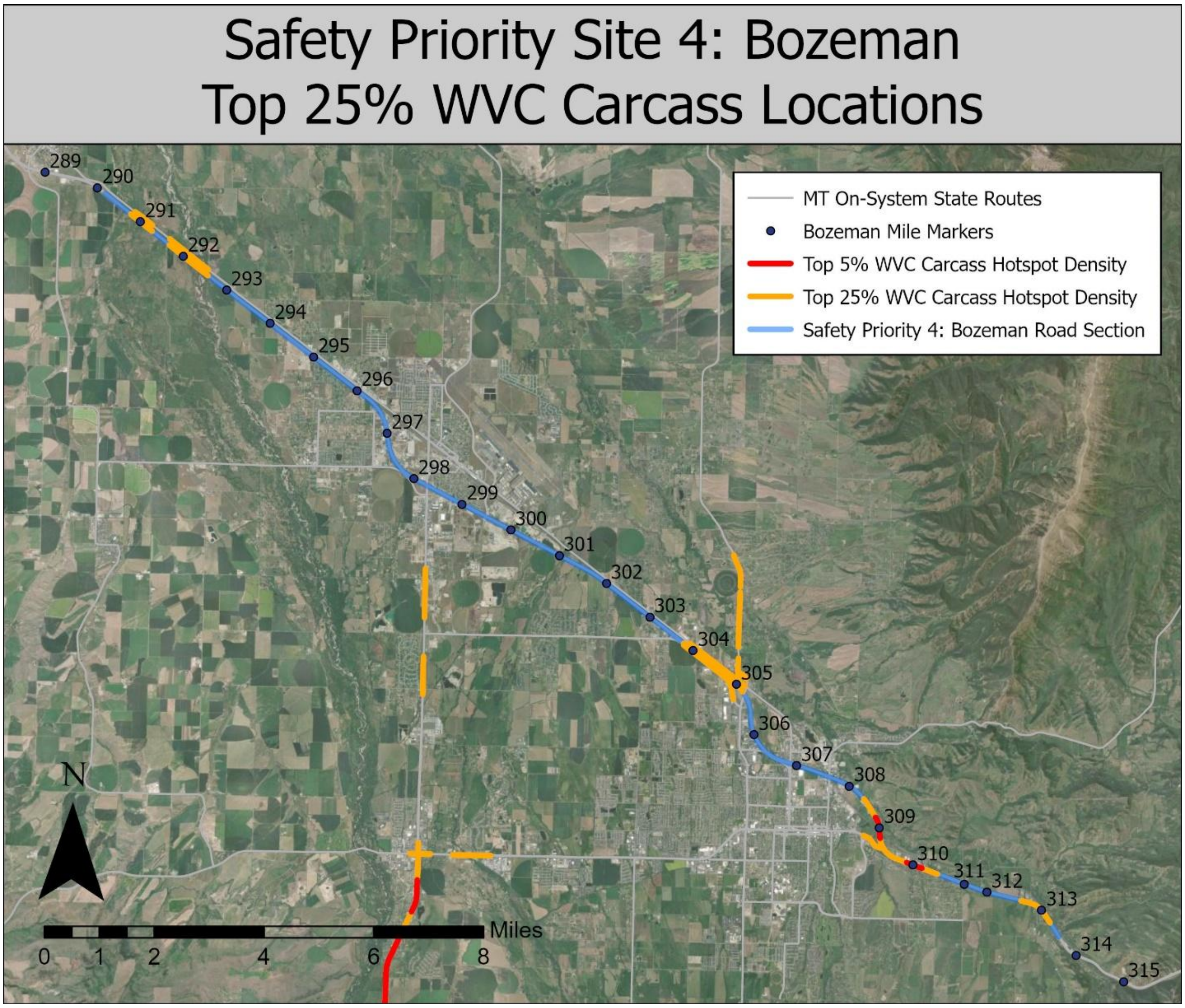


Figure 147: Safety priority site 4 (Bozeman), top 25% carcass locations.

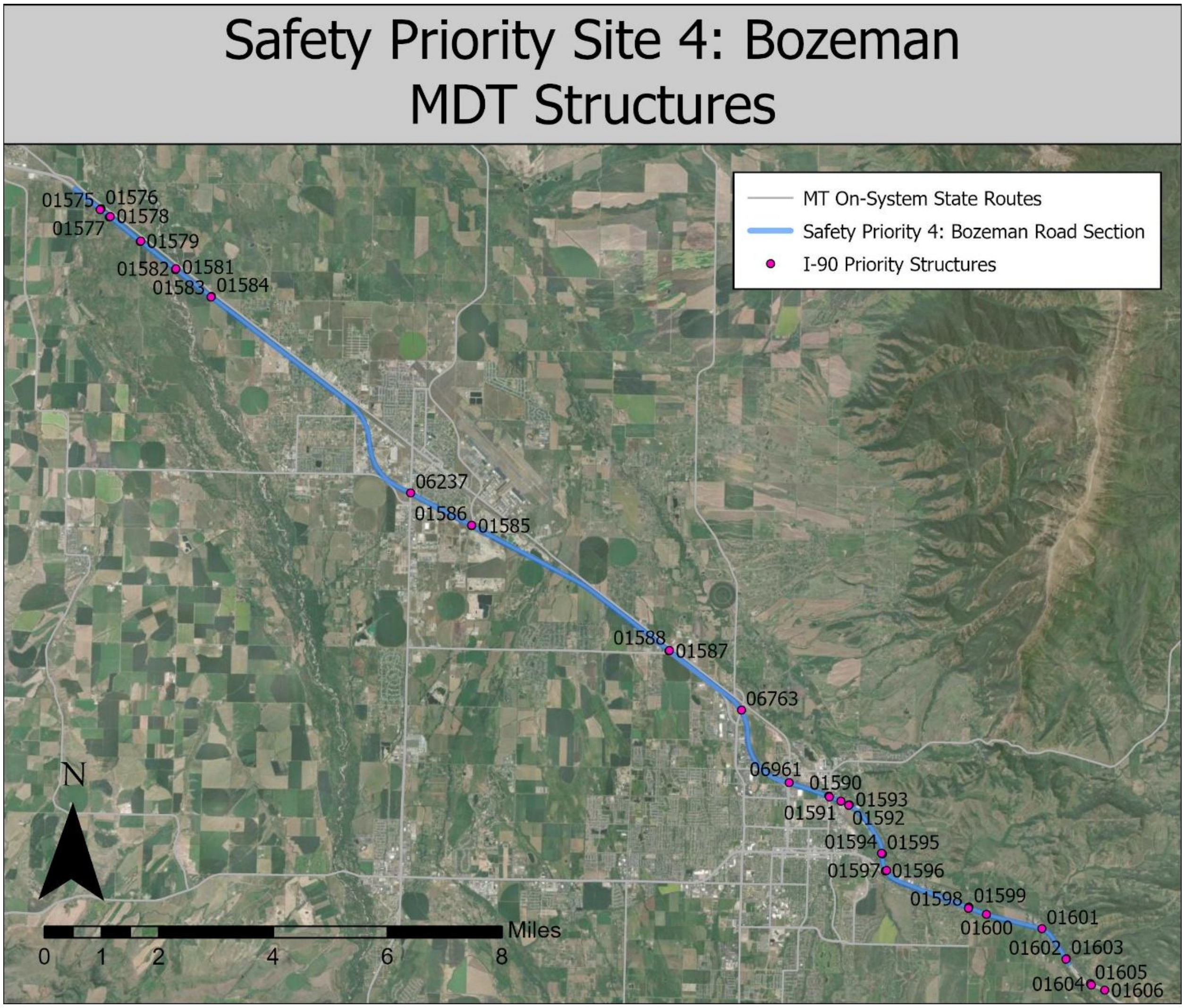


Figure 148: Safety priority site 4 (Bozeman), MDT structures.

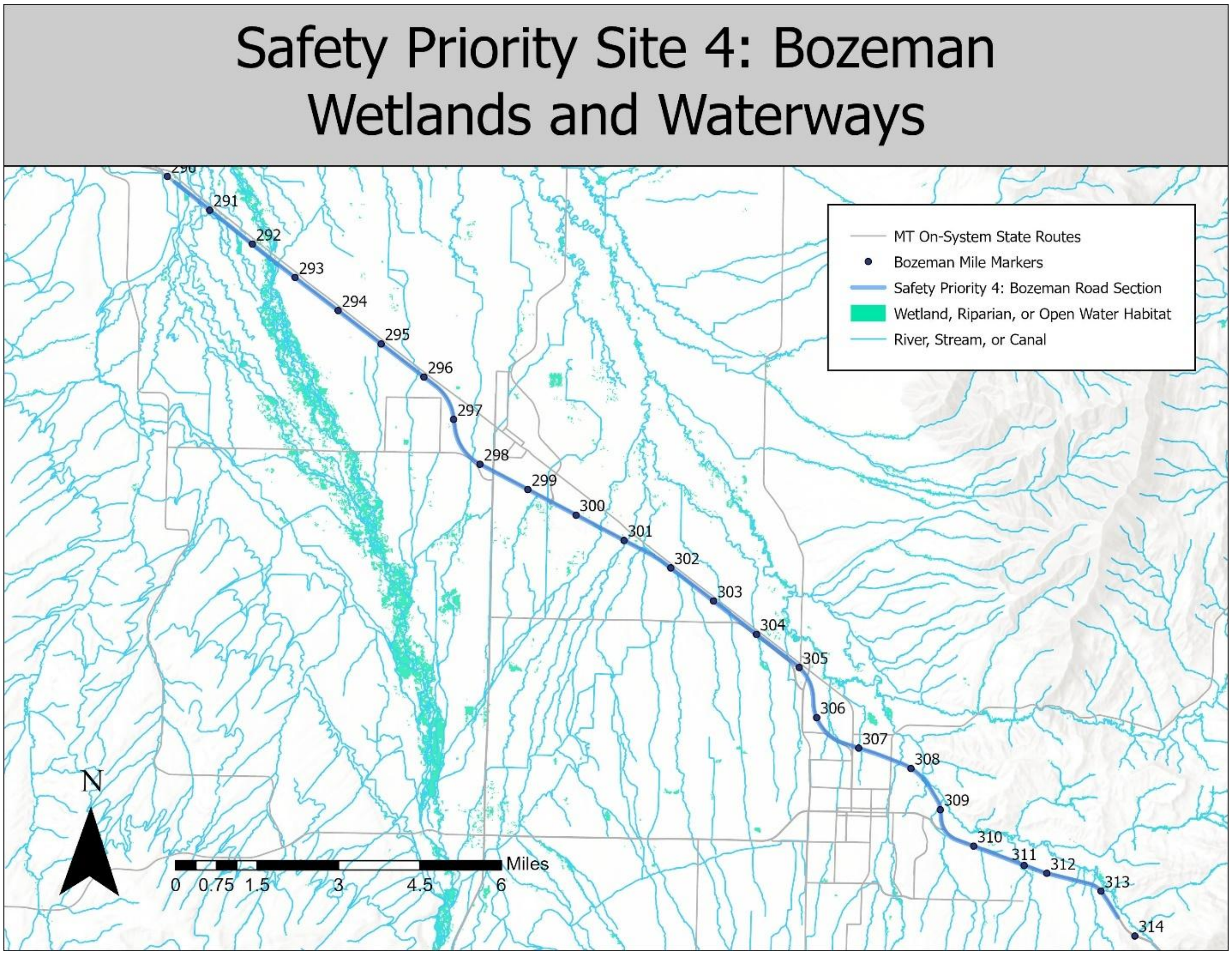


Figure 149: Safety priority site 4 (Bozeman), wetlands and waterways.

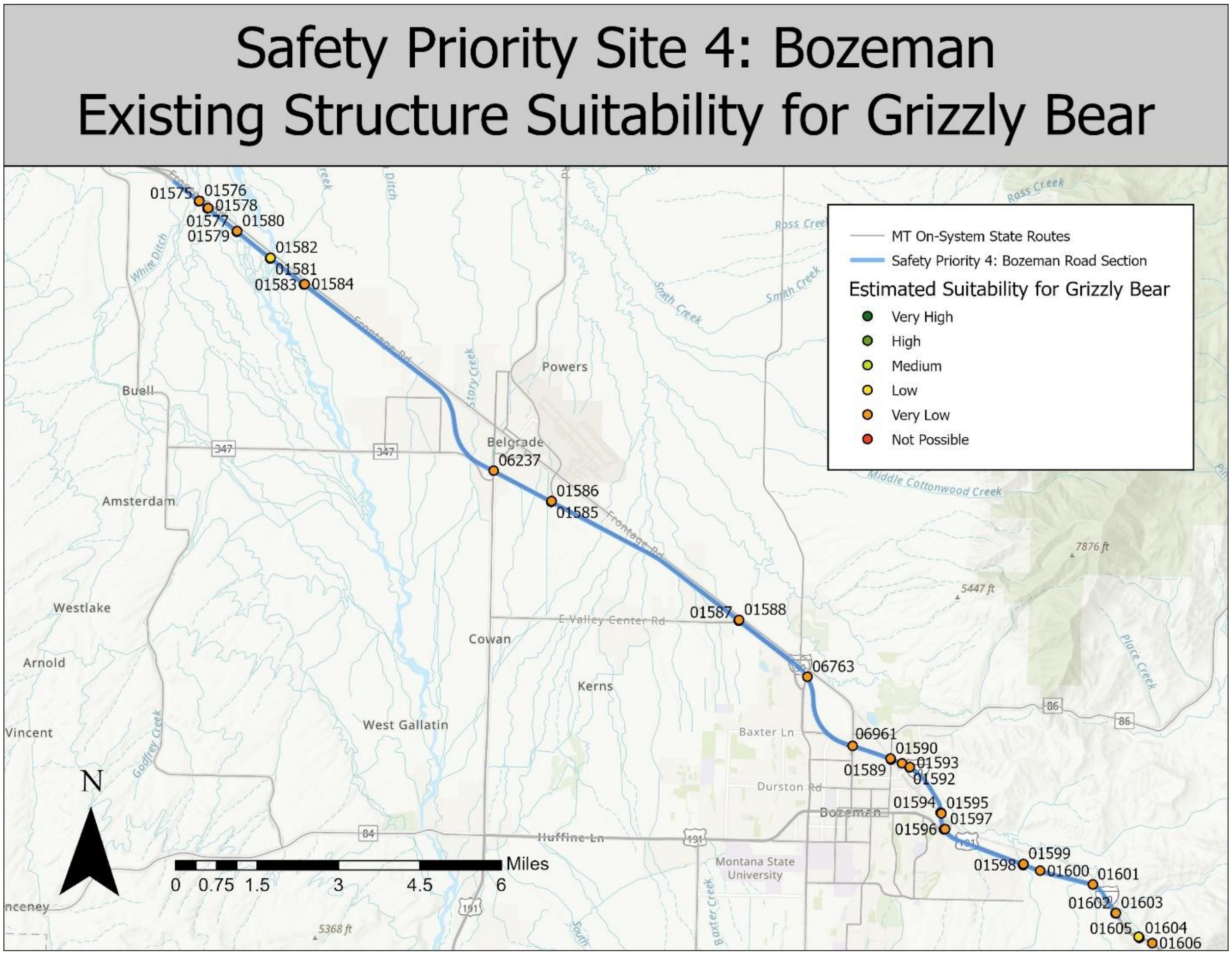


Figure 150: Safety priority site 4 (Bozeman), estimated suitability of existing structures for grizzly bears.

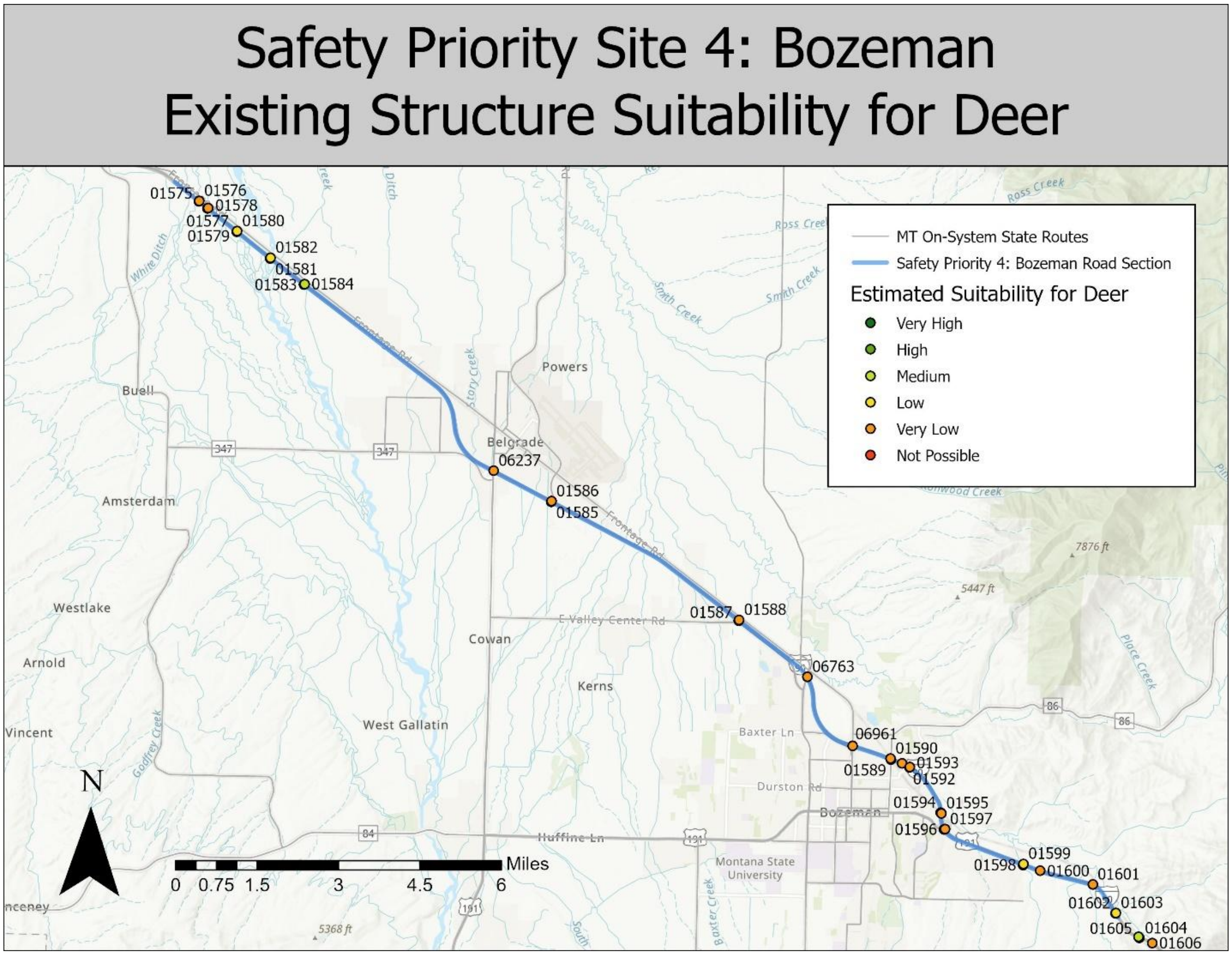


Figure 151: Safety priority site 4 (Bozeman), estimated suitability of existing structures for deer.

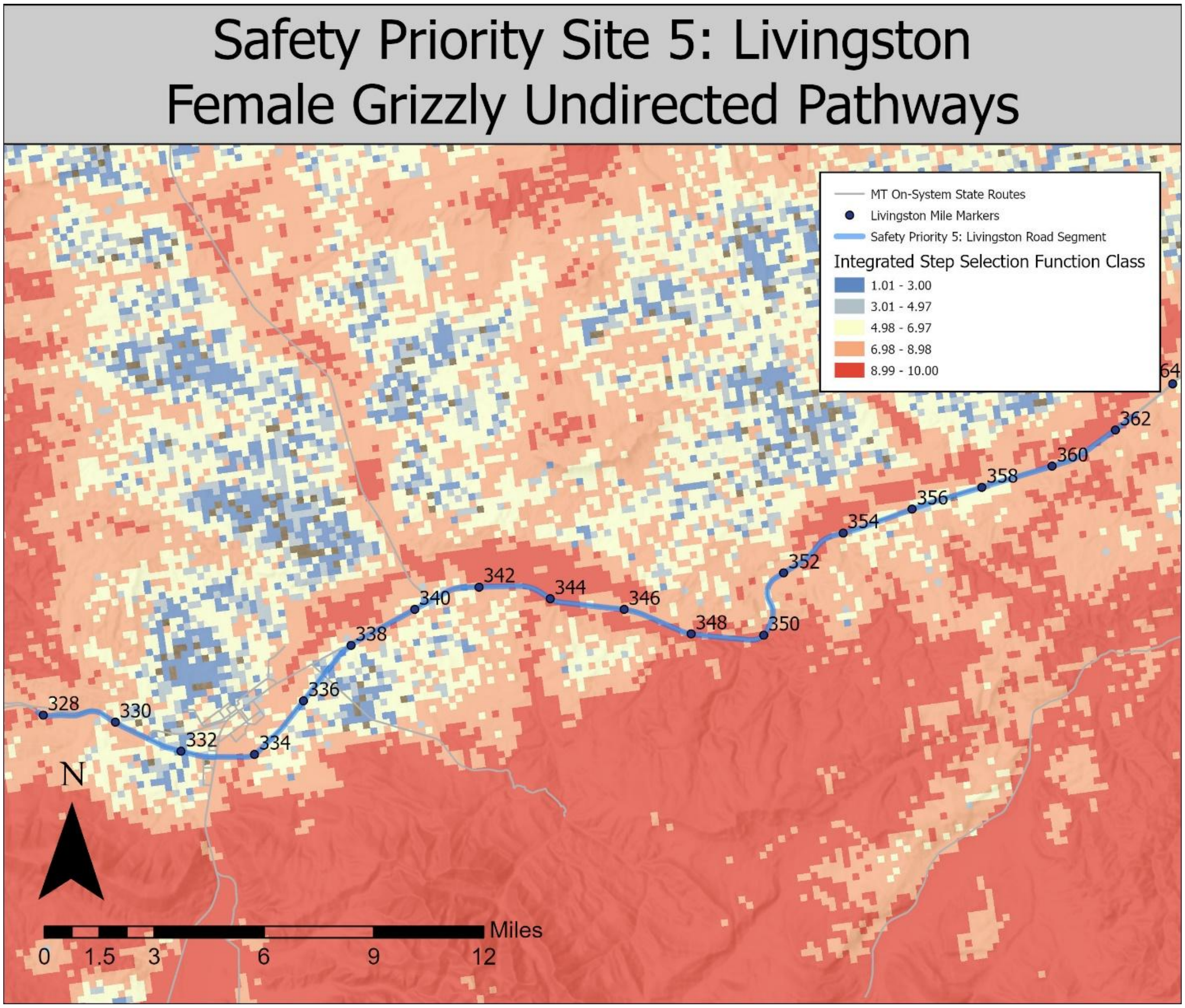


Figure 152: Safety priority site 5 (Livingston), undirected pathways for female grizzly bears.

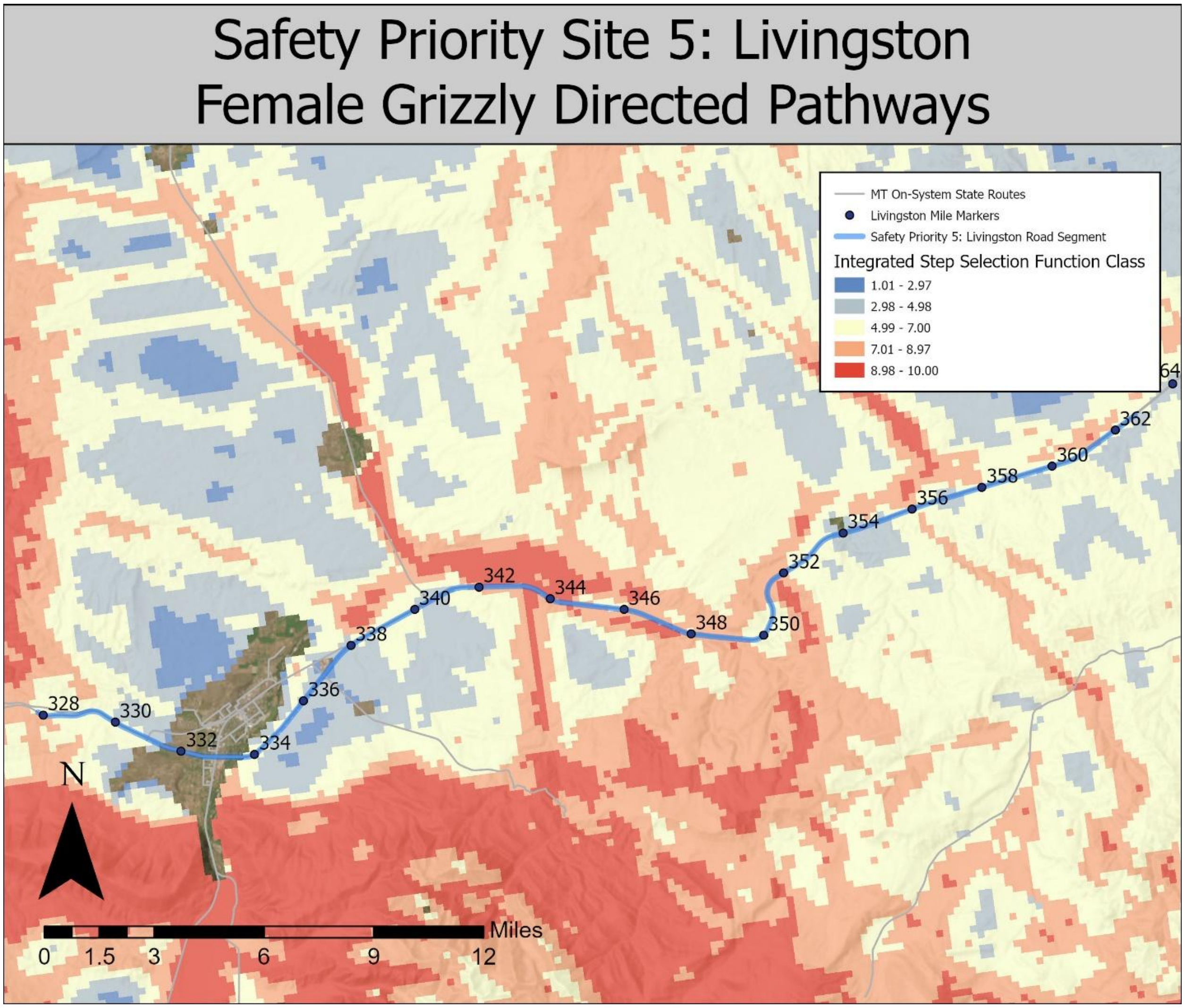


Figure 153: Safety priority site 5 (Livingston), directed pathways for female grizzly bears.

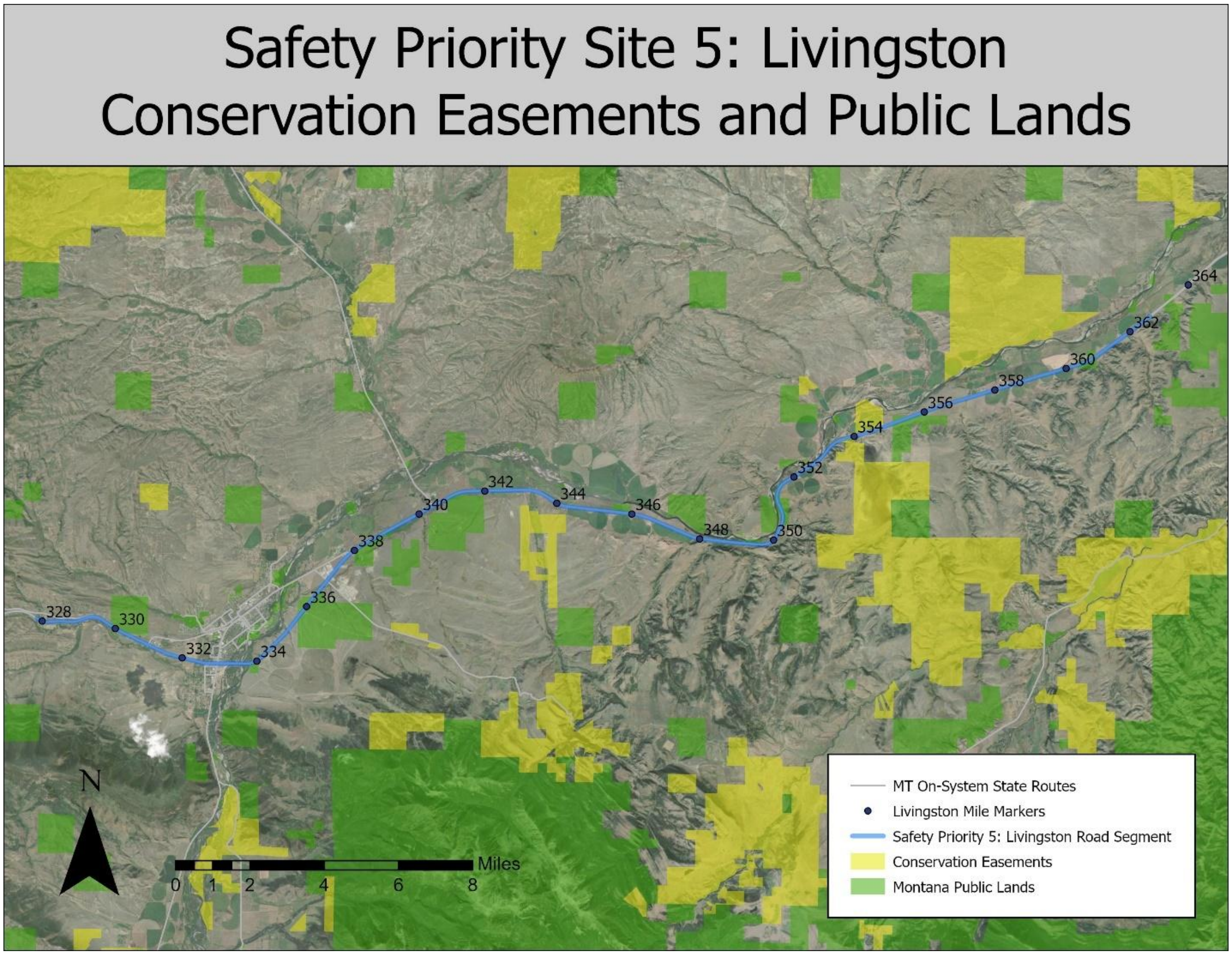


Figure 154: Safety priority site 5 (Livingston), conservation easements and public lands.

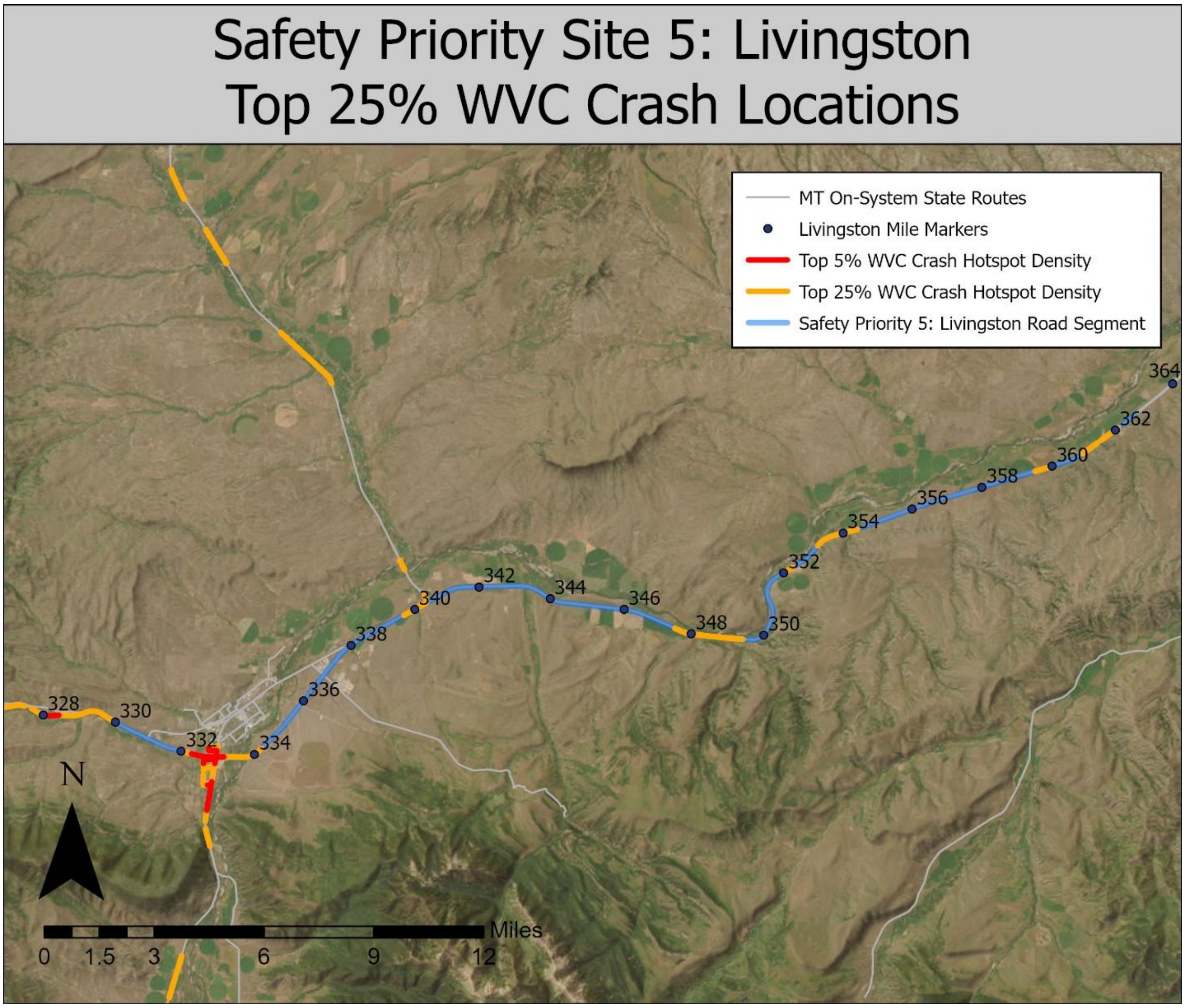


Figure 155: Safety priority site 5 (Livingston), top 25% crash locations.

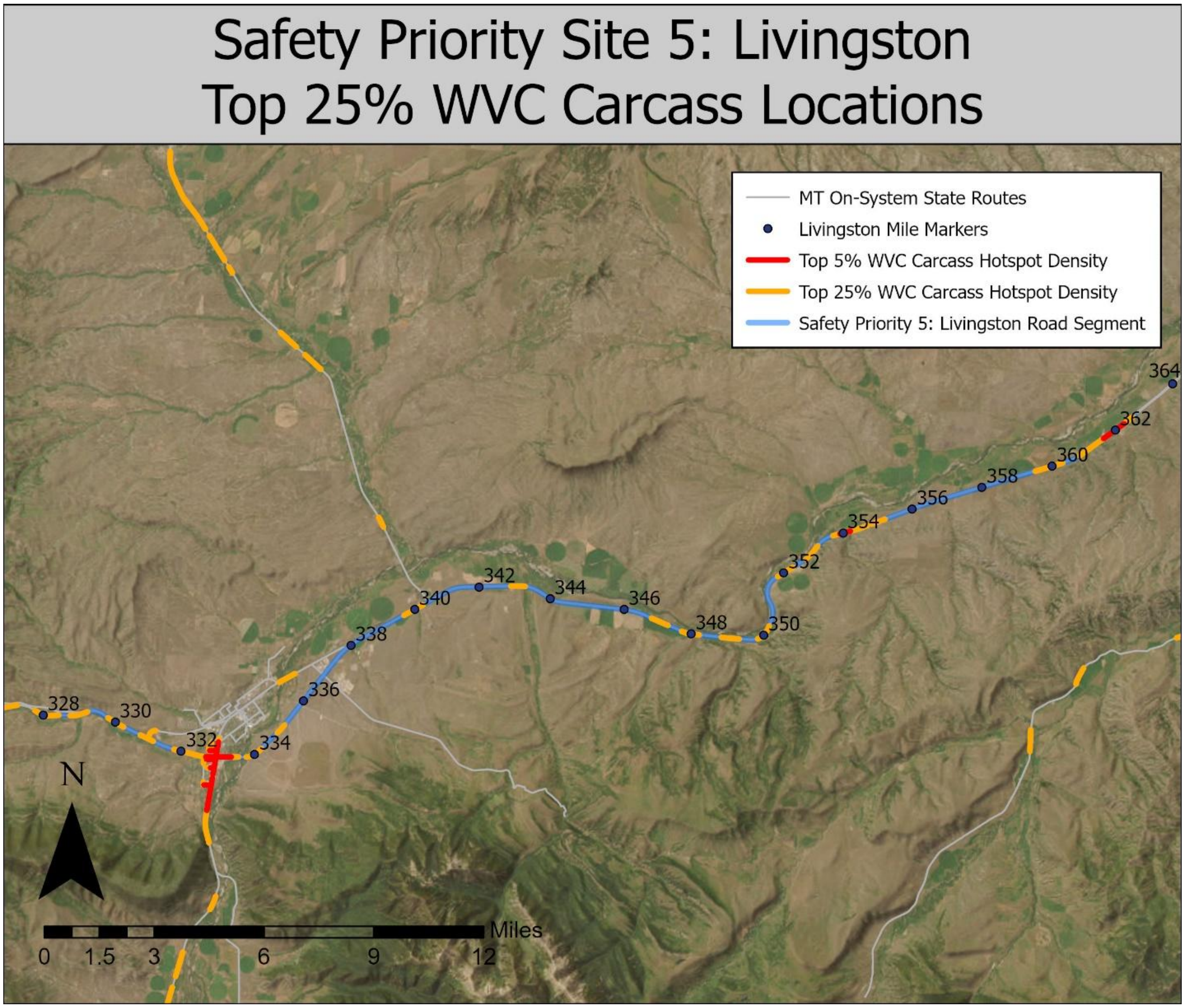


Figure 156: Safety priority site 5 (Livingston), top 25% carcass locations.

Figure 157: Safety priority site 5 (Livingston), MDT structures.

Figure 158: Safety priority site 5 (Livingston), wetlands and waterways.

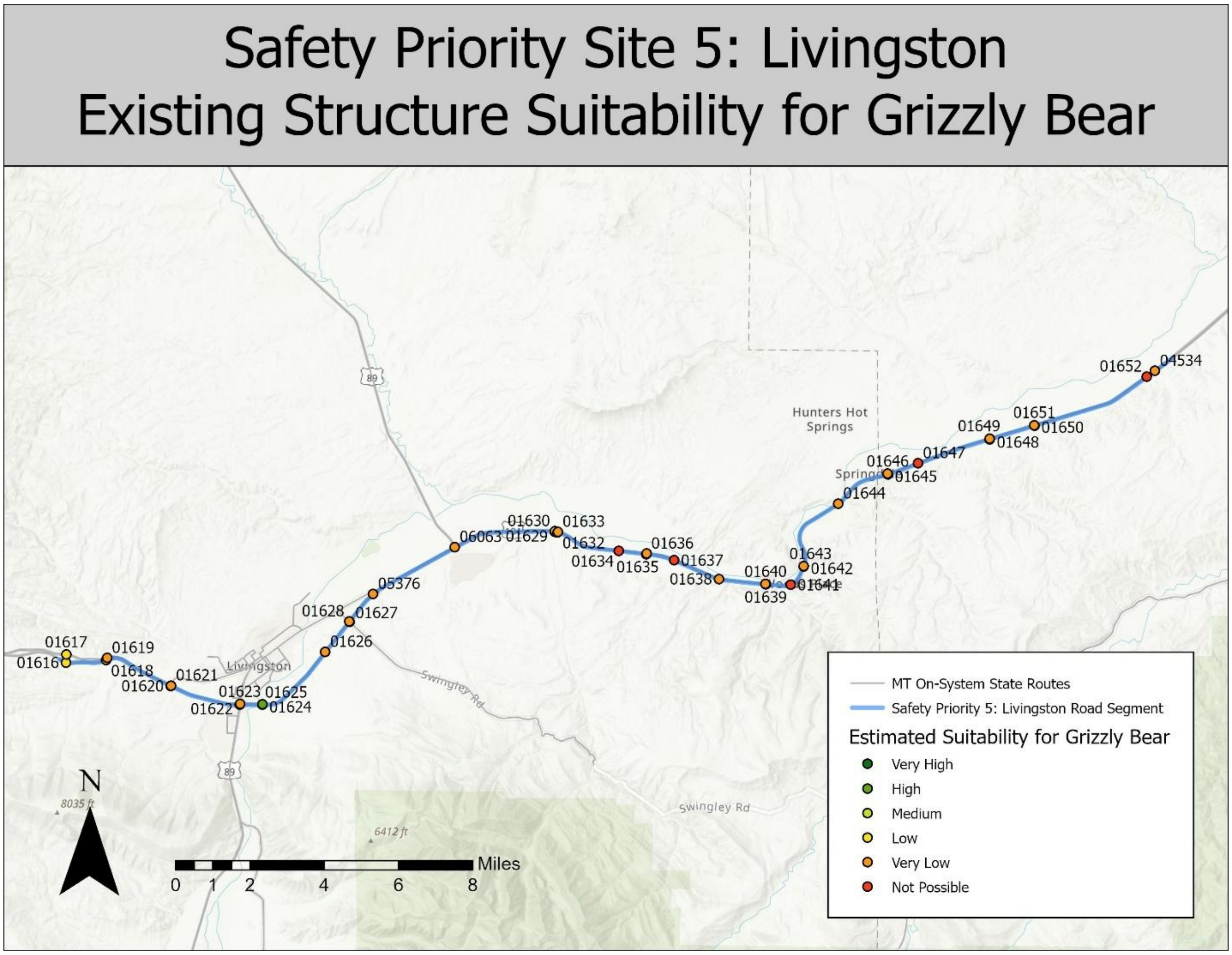


Figure 159: Safety priority site 5 (Livingston), estimated suitability of existing structures for grizzly bears.

Figure 160: Safety priority site 5 (Livingston), estimated suitability of existing structures for deer.