An Assessment of Existing and Potential Future Mitigation Measures Related to Grizzly Bears along US Highway 93, Flathead Indian Reservation, Montana, USA

Prepared by:

Payton J. Adams, BSc
Marcel P. Huijser, PhD
Samantha C. Getty, BSc

Funded by:
United States Fish and Wildlife Service
Tribal Wildlife Grants Program

Published by:
Confederated Salish and Kootenai Tribes

Pablo, Montana

January 2023

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle An assessment of existing and potential future mitigation measures related to grizzly bears along US Highway 93, Flathead Indian Reservation, Montana, USA		5. Report Date January 2023 6. Performing Organization Code
7. Author(s) P.J. Adams, M.P. Huijser & S.C. Getty		8. Performing Organization Report No.
9. Performing Organization Name and Address Confederated Salish and Kootenai Tribes, P.O. Box 278, Pablo, Montana 59855		10. Work Unit No. 11. Contract or Grant No. Contract # 22-153 Grant # F20AS00050
12. Sponsoring Agency Name and Address United States Fish and Wildlife Service Tribal Wildlife Grants Program And the Confederated Salish and Kootenai Tribes		13. Type of Report and Period Covered Final Report January 2021 - January 2023 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

The purpose of this report is to provide recommendations for mitigation measures along US Highway 93 North on the Flathead Indian Reservation. The measures are aimed at: 1. Reducing direct road mortality for grizzly bears, and 2. Allowing for connectivity for grizzly bears between the areas on both sides of the highway. The recommendations are for: 1. The 11.6 mile-long (18.7 km) road section between mile reference post 36.8 and 48.4 (from just south of "Post Creek", north of St. Ignatius until just north of Ronan) which has not been reconstructed yet (as of January 2023), and 2. The other road sections that have already been reconstructed and (partially) mitigated, but where adaptive management may increase the effectiveness of the mitigation measures for grizzly bears. The recommendations are based on a literature review, as well as existing data on roadkilled grizzly bears, the use of existing wildlife crossing structures by grizzly bears, road crossing locations of GPS collared grizzly bears, traffic volume, and economics associated with collisions and mitigation measures.

17. Key Words	18. Distribution Statement
Animals, Barriers, Bears, Carcasses, Collisions, Connectivity, Conservation, Costs, Crashes, Crossings, Crossing Structures, Ecology, Economics, Escape, Exit, Fences, Fencing, Gates, Grizzly bears, Habitat, Infrastructure, Jump-outs, Mammals, Measures, Mitigation, Mortality, Overpasses, Ramps, Safety, Traffic, Transportation, Underpasses, Vehicle, Wildlife	No restrictions. This document is available through the: National Technical Information Service. Springfield, VA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	69	

DISCLAIMER STATEMENT

ACKNOWLEDGEMENTS

The authors would like to thank the United States Fish and Wildlife Service for funding this project. Specifically, the authors would like to thank the following people and organizations who contributed to various aspects of the project, including data collection and data management in the years prior:

- Tiffany Allen (Western Transportation Institute -Montana State University)
- Dale Becker (Confederated Salish & Kootenai Tribes)
- Whisper Camel-Means (Confederated Salish & Kootenai Tribes)
- Cecily Costello (Montana Fish, Wildlife & Parks)
- Stacy Courville (Confederated Salish & Kootenai Tribes)
- Elizabeth Fairbank (Western Transportation Institute -Montana State University)
- Kari Kingery (Confederated Salish & Kootenai Tribes)
- Jeremiah Purdum (Western Transportation Institute -Montana State University)
- Marie Stump (Montana Department of Transportation).

In addition, the authors would like to thank the anonymous respondents to the survey included in this report. The survey was sent to representatives of the Confederated Salish and Kootenai Tribes, the Montana Department of Transportation, the Federal Highway Administration, and the United States Fish and Wildlife Service.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SUMMARY

Based on a literature review, over 86% of all known and probable grizzly bear mortality in the lower 48 states of the United States is human-caused. Vehicle collisions represent just under 10% of all known and probable mortality, and just over 11% of the human-caused mortality. Compared to the other grizzly bear recovery areas, the Northern Continental Divide Ecosystem has the highest direct road mortality; about 14% of all known mortality and about 16% of all known human-caused mortality. In general, grizzly bears are more likely to cross low volume roads than high volume roads. Most highway crossings occur at night when highway traffic volume is lowest. With increasing traffic volume from about 10 vehicles per hour to about 100 vehicles per hour, grizzly bears strongly reduced crossing a highway; at 100 vehicles per hour or more, a highway became an almost complete barrier to grizzly bears. Finally, grizzly bears are more likely to cross a road if the habitat adjacent to the road is of high quality. Highway crossing locations were flatter, closer to cover in open habitat types, and within grassland or deciduous forest vegetation types.

Based on a literature review, for wildlife fences to substantially reduce collisions with wild large mammals, especially deer species, they should be implemented over relatively long distances; at least 5 miles (3 km) of road length or more. For wide roaming species such as grizzly bears, having long road lengths fenced is likely even more important than for species with smaller home ranges such as white-tailed deer. If fence lengths are too short, and if no suitable wildlife crossing structures are provided, there is a severe risk of moving the road crossings and road mortality rather than reducing them. Therefore, it is likely necessary to have very long fenced road sections for grizzly bears; the road length should extend as far as the suitable habitat, plus an additional buffer zone. Gaps in the fence at access roads, driveways, or access points to agricultural fields should be mitigated and maintained to reduce the probability that grizzly bears can enter the fenced road corridor. Wildlife guards or modified cattle guards are not an effective barrier for black bear and other species with paws, including grizzly bear. However, electrified barriers can be a substantial barrier, in some cases even an absolute barrier to bears. Note that all gaps must be mitigated and maintained, as a system that relies on barriers to keep animals off the road is only as good as its weakest component.

Based on a literature review, the only measure that can substantially reduce the barrier effect for wildlife of a heavily traveled highway is to physically separate the animals from traffic through wildlife crossing structures under or over the road (underpasses or overpasses). When combined with wildlife fences, wildlife use of crossing structures is higher than without fences. Crossing structures on their own, without fences, do not reduce direct road mortality. In general, wildlife crossing structures should be located where connectivity for wildlife leads to the greatest conservation benefits, e.g. increased population survival probability by connecting small and isolated populations or allowing for recolonization, maintaining or restoring seasonal migration, and allowing for daily movements of animals that have their home range on both sides of a road. However, crossing structures are more likely to be considered where the adjacent land is likely to remain good wildlife habitat (protected areas, private land with conservation easement), where there is suitable topography (e.g. a road-cut for a wildlife overpass, a road-fill for an underpass), or streams and rivers, or roads that already require a culvert or bridge for hydrological or traffic reasons. However, structures that are built for other reasons (e.g. hydrology) are not necessarily

in the best location for wildlife, nor are they necessarily the right type (e.g. overpass vs. underpass), nor do they necessarily have the dimensions that would make it suitable for the target species. For grizzly bear populations to be connected on either side of a road, overpasses (about 50-70 m wide from the animal's perspective) are the best performing crossing structure type by far, especially for sows with cubs. Open span bridges (at a minimum about 12 m wide and 5.0 m high) are the next best option, but these do not receive nearly as much use by grizzly bears compared to overpasses, especially not by sows with cubs. Nonetheless, such open span bridges still receive measurable use by grizzly bear sows with cubs. Overall, wildlife crossing structures can provide genetic connectivity for both black bears and grizzly bears. In general, the longer a structure has been in place, the higher the use by grizzly bears. In addition, crossing structures with a greater distance from buildings had higher use by grizzly bears. Grizzly bears showed demonstrable preference for wider crossing structures. While grizzly bears increased their use of crossing structures with time across a wide range of structure widths, the rate of increase was about 3 times faster for wider crossing structures. In other words, wider crossing structures more quickly reach their maximum performance in allowing for successful grizzly bear crossings compared to narrower structures.

Between 2010 and 2022 (12 years), there were 19 reported roadkilled grizzly bears along US Highway 93 North on the Flathead Indian Reservation; an average of 1.58 per year (SD = 2.18). This period is after most of the road sections were upgraded and partially mitigated (with the exception of the section through the Ninepipe wetland). The mortalities were all between mile reference post 32 (just south of St. Ignatius) and 46 (just south of Ronan). The highest number of reported grizzly bear road mortalities in a calendar year was 8 individuals in 2018. The roadkilled grizzly bears included adult males and adult females with cubs.

While not all wildlife crossing structures along US Highway 93 North on the Flathead Indian Reservation were monitored with a trail camera in all years, the total number of successful grizzly bear crossings at the wildlife crossing structures was 76 (2009 through 2022). Pistol Creek 1 (west of St. Ignatius), and Post Creek 2 and 3 (north of St. Ignatius) received the highest grizzly bear use. The average number of detected successful crossings by grizzly bears per year was 5.43 (SD=6.33), but there was substantial variation (minimum 0, maximum 21). Note that in some years, at some crossing structures, a single animal is suspected (because the individuals were not marked) to have used a crossing structure regularly during certain periods (e.g. Pistol Creek 1 in 2011, and Post Creek 2 in 2022). Grizzly bears used the crossing structures almost exclusively during the dark hours between 8 pm and 6 am. Almost all crossings by grizzly bears through the wildlife crossing structures were by single individuals (66 animals, 86.8%). There were 10 individuals (13.2%) that crossed as a member of a group. The 10 individuals were distributed over 4 different groups. Two of these groups were, or were suspected, to be an adult female and her cubs of the year. One of the sows and cubs used Pistol Creek 1 and the other used Post Creek 2. The 2 observations or suspected observations of a sow with cubs were 10 years apart; one in 2011, and one in 2021.

There were 178 road crossings by GPS collared grizzly bears (5 males, 12 females) of US Highway 93 North in total between 27 May 2006 and 13 November 2022. Female collared grizzly bears had more recorded crossings than males (females n=158, males n=20), but relatively few males were provided with a collar to begin with. Most of the collared females were accompanied by at least 1 juvenile during a calendar year. The number of times per year a collared bear crossed the highway varied greatly: between 2 and 6 for collared males, and between 1 and 22 for collared females. Many of the bears had a collar in more than one calendar year, and the total number of recorded highway crossing per bear over the years it had a collar varied between 2 and 39. Of the 178 crossings of US Highway 93 North, 94 crossings met the criteria for spatial and time accuracy of the crossing. Collared grizzly bears crossed US Highway 93 North on the Flathead Indian reservation between April and November. The highest number of crossings were recorded in July, August and September. With a few exceptions, most of the highway crossings by GPS Collared grizzly bears occurred between dusk and dawn (between 7 pm and 5 am).

Most of the crossings by the GPS collared grizzly bears were:

- Mile reference post 34-35: Just north of St. Ignatius around the upgraded and partially mitigated road section around the wildlife crossing structures Post Creek 1, Post Creek 2, and Post Creek 3.
- Mile reference post 37-45: The road section that is not upgraded or mitigated yet through the Ninepipe wetland area.
- Mile reference post 50-51: Just south of Pablo around the wildlife crossing structure at Mud Creek.

The highway crossings by collared grizzly bears were strongly associated with creek crossings and their riparian habitat and cover (i.e. near the Post Creek 1, 2, 3 wildlife crossing structures, Post Creek, Crow Creek, and Mud Creek). The road section through the Ninepipe wetland area (between Post Creek until just south of Ronan (mile reference post 37.8-46.0)) has more diffuse highway crossings by grizzly bears. While there was not always a wildlife crossing structure nearby, none of the road crossings by GPS collared grizzly bears was documented by any camera in any crossing structure. While some grizzly bears use the existing wildlife crossing structures, most grizzly bears that cross the highway do so at grade, both in the partially mitigated road sections with wildlife crossing structures and in the currently unmitigated road section through the Ninepipe wetland. This is especially true for sows with cubs.

US Highway 93 North was an almost complete barrier to grizzly bear movements for the majority of the day. Only at night does the highway become partially permeable to grizzly bears. However, there were no hours of the day where traffic volume was below 10 vehicles per hour and where the barrier effect would be considered minimal. Depending on the road section, the month and the chosen threshold (≤10, ≤25, ≤75, and ≤100 vehicles per hour), US Highway 93 North was only somewhat permeable to grizzly bears between 0 and 7 hours out of the 24 hours in a day.

Finally, recommendations for mitigation measures for grizzly bears were formulated for two road sections:

- The road section through the Ninepipe wetland area (not reconstructed or mitigated yet).
- The already reconstructed and partially mitigated road sections.

The recommendations include road lengths that would require fences, dig barriers, and other associated measures, as well as suitable crossing structures for grizzly bears, especially for sows with cubs. In general, if direct road mortality is to be substantially reduced and if connectivity for

grizzly bears is required, mitigation with wildlife fences and very wide crossing structures is needed over long distances.

1 INTRODUCTION

1.1 Background

Between 2004 and 2010, a 56 mile (90 km) long road section of US Highway 93 North between Evaro and Polson on the Flathead Indian Reservation was reconstructed and partially mitigated for wildlife (Huijser et al. 2016a) (Figure 1, Appendix A). The mitigation measures included the installation of wildlife crossing structures at 39 locations and approximately 8.71 miles (14.01 km) of road with wildlife exclusion fences on both sides of the highway (Figures 2 and 3, Appendix B and C). The mitigation measures were aimed at improving safety for the traveling public through reducing wildlife-vehicle collisions while simultaneously allowing wildlife to continue to move across the road (Huijser et al. 2016a). The reconstruction of US Highway 93 North took place at different periods for different road sections (Appendix A).

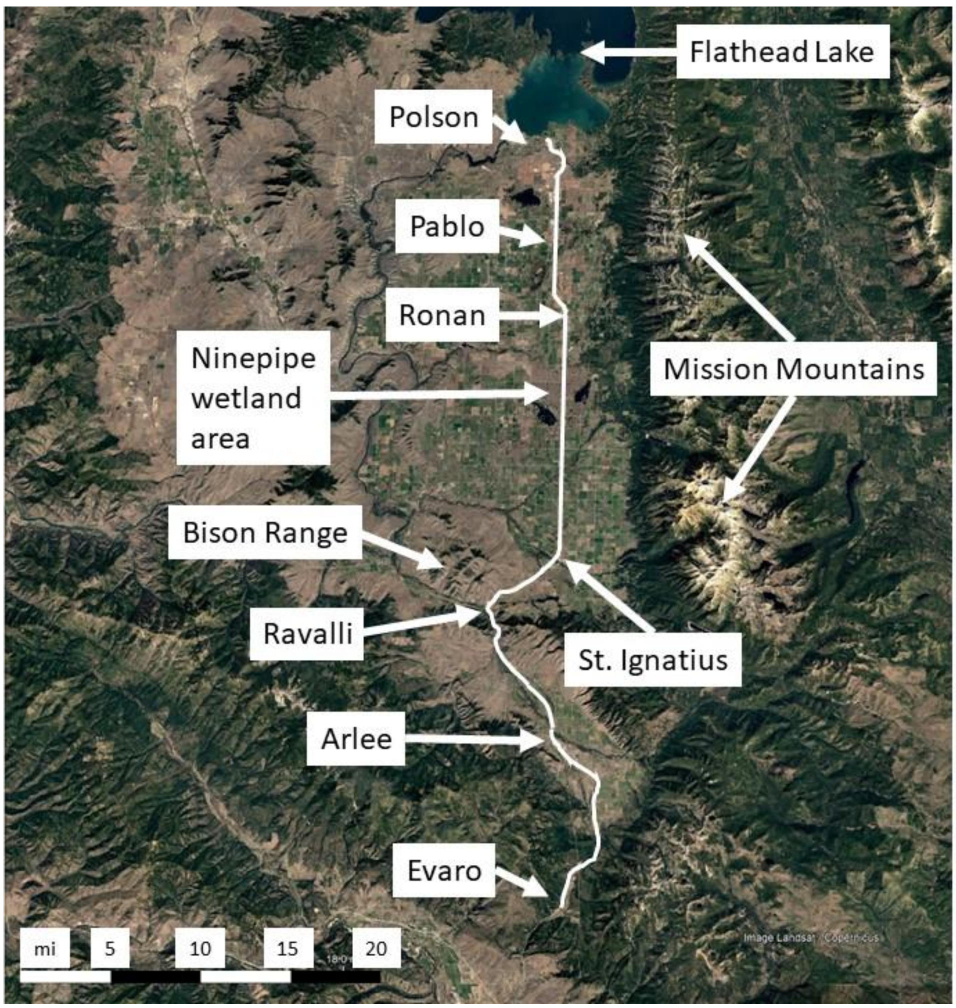


Figure 1: US Highway 93 North between Evaro and Polson on the Flathead Indian Reservation.

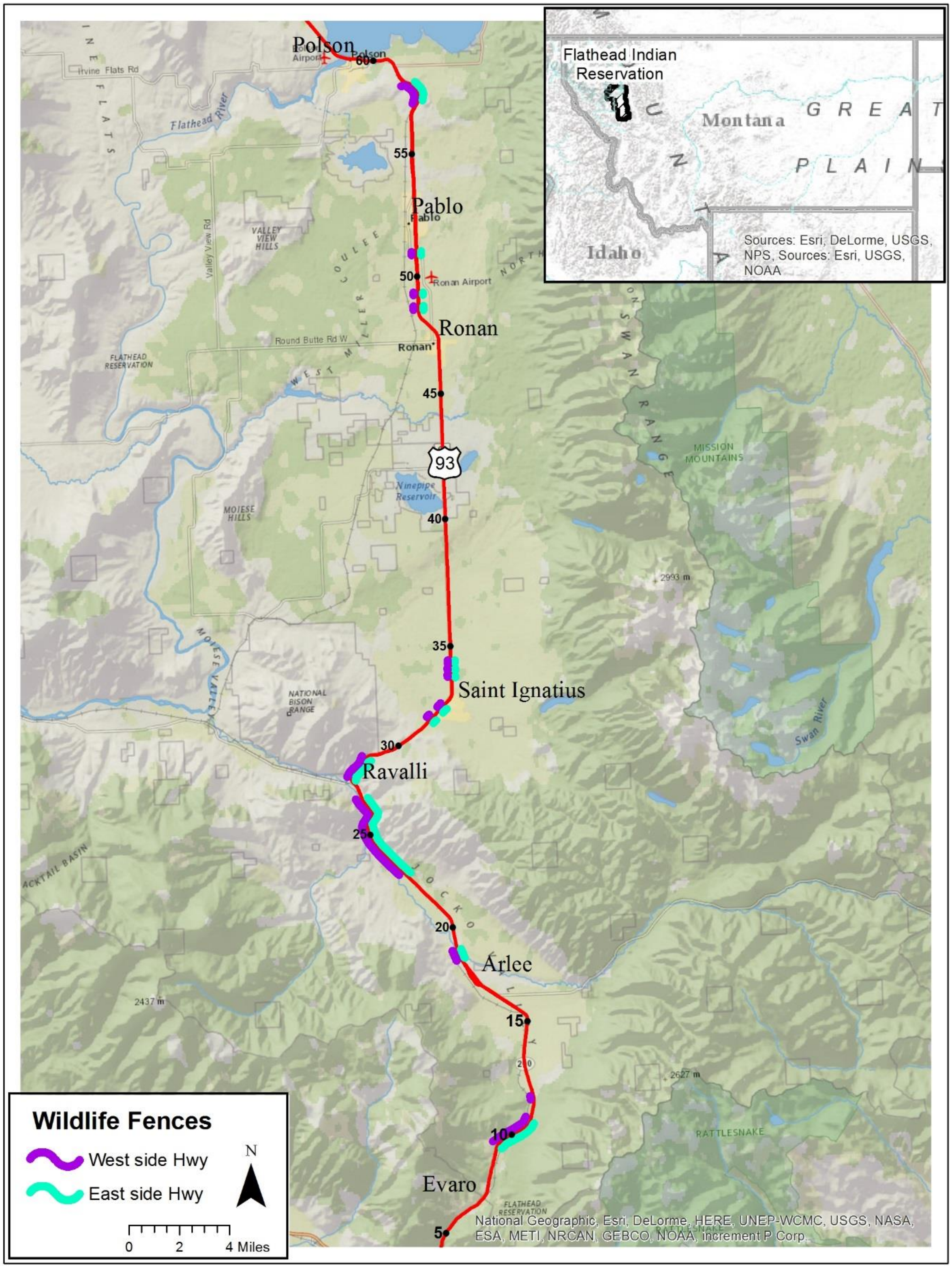


Figure 2: The existing wildlife fences in relation to the mile reference posts (from Huijser et al. 2016a).

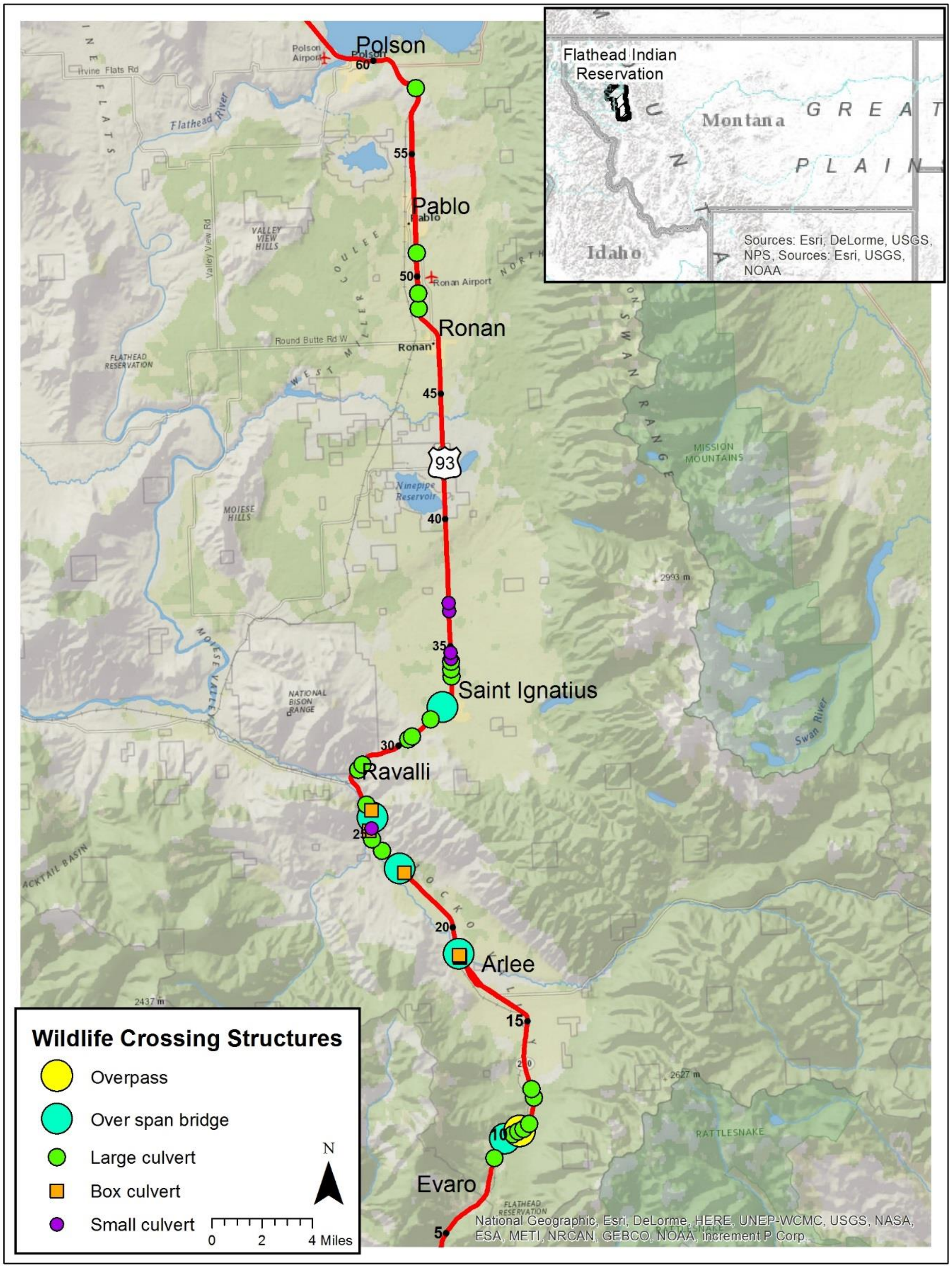


Figure 3: The existing wildlife crossing structures in relation to the mile reference posts (from Huijser et al. 2016a).

1.2 Purpose of this report

The 11.6 mile-long (18.7 km) road section between mile reference post 36.8 and 48.4 (from just south of “Post Creek” (north of St. Ignatius) until north of Ronan) has not been reconstructed yet (as of January 2023) (Figure 4). This road section bisects the Ninepipe wetland area and was subject to a supplemental Environmental Impact Statement (FHWA 2001). This road section does not have wildlife fences nor wildlife crossing structures. However, preparations are underway to also reconstruct this section of the highway.

The purpose of this report is to provide recommendations for mitigation measures along US Highway 93 North on the Flathead Indian Reservation. The measures are aimed at:

1. Reducing direct road mortality for grizzly bears.
2. Allowing for connectivity for grizzly bears between the areas on both sides of the highway.

The recommendations are for:

1. The 11.6 mile-long (18.7 km) road section between mile reference post 36.8 and 48.4 (from just south of “Post Creek”, north of St. Ignatius till north of Ronan) which has not been reconstructed yet (as of January 2023).
2. The other road sections that have already been reconstructed and (partially) mitigated, but where adaptive management may increase the effectiveness of the mitigation measures.

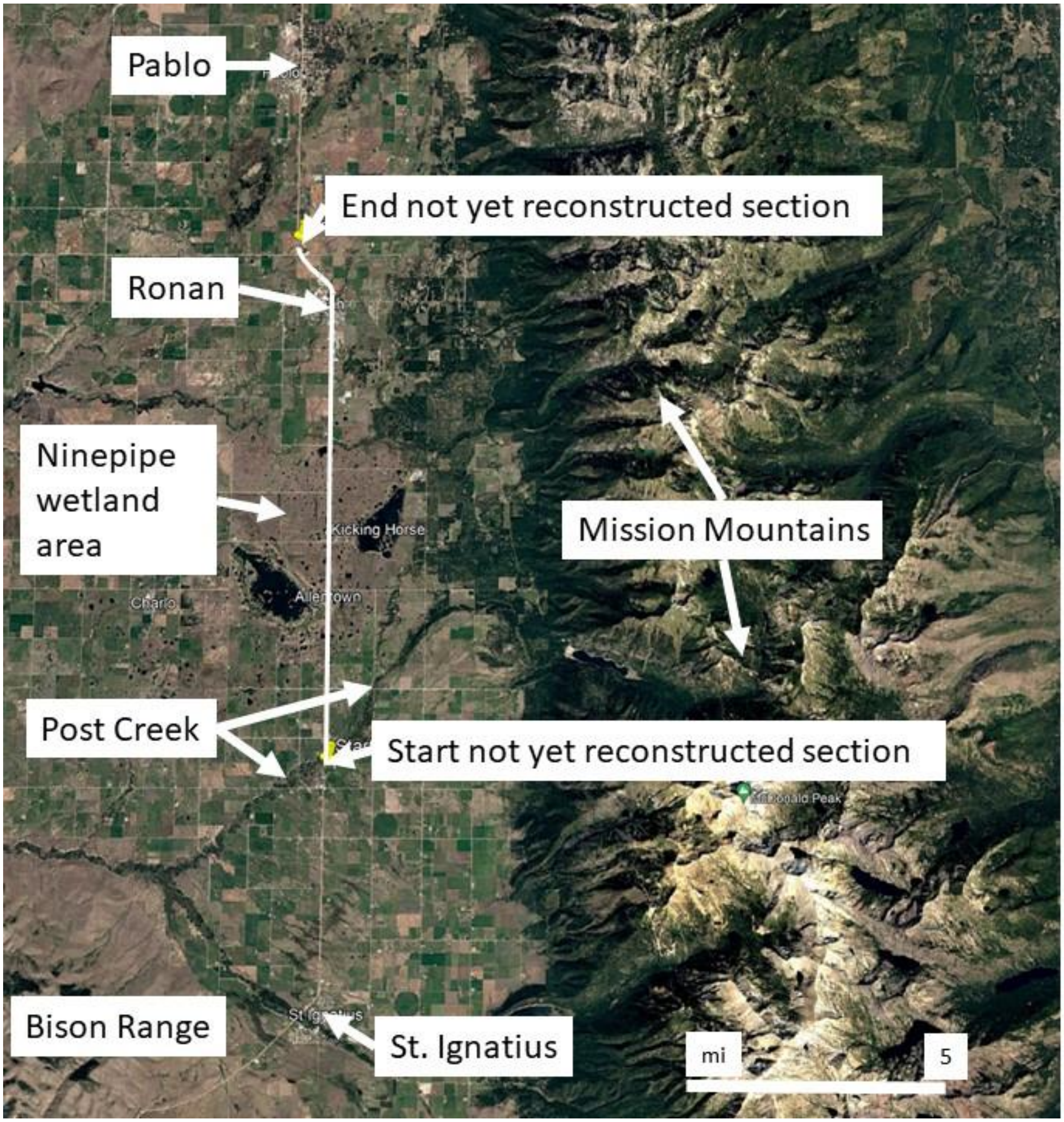


Figure 4: The section of US Highway 93 North through the Ninepipe wetland area that has not been upgraded or reconstructed yet.

2 LITERATURE REVIEW: IMPACTS

2.1 Impacts of roads and traffic on wildlife in general

The impacts of roads and traffic on wildlife are diverse and may include (e.g. Forman et al., 2003; van der Ree et al., 2015) (Figure 5):

- *Habitat loss.* The road surface and roadbed destroy or affect natural vegetation, soil and hydrology. Along high-speed paved roads, the clear zone immediately adjacent to the pavement allows drivers an opportunity to regain control of their vehicle after having left the road surface. The vegetation in the clear zone is mowed and cut frequently as larger trees and shrubs form obstacles that may result in a more serious crash. The road, shoulder and right-of-way management practices lead to habitat loss for most wildlife species.
- *Direct wildlife road mortality.* Collisions with large mammals are not only a threat to human safety. The animals involved typically die as the result of a crash. Small species such as invertebrates, amphibians, reptiles and small mammals are also killed by vehicles, though collisions with small species rarely result in vehicle damage and are generally not a threat to human safety. Moreover, carcasses of small animal species are rarely detected and recorded.
- *Barrier to wildlife movements.* Most animal species do not cross roads as often as they cross natural terrain, and only a portion of their crossing attempts are successful. This leads to smaller and more isolated habitat patches that can affect the population survival probability of a species in an area. Small species that need cover (e.g. invertebrates, amphibians, reptiles, small mammals) and species that are sensitive to human presence and disturbance (regardless of their size) are particularly affected.
- *Decrease in habitat quality in a zone adjacent to the road.* Noise, light, air and water pollution, erosion, and increased access for humans into areas adjacent to roads can affect the habitat quality in a zone adjacent to transportation infrastructure. Depending on the parameter and species concerned, the road effect zone may vary between a few feet up to several miles.
- *Right-of-way habitat and corridor.* The vegetation in the right-of-way, between the edge of the pavement or travel lanes and the right-of way boundary, is subject to severe disturbance (soil, hydrology, pollution, mowing or cutting, grading, seeding of non-native species etc.). Non-native and invasive plant and animal species can spread alongside the infrastructure and can also spread into the surrounding areas. If the transportation corridor is surrounded by natural vegetation with little disturbance, the habitat and the species in the right-of-way, and the spread into the surrounding areas can be considered a conservation problem. On the other hand, if the surrounding landscape is already heavily impacted by humans (e.g. (sub)urban and agricultural areas), then the narrow strip alongside roads and railroads can be a refugium for native species, and, because of the linear nature of transportation infrastructure right-of-ways, may form corridors connecting the remaining habitat patches in the fragmented landscape. However, this corridor can also be a population sink for some species because of the hazards associated with roads and traffic.

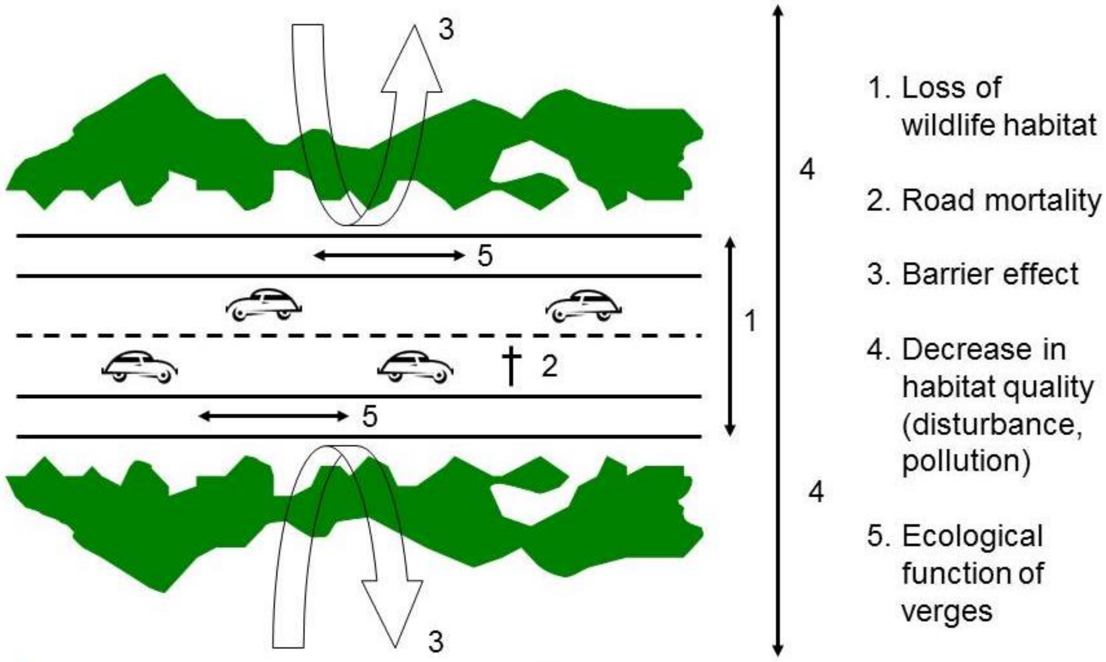


Figure 5: The effects of roads and traffic on wildlife.

2.2 Impacts of roads and traffic on grizzly bears

The sections below focus on grizzly bears and summarize the effects for this species from direct road mortality, the barrier effect, and a decrease in habitat quality in a zone adjacent to roads.

2.2.1 Direct road mortality

In the lower 48 states of the United States, over 86% of all known and probable grizzly bear mortality is human-caused (Table 1) (U.S. Fish and Wildlife Service 2021). Vehicle collisions represent just under 10% of all known and probable mortality, and just over 11% of the known human-caused mortality (Table 1). Compared to the other recovery areas, the Northern Continental Divide Ecosystem has the highest direct road mortality; about 14% of all known mortality and about 16% of all known human-caused mortality (Table 1). In Banff and Yoho National Park in Canada, human-caused mortality was 90.84% (119 out of 131 known mortalities) (Benn & Herrero 2002). Here, highway and railroad mortality combined was 19% of the known human-caused mortality (Benn & Herrero 2002).

Table 1: All known and probable grizzly bear mortalities in and around the 3 regions that are currently occupied by grizzly bears in the lower 48 states between 2002–2019. The numbers include both independent-age bears and dependent young, both inside and outside the demographic monitoring areas (DMA) associated with each recovery area. Source for the mortality numbers: U.S. Fish and Wildlife Service 2021.

	Greater Yellowstone Ecosystem (GYE)	Northern Continental Divide Ecosystem (NCDE)	Cabinet Yaak Ecosystem (CYE) and US portion of the Selkirk Ecosystem (SE)	All 3 areas combined
Total mortality (N)	650	474	55	1179
Human caused mortality (N)	554	421	42	1017
Vehicle collisions (N)	46	66	0-2	112-114
Human caused mortality (% of total mortality)	85.23	88.82	76.36	86.26
Vehicle collisions (% of total mortality)	7.08	13.92	0.00-3.64	9.50-9.67
Vehicle collisions (% of human caused mortality)	8.30	15.68	0.00-4.76	11.01-11.21

Despite the human-caused mortality, including vehicle collisions, the resiliency of the grizzly bear populations in the GYE and NCDE is considered “high” (U.S. Fish and Wildlife Service 2021). The resiliency of the population in the SE and CYE is considered “moderate” and “low” respectively (U.S. Fish and Wildlife Service 2021).

2.2.2 Barrier effect

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). With increasing traffic volume from about 10 vehicles per hour to about 100 vehicles per hour, grizzly bears strongly reduced crossing a highway; at 100 vehicles per hour or more, a highway became an almost complete 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). The same highway (about 1,800 vehicles per day in 2016, MDT 2023b) was found to show evidence of the start of genetic isolation of grizzly bears on both sides of the highway (Kendall et al. 2009). The same highway (about 3,000 vehicles per day in 2016, MDT 2023b) further to the west was found to effectively isolate other grizzly bear populations (Kendall et al. 2016). 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, 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).

2.2.3 Reduced habitat quality

In general, grizzly bears avoid areas adjacent to "medium" and "high volume" roads and areas with high road density, including unpaved roads that are open to vehicles. In one study, grizzly bears avoided areas adjacent to roads with 20-100 vehicles per day and strongly avoided areas adjacent to roads with over 100 vehicles per day (Northrup et al. 2012). In another study, grizzly bears avoided areas adjacent to roads with more than 10 vehicles per day (Mace et al. 1996). In areas where a road was more perceptible, grizzly bears avoided areas adjacent to roads at a greater distance compared to areas where a road was less perceptible (Parsons et al. 2020). This suggests that measures along roads that reduce visual and noise disturbance radiating from a road may result in higher grizzly bear use of areas adjacent to roads. Furthermore, grizzly bears that stayed alive, selected areas further from roads than grizzly bears that died (Schwartz et al. 2010, Parsons et al. 2021). Female grizzly bears had a stronger avoidance of areas adjacent to paved roads than male grizzly bears (Gibeau et al. 2002). When males were close to roads it was typically within high quality habitat with cover, and during the dark hours with the least human activity (Gibeau et al. 2002). The distance over which areas adjacent to a highway are avoided may be up to 500 m (Waller & Servheen 2005). Road densities greater than 0.6 km/km^2 and roads with vehicles negatively affected grizzly bear density (Lamb et al. 2018). High grizzly bear density occurred in large areas with no or few roads (Lamb et al. 2018). Higher grizzly bear abundance in areas with lower road density was also found elsewhere (Graves et al. 2011).

3 LITERATURE REVIEW: MITIGATION MEASURES

3.1 Introduction

The sections below summarize the effectiveness of mitigation measures for grizzly bears. The measures are aimed at:

- Reducing direct road mortality.
- Reducing the barrier effect of roads and traffic.

3.2 Reducing direct road mortality

For major through roads, road removal, permanent-, seasonal- or night-time road closure, are typically not an option. Wildlife culling, relocation, or anti-fertility treatment are also typically undesirable. While animal detection systems can substantially reduce collisions with large wild mammals (range 33-97% reduction), many animal detection system projects suffer from technical, management, political and financial problems. Furthermore, animal detection systems do not reduce the barrier effect of a road and traffic as the animals still need to cross at grade. The most robust and effective measure to reduce wildlife-vehicle collisions with large wild mammals is to construct barriers (fences or walls) that keep the animals from accessing the highway (see review in Huijser et al. 2021). However, because well-designed, -constructed and --maintained wildlife fences are a near absolute barrier for the target species, fences are typically combined with wildlife crossing structures (see next section). When combined with wildlife crossing structures, the fences also guide the animals towards these safe crossing opportunities (Dodd et al. 2007a, Gagnon et al. 2010). Wildlife fences and wildlife crossing structures are almost always implemented together, regardless of whether the primary objective is to reduce wildlife-vehicle collisions or to reduce the barrier effect of roads and traffic for wildlife. However, the identification and prioritization of the road sections that are selected for mitigation very much depend on whether human safety or biological conservation is the departure point (Huijser et al. 2019).

Wildlife fences typically reduce collisions with large wild mammals by over 80% (Huijser et al. 2016b). However, it is essential, that the fences are consistent with the climbing, jumping, and digging capability of the species that one wants to keep off the road. The strength of the animals should also be taken into consideration. Most large mammal fences in North America are primarily designed to keep large ungulates from entering the highway. These fences are typically 8 ft (2.4 m) tall, have wooden posts, and woven wire mesh fence material (Huijser et al. 2022a). While grizzly bears are not likely to climb such a fence, a dig barrier (i.e. an additional fence that is dug into the soil and attached to the main fence) is recommended (Huijser et al. 2022a). If black bears are among the target species too, consider a taller fence (10 ft (305 cm), metal posts, chain-link fence material, a dig barrier, and an overhang (Huijser et al. 2022a).

For wildlife fences to substantially reduce collisions with wild large mammals, they should be implemented over relatively long distances; at least 5 miles (3 km) of road length or more (Huijser et al. 2016b). Because of fence-end effects, shorter fence lengths are less effective in reducing collisions (about 50% reduction on average), and they are extremely variable in their effectiveness (0–94% reduction in collisions) (Huijser et al. 2016b). For wide roaming species such as grizzly bears, having long road lengths fenced is likely more important than for species with smaller home ranges such as white-tailed deer. Therefore, it is likely beneficial to have very long road sections (e.g. dozens of miles or longer) fenced for grizzly bear; the road length should extend as far as the suitable habitat, plus an additional buffer zone (see Huijser et al. 2015). If fence lengths are too short, and if no suitable wildlife crossing structures are provided (see next section), there is a severe risk of moving the road crossings and road mortality rather than reducing them (see e.g. Huijser & Begley 2022). Gaps in the fence at access roads, driveways, or access points to agricultural fields should be mitigated to reduce the probability that grizzly bears can enter the fenced road corridor. Wildlife guards or modified cattle guards are not an effective barrier for black bear and other species with paws, including grizzly bear (Allen et al. 2013). However, electrified barriers can be a substantial barrier, in some cases even an absolute barrier to bears (Huijser et al. 2022b). Note that all gaps in a fence should be mitigated and maintained, as a system that relies on barriers to keep animals off the road is only as good as its weakest component (see e.g. Huijser et al. 2022b).

3.3 Reducing the barrier effect of roads and traffic

Most highways have a high enough traffic volume that they are an absolute or near absolute barrier to grizzly bears. Only if traffic volume is below 100 vehicles per hour, a road becomes, at least in theory, partially permeable to grizzly bears (Waller & Servheen 2005). The only measure that can substantially reduce the barrier effect for wildlife of a heavily traveled highway is to physically separate the animals from traffic through wildlife crossing structures under or over the road (underpasses or overpasses). When combined with wildlife fences, wildlife use of the crossing structures is higher than without fences (Dodd et al. 2007a, Gagnon et al. 2010). Note that crossing structures on their own (i.e. without fences) do not reduce direct road mortality (Rytwinski et al. 2016).

Wildlife crossing structures should be located where connectivity for wildlife leads to the greatest conservation benefits, e.g. increased population survival probability by connecting small and isolated populations or allowing for recolonization, maintaining or restoring seasonal migration, and allowing for daily movements of animals that have their home range on both sides of a road. However, crossing structures are more likely to be considered where the adjacent land is likely to remain good wildlife habitat (protected areas, private land with conservation easement), where there is suitable topography (e.g. a road-cut for a wildlife overpass, a road-fill for an underpass), or streams and rivers, or roads that already require a culvert or bridge for hydrological or traffic reasons. However, structures that are built for other reasons (e.g. hydrology) are not necessarily in the best location for wildlife, nor are they necessarily the right type (e.g. overpass vs. underpass), nor do they necessarily have the dimensions that would make it suitable for the target species.

Wildlife use of crossing structures can be very substantial:

- >15,000 crossings by 16 wildlife species at six underpasses, State Route (SR) 260, Arizona over 7 years (Dodd et al. 2007b).
- >49,000 crossings by mule deer at 7 underpasses, US Highway 30, Wyoming, over 3 years (Sawyer et al. 2012).
- >4,300 desert bighorn sheep at 3 overpasses, Highway 93, Arizona, over 2 years (Arizona Game and Fish Department 2015).
- >150,000 crossings by 11 species of large mammals at over 24 crossing structures, Trans-Canada Highway, Banff National Park, Alberta, Canada (Clevenger & Barrueto 2014).
- >22,000 crossings per year by more than 2 dozen wildlife species at 29 crossing structures, US Highway 93 North, Montana (Huijser et al. 2016a).

Along 3 relatively long fenced road sections of US Highway 93 North on the Flathead Indian Reservation (Evaro, Ravalli Curves, and Ravalli Hill), connectivity for deer (white-tailed deer and mule deer combined) remained similar or increased after highway reconstruction (Huijser et al. 2016a). Black bear highway crossings remained similar after highway reconstruction (Huijser et al. 2016a). Since there was no indication of an increase in deer population size after reconstruction compared to preconstruction, the researchers concluded that the highway reconstruction and the associated mitigation measures did not reduce habitat connectivity for deer. Instead, when the learning curve is considered, habitat connectivity for deer across the highway increased in the mitigated road sections (Huijser et al. 2016a). The researchers did not have data on potential changes in black bear population size before and after highway reconstruction.

For grizzly bear populations to be connected on either side of a road, overpasses (about 50-70 m wide from the animal's perspective) are the best performing crossing structure type by far, especially for sows with cubs (Ford et al. 2017). Open span bridges (at a minimum about 12 m wide and 5.0 m high) are the next best option, but these do not receive nearly as much use by grizzly bears compared to overpasses, especially not by sows with cubs (Ford et al. 2017). Nonetheless, such open span bridges still receive measurable use by grizzly sows and cubs (Ford et al. 2017). Overall, wildlife crossing structures along the Trans-Canada Highway in Banff National Park provided genetic connectivity for both black bears and grizzly bears (Sawaya et al. 2014).

In general, the longer a structure has been in place, the higher the use by grizzly bears (Ford et al. 2022). In addition, crossing structures with a greater distance from buildings had higher use by grizzly bears (Ford et al. 2022). Grizzly bears showed demonstrable preference for wider crossing structures (Ford et al. 2022). While grizzly bears increased their use of crossing structures with time across and range of structure widths, the rate of increase was about 3 times faster for wider crossing structures (Ford et al. 2022). In other words, wider crossing structures more quickly reach their maximum performance in allowing for successful grizzly bear crossings.

4 GRIZZLY BEAR ROAD MORTALITY ALONG US HIGHWAY 93 NORTH

4.1 Grizzly bear road mortality numbers

There were 22 grizzly bear road mortalities reported between 1998 through 2022 along US Highway 93 North on the Flathead Indian reservation (see appendix D for the raw data). Most of the roadkilled grizzly bears were reported from 2010 onwards, after highway reconstruction and partial mitigation was completed (with the exception of the section through the Ninepipe wetland area) (Figure 6). Between 2010 and 2022 (12 years), there were 19 reported roadkilled grizzly bears; an average of 1.58 per year (SD = 2.18). The highest number of reported grizzly bear road mortalities in a calendar year was in 2018; 8 individuals. Grizzly bear road mortality was only reported from May through December (Figure 7). May, July, September, and October had the highest numbers.

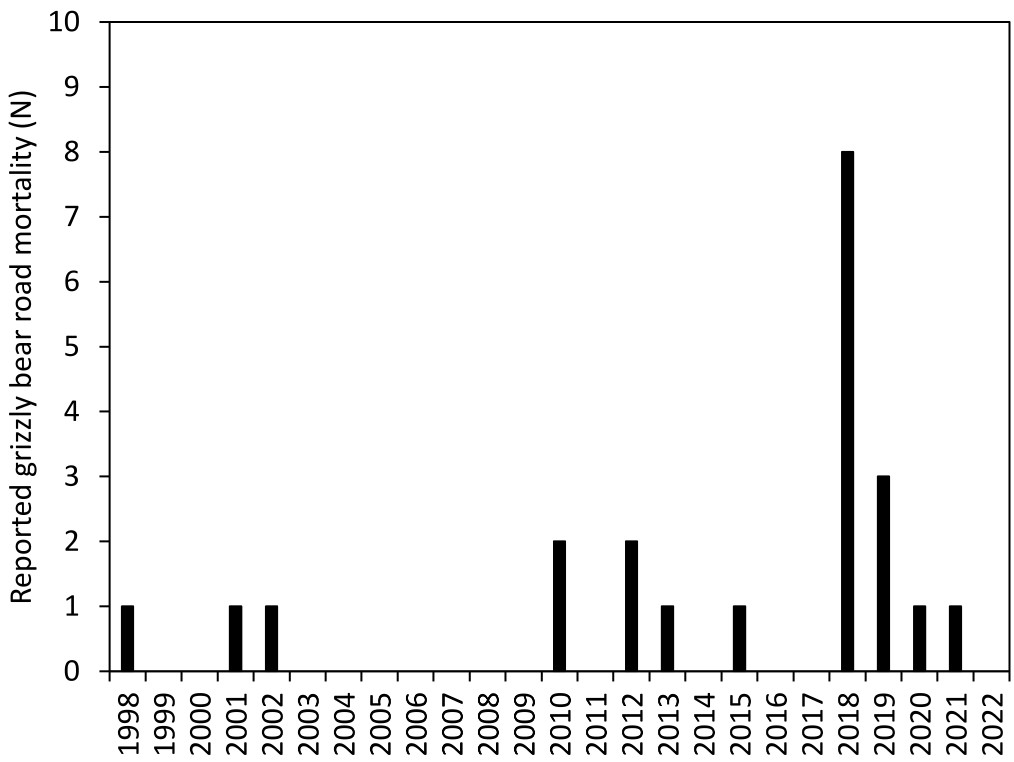


Figure 6: The number of reported roadkilled grizzly bears per year (1998-2022) along US Highway 93 North on the Flathead Indian Reservation.

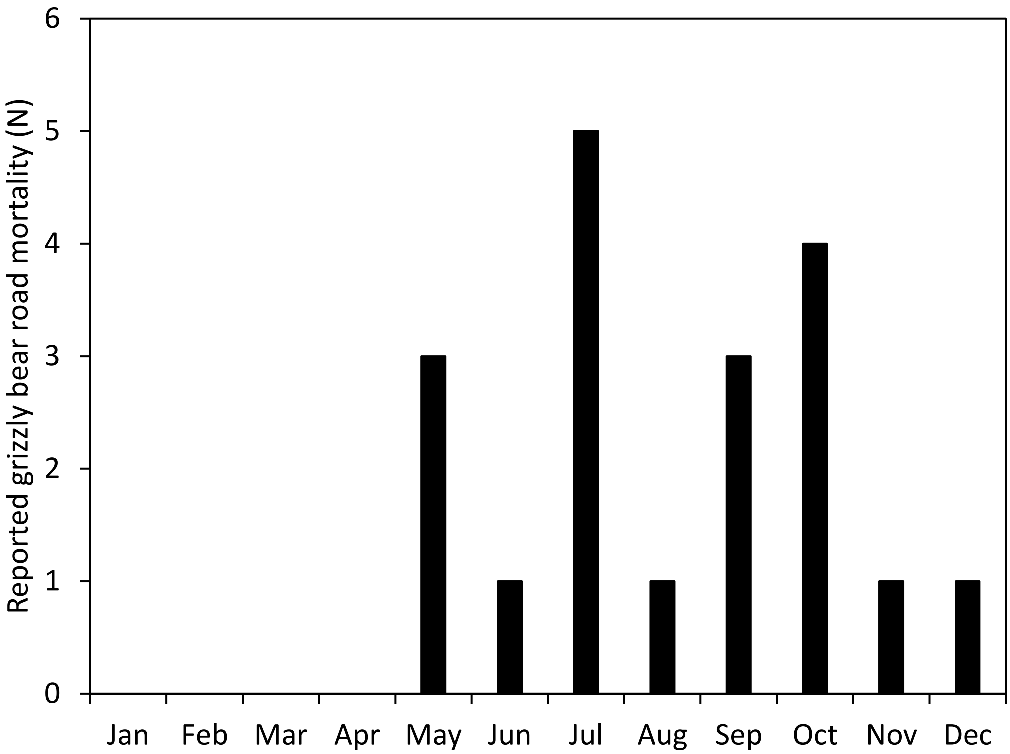


Figure 7: The number of reported roadkilled grizzly bears per month (1998-2022) along US Highway 93 North on the Flathead Indian Reservation. Note that the month was only known for 19 out of the 22 reported grizzly bear mortalities.

4.2 Location, sex and age of roadkilled grizzly bears

The reported grizzly bear road mortalities were located between mile reference post 32 (near Sabine Creek underpass between Ravalli and St. Ignatius) and mile reference post 46 (just south of Ronan, just south of the junction with Little Marten road / Timberlane road) (Figure 8). The reported grizzly bear road mortalities included 9 males, 9 females, and 4 unknown sex (Figure 8). The reported grizzly bear road mortalities included 7 adults, 3 subadults, 7 cubs of the year, and 5 of unknown age (Figure 9). The reported male grizzly bears included 3 adults, 1 subadults, and 5 cubs of the year. The reported female grizzly bears included 4 adults, 2 subadults, 2 cubs of the year, and 1 unknown age.

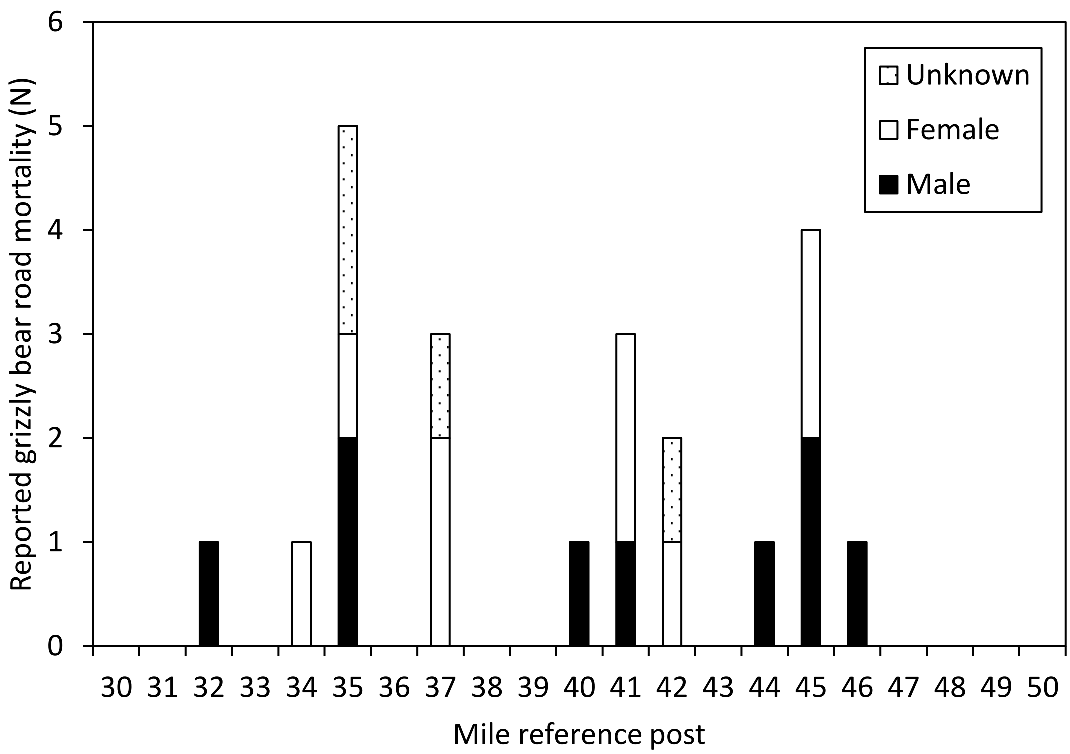


Figure 8: The sex of the reported roadkilled grizzly bears (1998-2022) at the nearest mile reference post along US Highway 93 North on the Flathead Indian Reservation. See Figures 2 and 3 and Appendix B and C for the mile reference posts in relation to the existing wildlife fences and wildlife crossing structures.

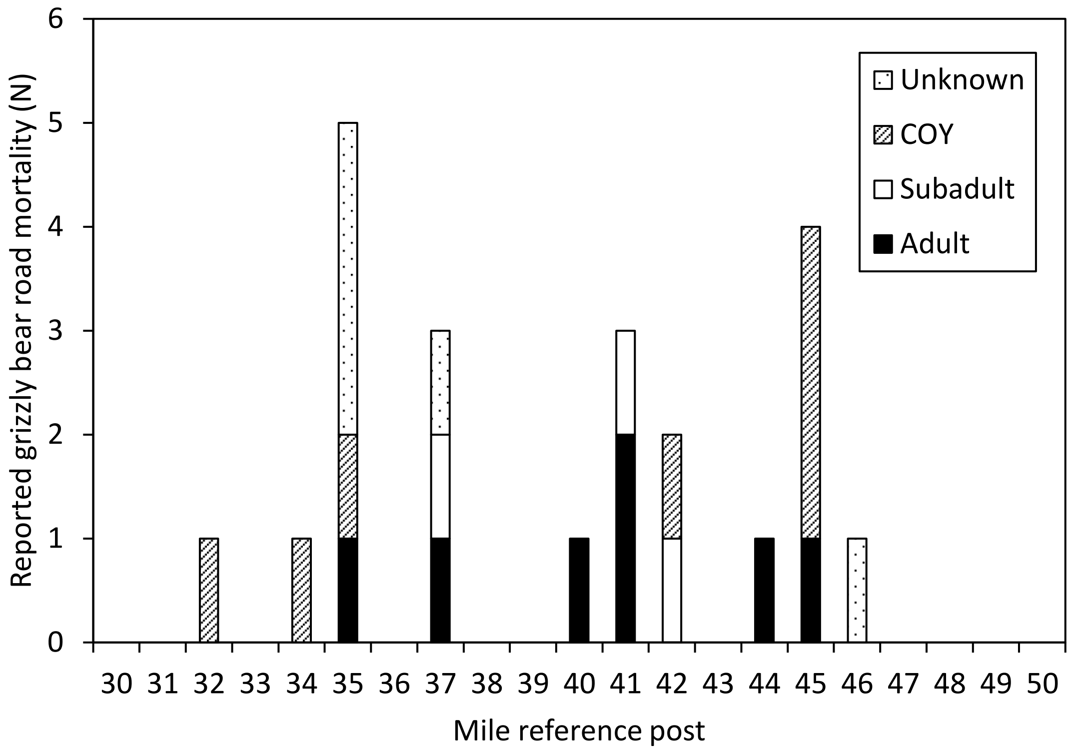


Figure 9: The age of the reported roadkilled grizzly bears (1998-2022) at the nearest mile reference post along US Highway 93 North on the Flathead Indian Reservation. COY = Cub of the year. See Figures 2 and 3 and Appendix B and C for the mile reference posts in relation to the existing wildlife fences and wildlife crossing structures.

5 GRIZZLY BEAR USE OF THE WILDLIFE CROSSING STRUCTURES ALONG US HIGHWAY 93 NORTH ON THE FLATHEAD INDIAN RESERVATION

5.1 Methods for detecting grizzly bear use of the wildlife crossing structures

The majority of the wildlife crossing structures (see Figure 3) were monitored for large mammals for multiple years between 2008 through 2015 (Huijser et al. 2016a). In 2008 and 2009 some crossing structures were monitored with tracking beds inside the structures (Huijser et al. 2016a). From 2010 onwards all monitoring took place with trail cameras (Huijser et al. 2016a). A selection of the crossing structures was monitored from 2016 through 2022. In 2022 a specific effort was undertaken at 11 wildlife crossing structures (Table 2) to detect grizzly bears as they approached the crossing structures. This effort was directed at measuring acceptance and rejection rates of the structures by grizzly bears in the area known to be frequented by grizzly bears. Other structures in this area include smaller culverts that are considered unsuitable for grizzly bears and a bridge (Mission Creek). While grizzly bears may use the bridge across Mission Creek, vandalism and theft of research equipment has occurred here in the past, and the researchers did not install new equipment here for this effort. Note that the monitoring effort was not equal for all crossing structures across all years and that there are limitations to comparing use between different crossing structures.

Table 2: The 11 structures that were monitored to evaluate the behavior (acceptance or rejection) by grizzly bears of the structures (listed from south (top) to north (bottom)).

Name Crossing structure
Ravalli Hill 1
Ravalli Hill 2
Pistol Creek 1
Pistol Creek 2
Sabine Creek
Post Creek 1
Post Creek 2
Post Creek 3
Spring Creek 1
Spring Creek 2
Mud Creek

In 2022, each of the 11 structures listed in Table 2 had 2 trail cameras (one on each side of the structure). These cameras ‘faced out’ and recorded large mammals, including grizzly bears, that came within 2 m (6.6 ft) of the structure entrances. The 2 m (6.6 ft) distance was marked by a post that was visible on the camera images. The animals can either “accept” the structure and pass through, or they can reject the structure and not pass through. Having a camera at both entrances of a structure allowed for the observation of each grizzly bear that approached, regardless of which side of the structure.

5.2 Grizzly bear use of the wildlife crossing structures

Between 2009 through 2022, The total number of successful grizzly bear crossings at the wildlife crossing structures along US Highway 93 North on the Flathead Indian Reservation was 76 (Table 3). Pistol Creek 1 (west of St. Ignatius), and Post Creek 2 and 3 (north of St. Ignatius) received the highest grizzly bear use. The average number of detected successful crossings per year was 5.43 (SD=6.33), but there was substantial variation (minimum 0, maximum 21) (Figure 10). Note that in some years, at some crossing structures, a single animal is suspected (because the individuals were not marked) to have used a crossing structure regularly during certain periods (e.g. Pistol Creek 1 in 2011, and Post Creek 2 in 2022). Also note that not all crossing structures were monitored for the same length of time; the monitoring effort was not the same for all structures and there are limitations to comparing the absolute use between different crossing structures.

Table 3: All detected successful grizzly bear crossings at the wildlife crossing structures (from south to north) along US Highway 93 North on the Flathead Indian Reservation (2009-2022).

Crossing Structure	Mile reference post	N	%
Finley Creek 1	10.04	1	1.32
Overpass	10.34	1	1.32
Ravalli Hill 1	28.11	2	2.63
Ravalli Hill 2	28.38	1	1.32
Pistol Creek 1	30.48	14	18.42
Post Creek 2	34.09	24	31.58
Post Creek 3	34.40	32	42.11
Mud Creek	50.96	1	1.32
Total		76	100.00

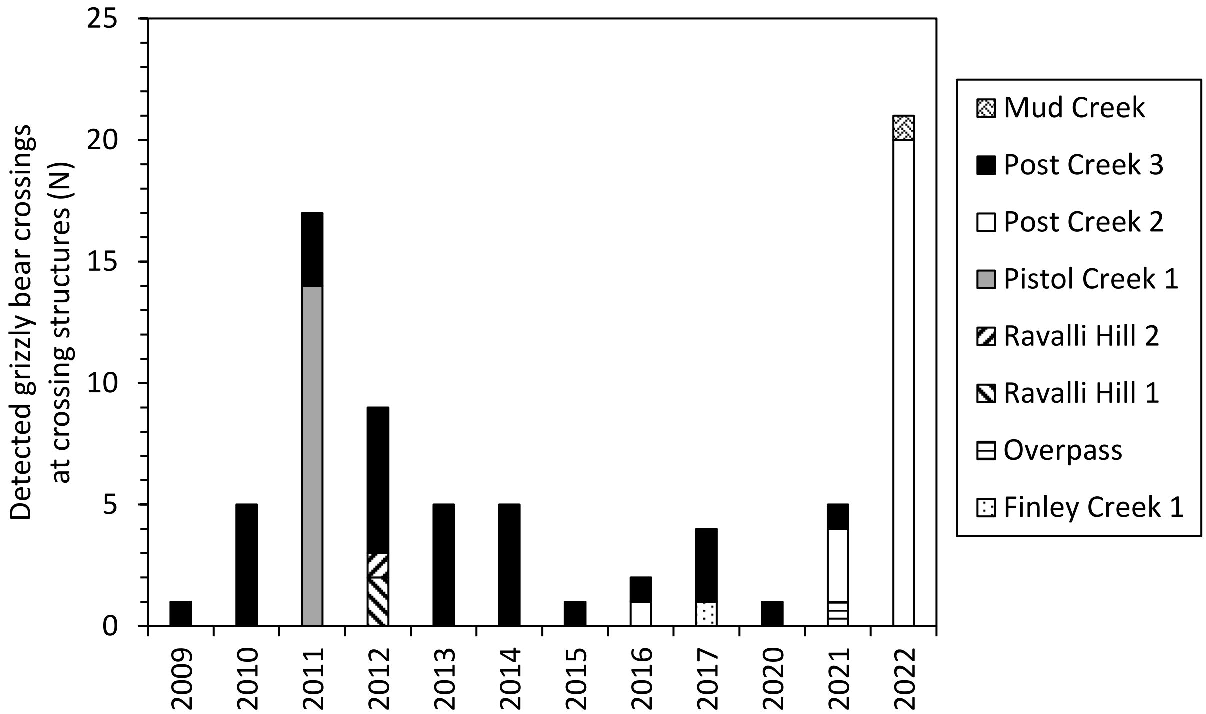


Figure 10: The number of detected successful grizzly bear crossings per year per wildlife crossing structure (from north (Mud Creek) to south (Finley Creek 1) along US Highway 93 North on the Flathead Indian Reservation (2009-2022).

Successful grizzly bear crossings at the crossing structures were detected from May through October, with a peak in July and a smaller peak in September (Figure 11). Grizzly bears used the crossing structures almost exclusively during the dark hours between 8 pm and 6 am (Figure 12).

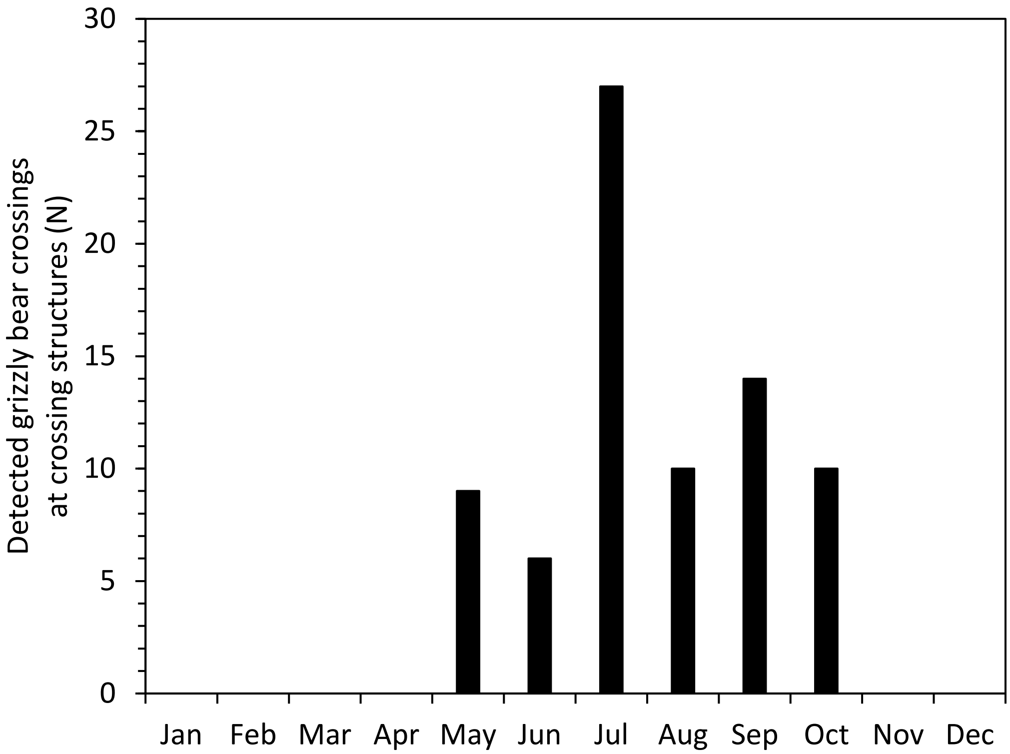


Figure 11: The number of detected successful grizzly bear crossings per month along US Highway 93 North on the Flathead Indian Reservation (2009-2022).

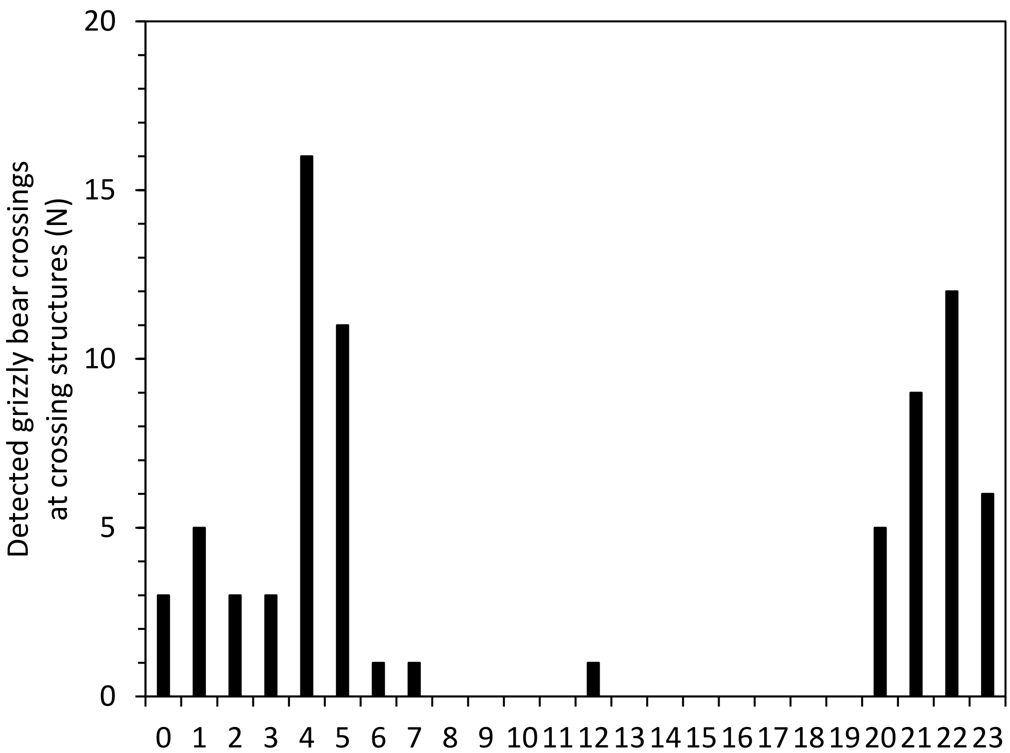


Figure 12: The number of detected successful grizzly bear crossings per hour of day along US Highway 93 North on the Flathead Indian Reservation (2009-2022). Hour 12 = between 12:00 and 13:00 (noon and 1 pm). Note: the time is Mountain Daylight Time (MDT, UTC-06:00).

Almost all crossings by grizzly bears through the wildlife crossing structures were by single individuals (66 animals, 86.8%) (Table 4). There were 10 individuals (13.2%) that crossed as a member of a group (Table 4). The 10 individuals were distributed over 4 different groups. Two of these groups were, or were suspected, to be an adult female and her cubs of the year. One of the sows with cubs used Pistol Creek 1 and the other used Post Creek 2 (Table 4, see Appendix B for dimensions of the structures). The two observations or suspected observations of a sow with cubs were 10 years apart; one in 2011, and one in 2021.

Table 4: All detected successful grizzly bear crossings at the wildlife crossing structures (from south to north) along US Highway 93 North on the Flathead Indian Reservation (2009-2022).

Single or group	Total number of individuals that crossed as single animal or in a group	Group composition	Number of individuals in each group	Crossing structure	Year	Comment
Single	66					2 running, 1 both running and walking, rest walked
Group	10	1 Adult and 2 cubs of the year	3	Pistol Creek 1	2011	Walked
		2 Subadults	2	Post Creek 3	2014	Running
		2 Subadults	2	Post Creek 3	2014	Walked
		3 Cubs of the year	3	Post Creek 2	2021	Running, sow may have run by camera before image was taken

All of the 21 grizzly bears that were detected in 2022 and that approached one of the 11 crossing structures (see methods) proceeded and accepted the structure. Apparently, the structures were all considered suitable by the animals that came within 2 m (6.6 ft) of the entrances. It is possible though that the decision to approach and use a structure was made at a greater distance than 2 m (6.6ft) from the entrance.

6 ROAD CROSSINGS BY GPS COLLARED GRIZZLY BEARS ALONG US HIGHWAY 93 NORTH

6.1 Introduction

The researchers analyzed data from grizzly bears that were equipped with a GPS collar to identify the number, timing, and location of road crossings by these bears along US Highway 93 North. The researchers also compared these data to the images obtained by the cameras in the wildlife crossing structure to investigate whether the road crossings were detected at the wildlife crossing structures or whether they occurred elsewhere at grade.

6.2 Methods

The researchers obtained locations of grizzly bears equipped with GPS collars from Montana Fish, Wildlife & Parks and from the Confederated Salish & Kootenai Tribes (Cecily Costello, Montana Fish, Wildlife & Parks; Payton Adams, Confederated Salish & Kootenai Tribes). The data related to road crossings across US Highway 93 North. Each record contained consecutive two locations for a grizzly bear; one location was on one side of the highway, the other one was on the other side of the highway. When equipping a grizzly bear with a collar, adult females are usually prioritized as they are the greatest conservation concern. Hence there were far more road crossing locations for female grizzly bears than for male grizzly bears.

6.2.1 Number of road crossings

The number of recorded road crossings per calendar year was calculated for each individual GPS collared grizzly bear. This number provides insight into how many bears contributed to the total number of road crossings and how often each individuals crossed US Highway 93 North when they were equipped with a GPS collar.

6.2.2 Location and time of road crossings

A straight line between two consecutive locations of a GPS collared grizzly bear on either side of the highway and its intersection with the highway resulted in an estimated road crossing location. The spatial and time accuracy of the road crossing estimate is higher if the distance between the 2 points on either side of the highway is short and if little time has passed between the 2 locations. Normally, a location is obtained from a collared bear every 3.5 hours (210 minutes) (Personal communication Cecily Costello, Montana Fish, Wildlife & Parks). However, some of the bears have a collar with a “geofence” in areas with relatively many people (Personal communication Cecily Costello, Montana Fish, Wildlife & Parks). If a bear enters such an area, more frequent locations are obtained; every 30 minutes (Personal communication Cecily Costello, Montana Fish, Wildlife & Parks).

For time and spatial analyses, the researchers excluded records that were deemed to have a road crossing location that was "too inaccurate". For a record to be included in spatial analyses for road crossing locations, a record needed to meet the following criteria:

- The distance between the 2 points on either side of the highway needs to be ≤2,000 m (1.24 mile).
- The time passed between when the 2 points on either side of the highway were obtained needs to be ≤250 minutes (4 hours and 10 minutes).

6.2.3 Comparison to crossing structure data

The highway was screened for the presence of crossing structures within 2,000 m of an estimated road crossing location. Thus, this included structures that were up to 2,000 m further north and up to 2,000 m further south than the estimated road crossing location (i.e. 4,000 m (2.49 mile) of road length in total). Road crossings by grizzly bears that occurred before the wildlife crossing structures were completed, were excluded from this analysis. For an underpass to be included in the analyses, it had to be a minimum of 3 m (9.84 ft) wide and 3 m (9.84 ft) high. The date and time of the road crossing based on the GPS data was compared to the images made by the cameras at the crossing structures. It was noted if no camera was present or if the camera was known not to be operational at the time of the crossing. Finally, the researchers looked for a potential matching record of a grizzly bear in any crossing structure that was equipped with a trail camera along US Highway 93 North on the Flathead Indian Reservation.

6.3 Results

6.3.1 Number of road crossings

There were 178 road crossings by GPS collared grizzly bears (5 males, 12 females) of US Highway 93 North in total between 27 May 2006 and 13 November 2022 (Table 5). Female collared grizzly bears had more recorded crossings than males (females n=158, males n=20), but relatively few males were provided with a collar to begin with. Most of the collared females were accompanied by at least 1 juvenile during a calendar year (Table 5). While GPS collared bears that never crossed the highway were not part of the data that were evaluated, the number of times per year a collared bear crossed the highway varied greatly: between 2 and 6 for collared males, and between 1 and 22 for collared females (Table 5). However. Many of the bears had a collar in more than one calendar year, and the total number of recorded highway crossing per bear over the years it had a collar varied between 2 and 39 (Table 5).

Table 5: The number of recorded crossings by individual GPS collared grizzly bears of US Highway 93 North per year on the Flathead Indian Reservation.

Name of bear	Total crossings (N)	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Males																		
Baptiste	4												4					
Cooney	4						4											
Duck	6									6								
FIR_18/19	2			2														
Walking Bear	4													4				
Subtotal	*20*	*0*	*0*	*2*	*0*	*0*	*4*	*0*	*0*	*6*	*0*	*0*	*4*	*4*	*0*	*0*	*0*	*0*
Females																		
Allison	39											10	22	7				
Cooley	11														4			7
Effie	31										16	10		5				
Ethyl	3								2	1								
FIR_13/14	2	2																
Kiki	2														2			
Macy	16													16				
Millie	2		2															
Piper	6													6				
Post Creek	8						2			4	2							
Rummy	2																	2
Tami	36											6	8	5	8	9		
Subtotal	*158*	*2*	*2*	*0*			*2*		*2*	*5*	*18*	*26*	*30*	*39*	*14*	*9*		*9*
Total	*178*	*2*	*2*	*2*			*6*		*2*	*11*	*18*	*26*	*34*	*43*	*14*	*9*	*0*	*9*

Highest number of juveniles observed with a female in a given year

	Unkn.
	0
	1
	2
	3

6.3.2 Location and time of road crossings

Of the 178 crossings of US Highway 93 North on the Flathead Indian Reservation by GPS collared grizzly bears, 94 crossings met the criteria for spatial and time accuracy of the crossing. Collared grizzly bears crossed US Highway 93 North on the Flathead Indian reservation between April and November (Figure 13). The highest number of crossings were recorded in July, August and September. With a few exceptions, most of the highway crossings occurred between dusk and dawn (between 7 pm and 5 am) (Figure 14).

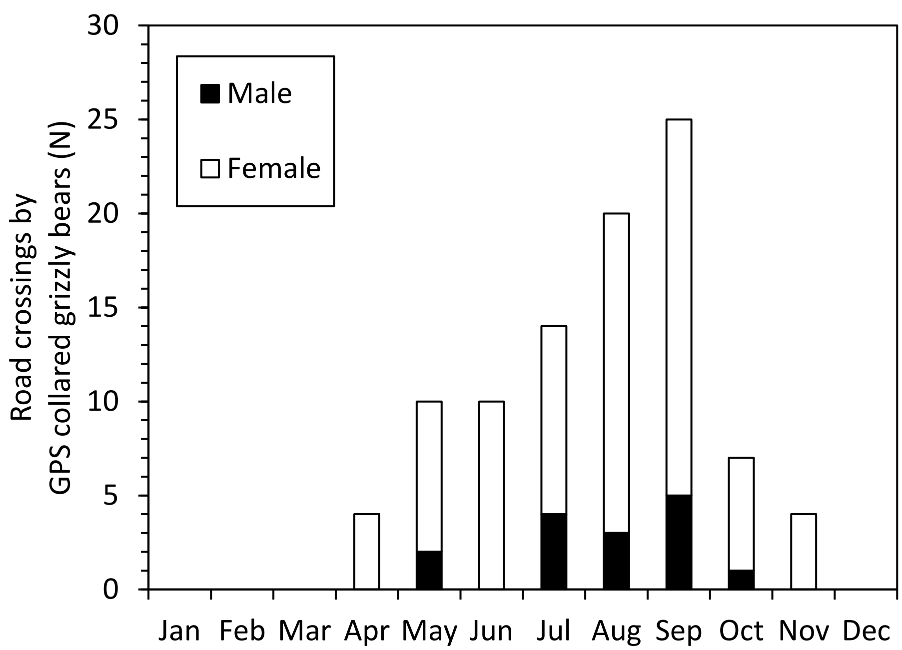


Figure 13: The number of recorded highway crossings per month for the GPS collared male and female grizzly bears (US Highway 93 North, Flathead Indian Reservation).

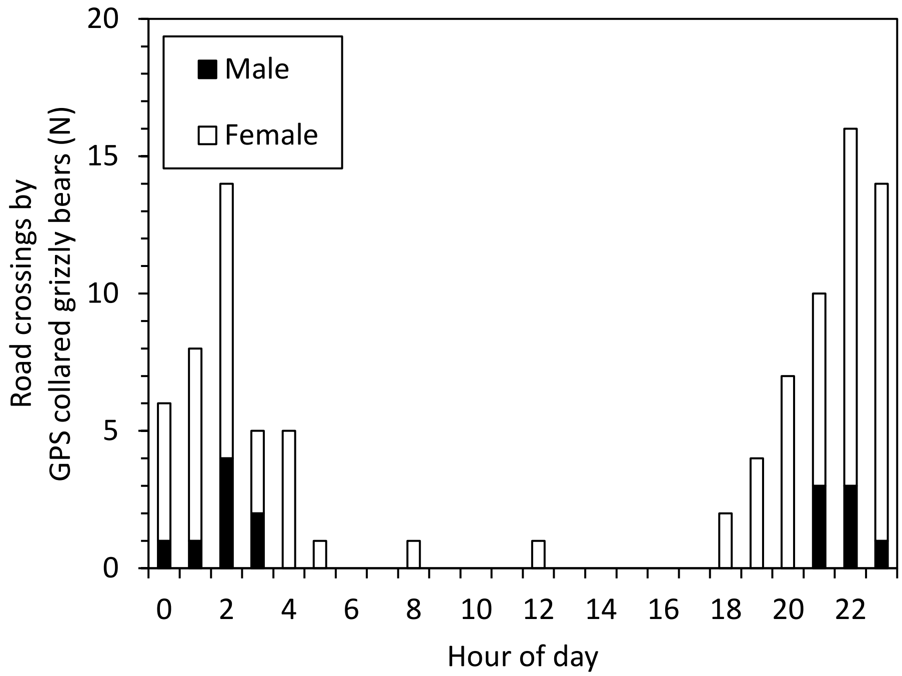


Figure 14: The number of recorded highway crossings by hour of day for the GPS collared male and female grizzly bears (US Highway 93 North, Flathead Indian Reservation). Note: the time is Mountain Daylight Time (MDT, UTC-06:00).

Most of the crossings by the GPS collared grizzly bears were between (Figure 15):

- Mile reference post 34-35: Just north of St. Ignatius around the upgraded and partially mitigated road section around the wildlife crossing structures Post Creek 1, Post Creek 2, and Post Creek 3.
- Mile reference post 37-45: The road section that is not upgraded or mitigated yet through the Ninepipe wetland area, including Post Creek at the south end.
- Mile reference post 50-51: Just south of Pablo around the wildlife crossing structures (one for each travel direction) at Mud Creek.

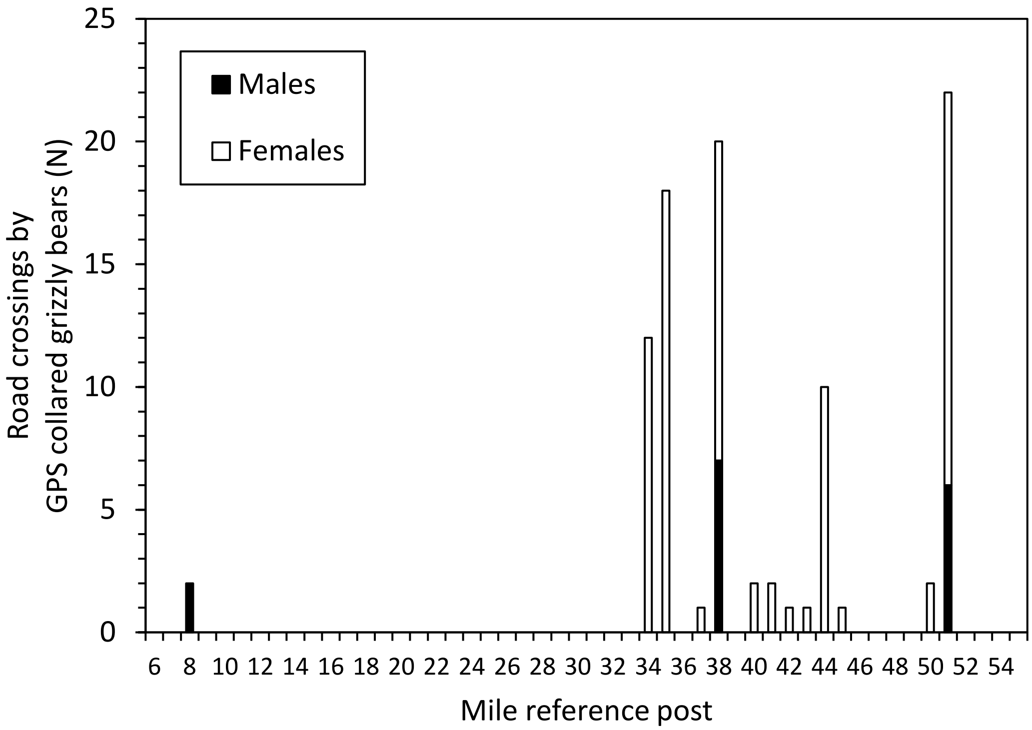


Figure 15: The number of recorded crossings of US Highway 93 North on the Flathead Indian Reservation by GPS collared male and female grizzly bears in the vicinity of each mile reference post.

Figures 16-22 show the highway crossings in selected areas with satellite images as the background. The drainages, creeks and associated riparian areas and cover between the wildlife crossing structure Post Creek 2 until about 0.40 miles north of wildlife crossing structure Post Creek 3 (mile reference post 34.0-35.0) are especially important to grizzly bears resulting in a relatively high concentration of highway crossings in this area. Here, the bears move both along the drainages and creeks, as well as between the neighboring drainages and creeks that are nearby. Further north, the unmitigated highway section near Post Creek (mile reference post 37.6-38.0) also has a relatively high concentration of highway crossings by collared bears. This is strongly associated with Post Creek and its riparian vegetation and cover. The road section through the Ninepipe wetland area (between Post Creek until just south of Ronan (mile reference post 37.8-46.0) has more diffuse highway crossings by grizzly bears, but there is another concentration at a creek crossing (Crow Creek) (mile reference post 44.15). Finally, the road section around Mud Creek, just south of Pablo (mile reference post 50.0-51.5) has another relatively high concentration of highway crossings by collared grizzly bears. Again, the highway crossings were associated with a creek and its riparian habitat and cover.

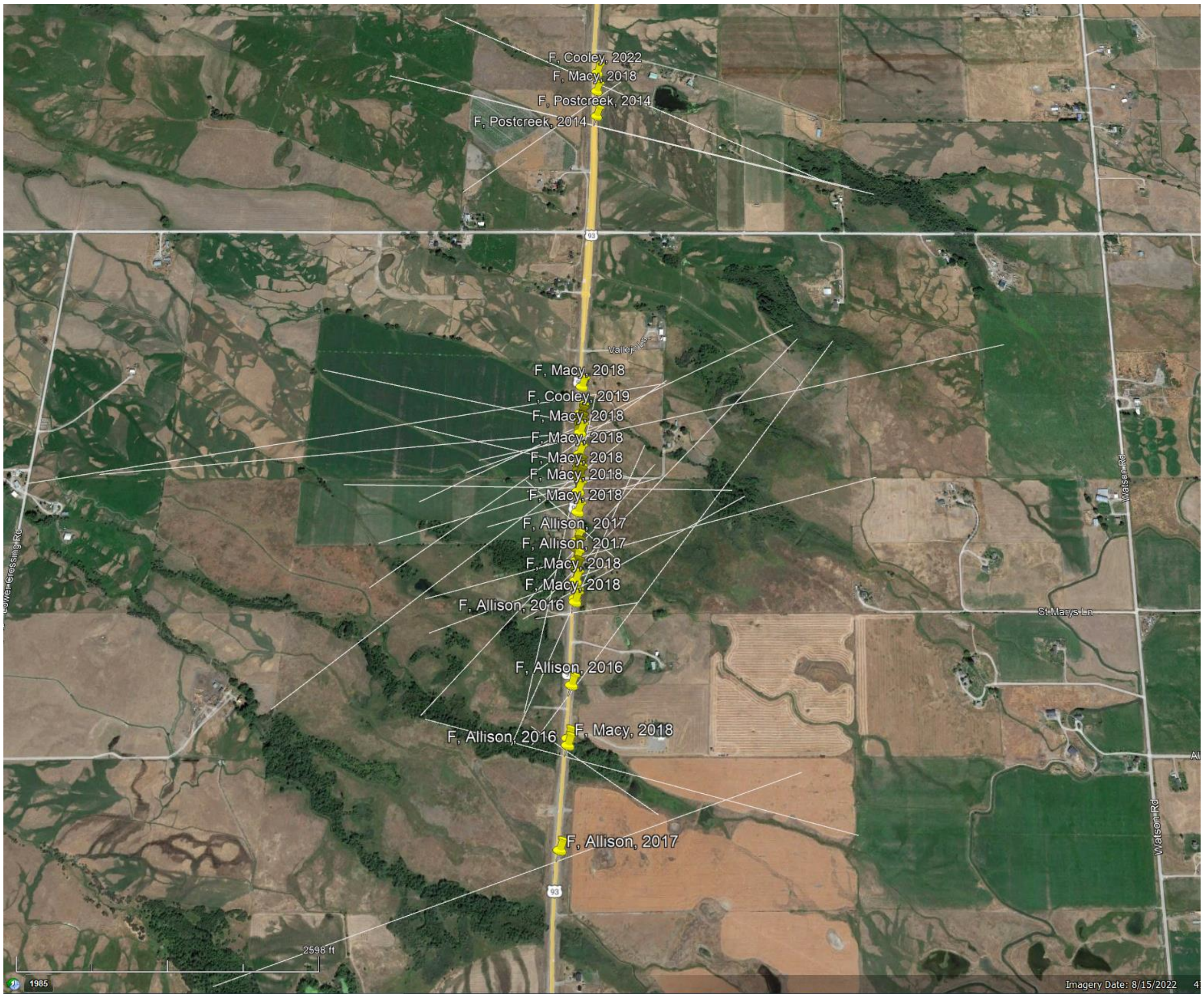


Figure 16: Road crossings by female GPS collared bears just north of St. Ignatius (Mile reference post 34-35, around the upgraded and partially mitigated road section around the wildlife crossing structures Post Creek 1, Post Creek 2, and Post Creek 3 (mile reference posts 33.81, 34.09, and 34.4 respectively) and associated short sections of wildlife fence. Each white line and associated yellow pin represent a road crossing.

Figure 17: Road crossings by male GPS collared bears near Post Creek (not reconstructed yet, not mitigated yet). The highway crosses Post Creek at mile reference post 37.80. Each white line and associated yellow pin represent a road crossing.

Figure 18: Road crossings by female GPS collared bears near Post Creek (not reconstructed yet, not mitigated yet). The highway crosses Post Creek at mile reference post 37.80. Each white line and associated yellow pin represent a road crossing.

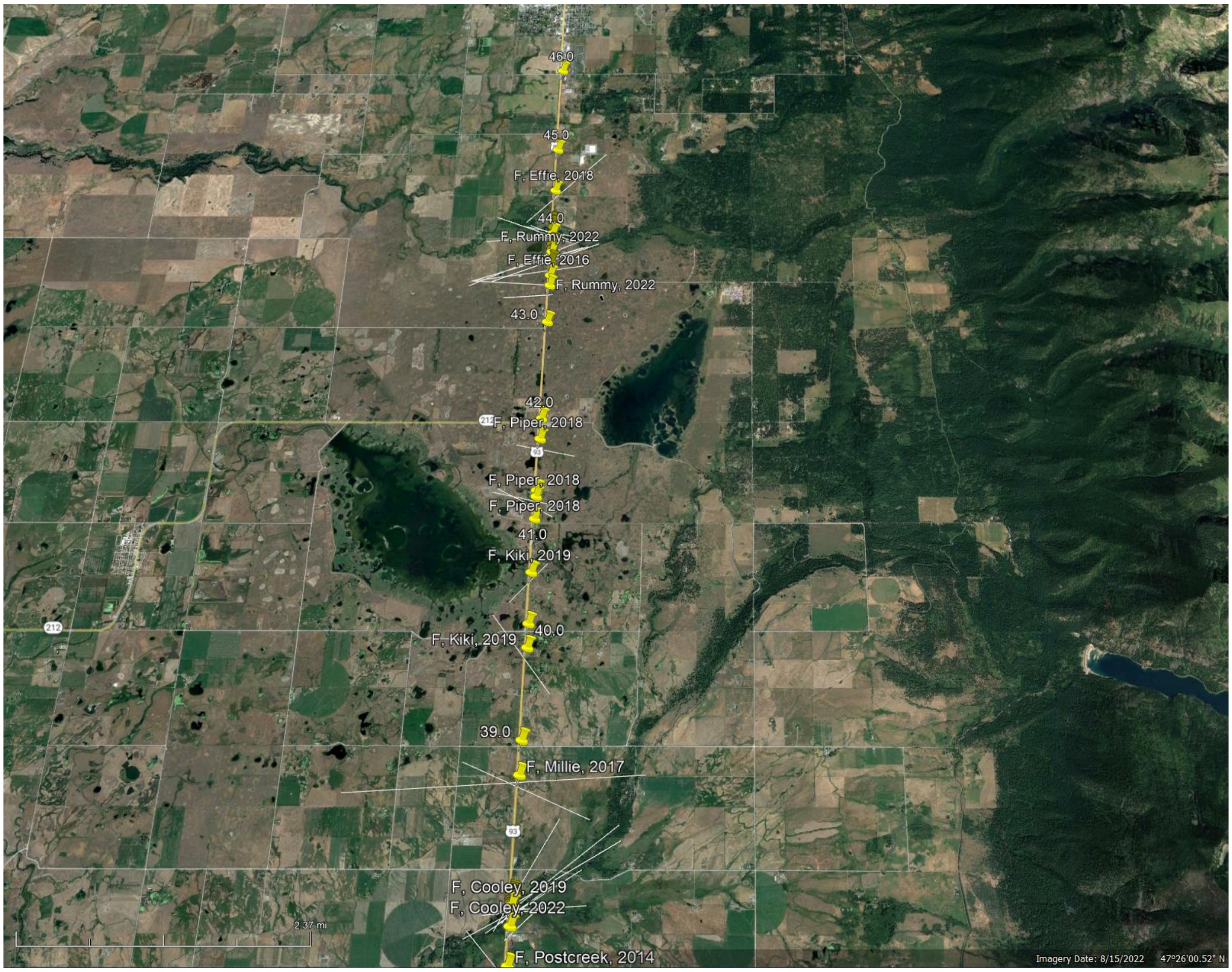


Figure 19: Road crossings by female GPS collared bears in the Ninepipe wetland area (not reconstructed yet, not mitigated yet) between Post Creek (bottom or south end at mile reference post 37.8; top or north end just south of Ronan at mile reference post 46.0). Each white line and associated yellow pin represent a road crossing.

Figure 20: Road crossings by female GPS collared bears south of Ronan at Crow Creek (mile reference post 44.15) in the Ninepipe wetland area (not reconstructed yet, not mitigated yet). Each white line and associated yellow pin represent a road crossing.

Figure 21: Road crossings by male GPS collared bears near Mud Creek (reconstructed, mitigated with a crossing structure at Mud Creek (mile reference post 50.94) connected to short sections of wildlife fence. Each white line and associated yellow pin represent a road crossing.

Figure 22: Road crossings by female GPS collared bears near Mud Creek (reconstructed, mitigated with a crossing structure at Mud Creek (mile reference post 50.94) connected to short sections of wildlife fence. Each white line and associated yellow pin represent a road crossing.

6.3.3 Comparison to crossing structure data

Out of the 94 road crossings by GPS collared grizzly bears, 3 crossed before the road reconstruction was completed and the wildlife crossing structures were built. These 3 crossings were excluded from the comparison to the data from the trail cameras installed at the wildlife crossing structures. Of the remaining 91 road crossings, none was documented by any camera in any crossing structure. Twenty-eight of the estimated crossing locations were in an area where 1. there were wildlife crossing structures present within 2000 m from the crossing location, and 2. all of these wildlife crossing structures had an operational trail camera installed (first column in Figure 23). None of these 28 crossings was documented by a camera in the crossing structures, nor by any other camera in other structures that were further than 2000 m away from the estimated road crossing location. Twenty-seven of the estimated crossing locations were in an area where 1. there were wildlife crossing structures present within 2000 m from the crossing location, and 2. only some of these wildlife crossing structures had an operational trail camera installed (second column in Figure 23). None of these 27 crossings was documented by a camera in the nearby crossing structures, nor by any other camera in other structures that were further than 2000 m away from the estimated road crossing location. Six of the estimated road crossing locations were in an area with wildlife crossing structures but none of them had an operational trail camera (third column in Figure 23). None of these 6 crossings was documented by any camera in other structures that were further than 2000 m away from the estimated road crossing location. Thirty estimated road crossing locations were in an area where there were no wildlife crossing structures present within 2000 m distance (last column in Figure 23). None of these 30 crossings was documented by a camera in structures that were further than 2000 m away from the estimated road crossing location.

While some grizzly bears use the existing wildlife crossing structures (see Chapter 5), most grizzly bears that cross the highway do so at grade, both in the partially mitigated road sections with wildlife crossing structures, and in the currently unmitigated road section through the Ninepipe wetland. This is especially true for sows with cubs.

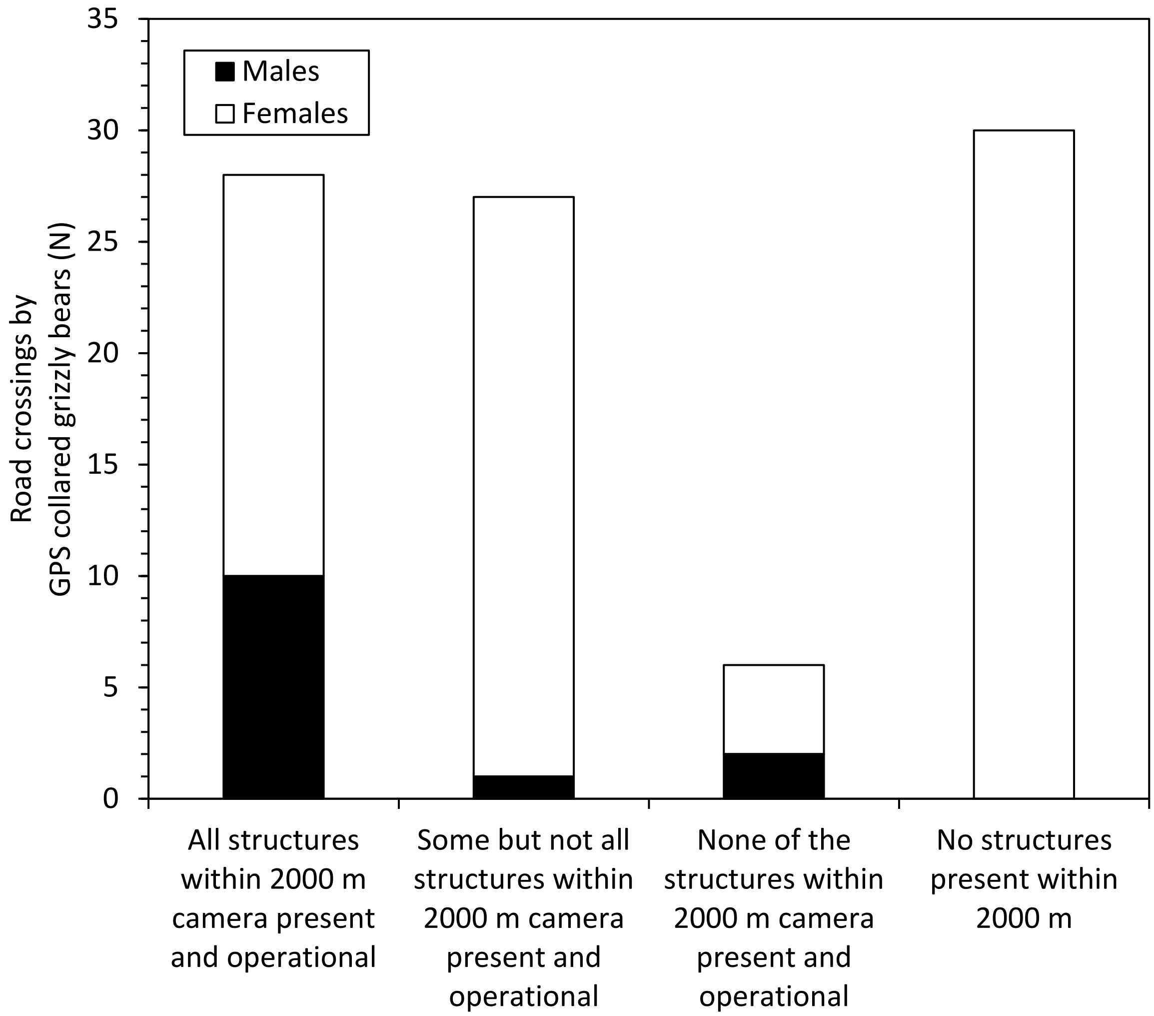


Figure 23: The number of road crossings by GPS collared male and female grizzly bears in relation to the presence of wildlife crossing structures within 2000 m from the estimated road crossing location, and whether these structures were equipped with an operational trail camera.

7 TRAFFIC VOLUME

In 2021, Annual Average Daily Traffic volume (AADT) of US Highway 93 North (both travel directions combined) was about 7,672 vehicles per day between St. Ignatius and the junction with State Route 212 (MDT 2023a). AADT was higher (about 9,196 AADT in 2021) just south of Ronan (MDT 2023a). At the nearest permanently installed traffic counter just south of Ravalli (mile reference post 26.3) the AADT was 8,495 (MDT 2023a).

The nearest permanently installed traffic counter just south of Ravalli generated more detailed data. The Average Daily Traffic (ADT) volume in July, September and October 2021 was 12,159, 9,679, and 8,399 respectively (Data provided by Marie Stump, Montana Department of Transportation). The traffic by hour of day varied greatly. It was highest during the middle of the day between 10 am and 6 pm, and lowest from midnight through 5 am. (Figure 24). More limited traffic counts were available from a site just north of St. Ignatius and a site between the junction with Highway 212 and Ronan. For these sites, the traffic by hour of day was similar to that of the site near Ravalli (Figure 25).

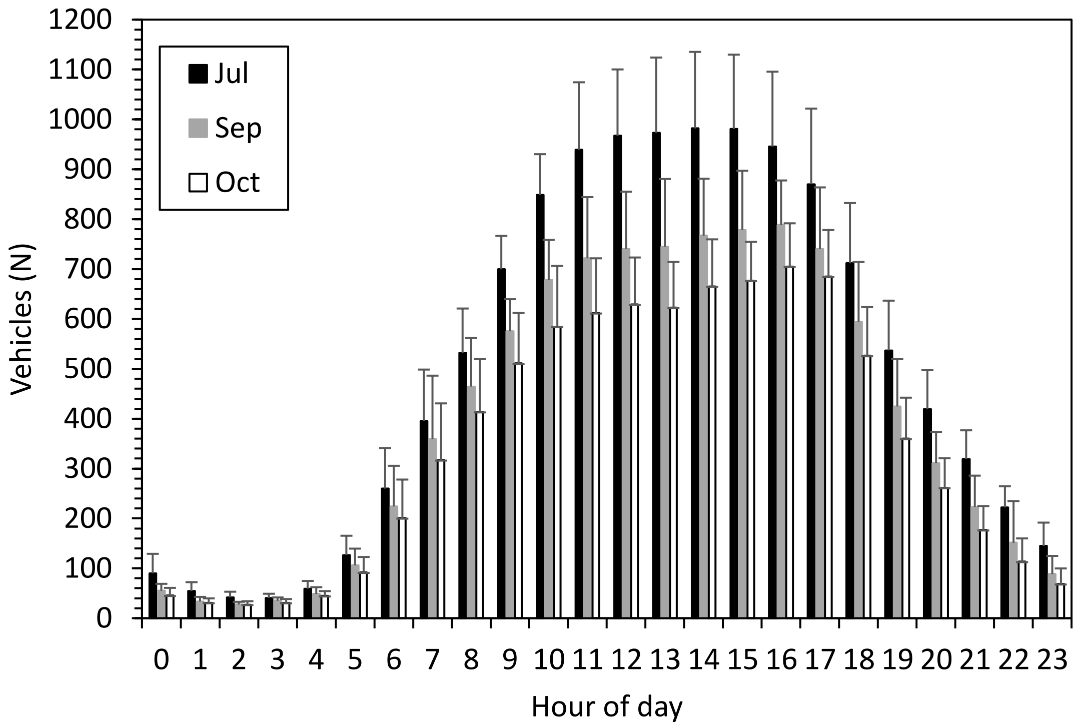


Figure 24: Hourly traffic volume and associated stand deviations in July, September and October 2021 just south of Ravalli (mile reference post 26.3). Hour 12 = between 12:00 and 13:00 (noon and 1 pm). Note: the time is Mountain Daylight Time (MDT, UTC-06:00).

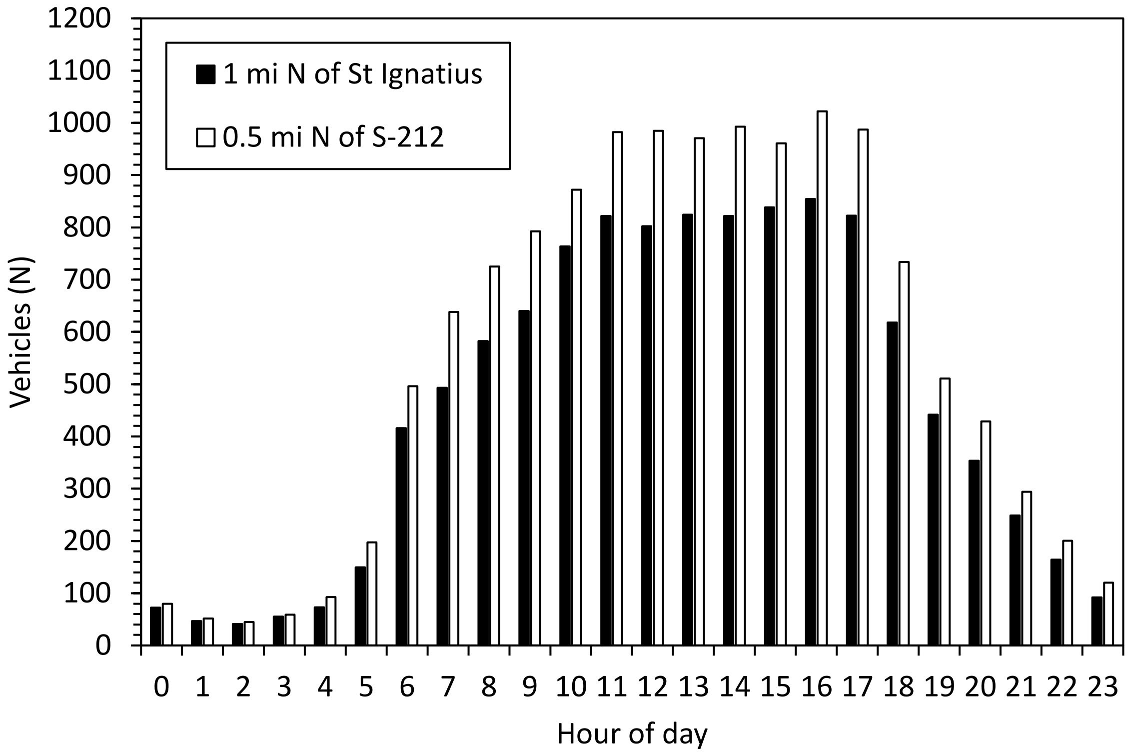


Figure 25: Hourly traffic volume between Tue 3 August 2021 and Thu 5 August 2021 1 mile north of St. Ignatius (location ID 24-3-003, near mile reference post 34.0), and 0.5 mi north of the junction with S-212 (location ID 24-3-027, near mile reference post 42.6). Hour 12 = between 12:00 and 13:00 (noon and 1 pm). Note: the time is Mountain Daylight Time (MDT, UTC-06:00).

With increasing traffic volume from about 10 vehicles per hour to about 100 vehicles per hour, grizzly bears strongly reduce crossing a highway; at 100 vehicles per hour or more, a highway became an almost complete barrier to grizzly bears (Waller & Servheen 2005). Based on the data from Waller and Servheen (2005), US Highway 93 North was a complete or an almost complete barrier to grizzly bear movements for the majority of the day (Figure 24-25). Only at night does the highway become partially permeable to grizzly bears. However, there were no hours of the day where traffic volume was below 10 vehicles per hour and where the barrier effect would be considered minimal (Waller & Servheen 2005) (Figure 24-25). Depending on the month and the chosen threshold (≤10, ≤25, ≤75, and ≤100 vehicles per hour), US Highway 93 North just south of Ravalli was only somewhat permeable to grizzly bears between 0 and 7 hours out of the 24 hours in a day (Figure 26). The barrier effect of US Highway 93 North for grizzly bears was similar for the site just north of St. Ignatius and for the site between the junction with Highway 212 and Ronan (Figure 27).

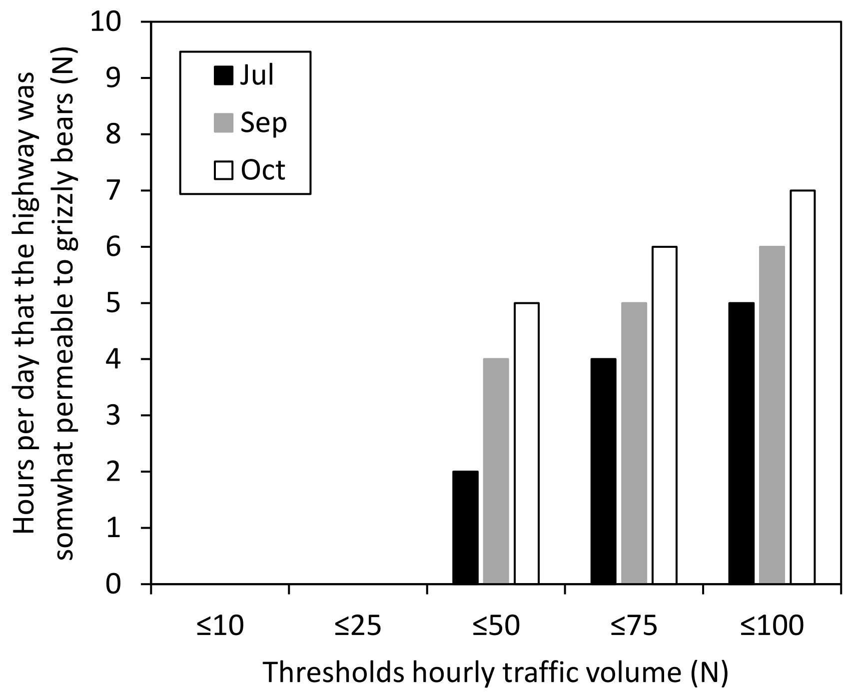


Figure 26: The number of hours per day in July, September and October in 2021 that US Highway 93 (just south of Ravalli) was somewhat permeable to grizzly bears (based on the threshold of 100 vehicles per hour (Waller & Servheen 2005).

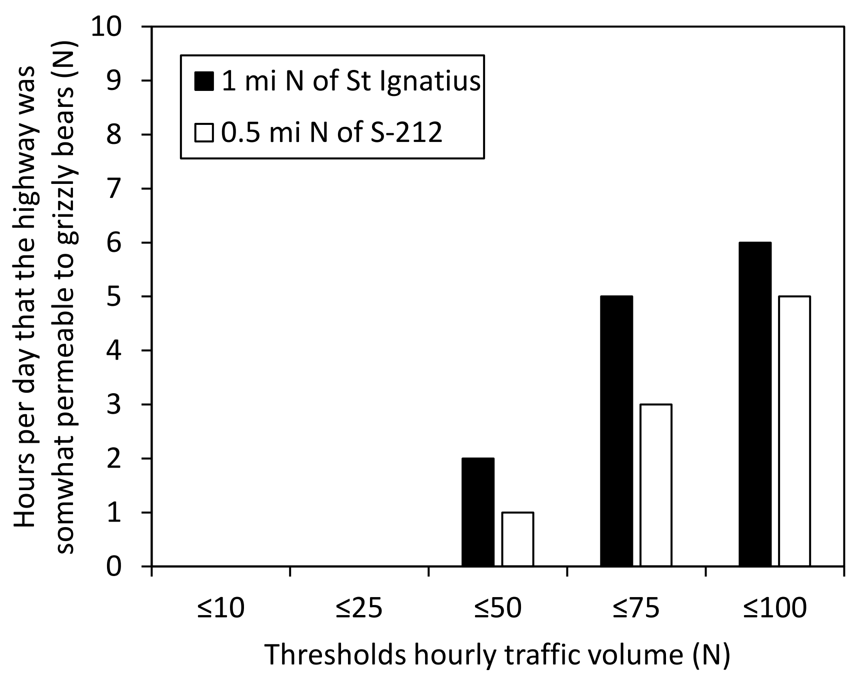


Figure 27: The number of hours per day between Tue 3 August 2021 and Thu 5 August 2021 that US Highway 93 (just north of St. Ignatius and just north of the junction with Highway 212) was somewhat permeable to grizzly bears (based on the threshold of 100 vehicles per hour (Waller & Servheen 2005)).

8 ECONOMICS

Wildlife fences and wildlife crossing structures can be considered expensive (see Huijser et al. 2009 and 2022c for updated estimates on costs). However, allowing wildlife-vehicle collisions to continue is also costly as there are expenses associated with vehicle repair, human injuries, human fatalities, and the passive use values of the animals involved (Huijser et al. 2009, 2022c). 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).

The passive use costs associated with a threatened species, the grizzly bear, were higher or much higher than the direct costs (Huijser et al. 2022c). The costs associated with mitigation measures (especially fences and wildlife crossing structures) were also updated from Huijser et al. (2009), and they were supplemented with new data. New cost-benefit analyses generated updated threshold values for deer, elk, moose, and an entirely new threshold value for grizzly bear. If collisions with these large wild mammal species reach or surpass the threshold values, it is economically defensible to install the associated type and combination of mitigation measures, both based on direct use and passive use parameters and their associated values.

The trend in increasing costs associated with vehicle repair costs, costs associated with human injuries and fatalities, and through including passive use values for wildlife is that we learn that the implementation of effective mitigation measures can be considered earlier and more readily than based on the cost-benefit model published in 2009.

Specifically for grizzly bears, their high passive use value resulted in a very low threshold, at least when compared to collisions with large common ungulates. For example, for 3% discount rate, and for a combination of wildlife fences, a large mammal underpass once every 2 km, a large mammal overpass once every 24 km, and jump-outs, the break-even point for grizzly bear is 0.009 collisions per kilometer per year. While collisions with grizzly bears are very rare compared to collisions with common large ungulates, there are road sections where this threshold is easily reached. For example, the approximately 22 km (13.7 miles) road length between St. Ignatius and Ronan on the Flathead Indian Reservation in Montana (USA), has had an average annual grizzly bear road mortality of 1.58 animals (between 2010-2022). Assuming an average annual road mortality of 1.58 grizzly bears along this road section, it translates into 0.072 grizzly bear collisions per km per year (0.12 per mile per year). This is 7.98 times higher than the 0.009 threshold for mitigation (wildlife fence, dig barrier, wildlife jump-outs, 1 large mammal underpass every 2 km, 1 large mammal overpass every 24 km, 3% discount rate), which suggests that multiple large wildlife crossing structures (e.g. bridges and overpasses) are economically defensible based on direct road mortality for grizzly bears alone. If collisions with other large mammal species are included (e.g. white-tailed deer, black bear), extensive mitigation measures along this road section would be even more advantageous based on the economics of collisions with large wild mammal species alone. Finally, large underpasses may also be required for hydrology, independent of reducing collisions with large mammals and improving habitat connectivity.

9 SURVEY WITH STAKEHOLDERS

The researchers developed a survey (see Appendix E) that was centered around measures aimed at:

- Reducing direct road mortality of grizzly bears along US Highway 93 North on the Flathead Indian Reservation.
- Reducing the barrier effect for grizzly bears of US Highway 93 North on the Flathead Indian Reservation.

The survey was targeted at representatives of the Confederated Salish and Kootenai Tribes, United States Fish and Wildlife Service, the Montana Department of Transportation, and the Federal Highway Administration.

The survey questions focused on the perspectives of the respondents regarding:

- The extent of the effects of the highway on grizzly bears.
- The desirable future situation.
- Measures supported to achieve this desirable future situation.

However, the response by agency personnel was very poor. Therefore, the results were not analyzed.

10 RECOMMENDATIONS

10.1 Currently unmitigated road section (including Post Creek and Ninepipe wetlands)

Install wildlife fences for the entire road length on both sides of the highway. Standard wild ungulate fences (8 ft (2.4 m tall), wooden posts, woven wire fence material) combined with a dig barrier are likely a substantial barrier to grizzly bears. For a fence to also be a barrier for black bears, a different fence design is required. Include wildlife-jump-outs, although a design that is suitable for white-tailed deer has not yet been identified. Note that fences without suitable wildlife crossing structures are likely ecologically damaging, including to grizzly bears, as they would result in a near absolute barrier.

Minimize the number of gaps in the wildlife fence for access roads, driveways and field access points. Mitigate the remaining gaps at access points with electrified barriers as wildlife guards (modified cattle guards are not an effective barrier for grizzly bears). Unmitigated and unmaintained gaps jeopardize the overall effectiveness of the mitigation measures in reducing direct road mortality of grizzly bears.

Install wildlife crossing structures suitable for grizzly bears (both sexes and all age categories), especially at Post Creek, and at various locations through the Ninepipe wetlands but especially at Crow Creek. Wildlife overpasses are the most suitable crossing structure for grizzly bears by far, especially for sows with cubs. If one or more wildlife overpasses are constructed, make the approaches very gradual (especially if the surrounding topography is flat), consider the appropriate soil depth on the structure to allow for natural vegetation to grow (similar to the surroundings), and implement a visual and sound barrier along the sides of the overpasses. At creek or other water crossings, especially Crow Creek, construct open span bridges (at a minimum 12.0 m wide × 5.0 m high). While these types of bridges receive use by grizzly bears, including by sows with cubs, their use is far lower than for wildlife overpasses.

If and where considered appropriate, restore habitat in areas adjacent to US Highway 93 North, especially on the approaches of wildlife crossing structures. Specifically for grizzly bears, well-functioning creeks, drainages, and associated riparian habitat, and cover are important for security during the day and for movement (day and night) in a landscape with relatively high human presence and disturbance. Minimize human presence and disturbance, including buildings, in the vicinity of wildlife crossing structures.

The measures suggested above are not a menu from which one or some should be chosen. Rather, the measures are components of a package. Only a well-designed, constructed, and maintained package of mitigation measures is likely to substantially reduce direct road mortality of grizzly bears and allow for all sex and age categories of grizzly bears to be able to readily and safely cross between the areas on either side of the highway.

10.2 Already reconstructed and partially mitigated road sections

Connect the existing sections of short fences:

- Especially connect the fences associated with wildlife crossing structures Post Creek 1, Post Creek 2, and Post Creek 3. Preferably, the wildlife fences should extend north to Post Creek and connect to the future wildlife fence that may be installed there until just south of Ronan (see previous section). In addition, the fence should preferably extend south to the built-up area of St. Ignatius).
- While a gap in the wildlife fence at St. Ignatius may be unavoidable, the fences associated with Mission Creek and Sabine creek should preferably be connected and extended to meet the existing fences at the top of Ravalli Hill. However, the road section between Ravalli Hill and St. Ignatius had less road mortality and fewer road crossings by GPS collared grizzly bears than the road section between St. Ignatius and Post Creek.
- Extend the fences at Mud Creek, just south of Pablo, further north until the built-up area of Pablo. Extend the fence further south, at least until the wildlife underpass Spring Creek 2.

Standard wild ungulate fences (8 ft (2.4 m tall), wooden posts, woven wire fence material) combined with a dig barrier are likely a substantial barrier to grizzly bears. For a fence to also be a barrier for black bears, a different fence design is required. Include wildlife-jump-outs, although a design that is suitable for white-tailed deer has not yet been identified. Note that fences without suitable wildlife crossing structures are likely ecologically damaging, including to grizzly bears, as they would result in a near absolute barrier.

Minimize the number of gaps in the wildlife fence for access roads, driveways and field access points. Mitigate the remaining gaps at access points with electrified barriers as wildlife guards (modified cattle guards are not an effective barrier for grizzly bears). Unmitigated and unmaintained gaps jeopardize the overall effectiveness of the mitigation measures in reducing direct road mortality of grizzly bears.

Fences without suitable wildlife crossing structures are likely ecologically damaging, including to grizzly bears, as they would result in a near absolute barrier. Consider the following replacements of existing crossing structure or adding additional crossing structures:

- Post Creek 1, 2, 3 area: The current underpasses in the area, e.g. Post Creek 1, 2, and 3, are about 7 m wide and 4-5 m high. While they do receive some use by grizzly bears, these bears are almost always single animals. Sows with cubs have only been detected, or suspected, two times between 2010 and 2022 (once at Pistol Creek 1 and once at Post Creek 2). Therefore, consider replacing the current underpasses, especially at Post Creek 2 and 3 with wider underpasses (at least 12 m wide, preferably much wider). Alternatively, consider installing a wildlife overpass between Post Creek 2 and 3, or just north of Post Creek 3. Long sections with fences with only the current structures in place would likely result in a substantial barrier for this species, especially for sows with cubs.
- Ravalli Hill – St. Ignatius area: Consider replacing the current underpasses with wider underpasses (at least 12 m wide, preferably much wider). Alternatively, consider

installing a wildlife overpass, potentially at or near Ravalli Hill and/or in the Pistol Creek area. Long sections with fences with only the current structures in place would likely result in a substantial barrier for this species, especially for sows with cubs.

- Mud Creek area: Consider replacing the current underpasses (one for each travel direction) with wider underpasses (at least 12 m wide, preferably much wider). Alternatively consider installing a wildlife overpass, potentially between Mud Creek and Spring Creek 2. Long sections with fences with only the current structures in place would likely result in a substantial barrier for this species, especially for sows with cubs.

If and where considered appropriate, restore habitat in areas adjacent to US Highway 93 North, especially on the approaches of wildlife crossing structures. Specifically for grizzly bears, well-functioning creeks, drainages, and associated riparian habitat, and cover are important for security during the day and for movement (day and night) in a landscape with relatively high human presence and disturbance. Minimize human presence and disturbance, including buildings, in the vicinity of wildlife crossing structures.

The measures suggested above are not a menu from which one or some should be chosen. Rather, the measures are components of a package. Only a well-designed, constructed, and maintained package of mitigation measures is likely to substantially reduce direct road mortality of grizzly bears and allow for all sex and age categories of grizzly bears to be able to readily and safely cross between the areas on either side of the highway.

11 REFERENCES

Allen, T.D.H, M.P. Huijser & D. Willey. 2013. Evaluation of wildlife guards at access roads. Effectiveness of wildlife guards at access roads. Wildlife Society Bulletin 37(2): 402–408.

Arizona Game and Fish Department. 2015. Evaluation of bighorn sheep overpass effectiveness long term monitoring, US Highway 93. April 2015. Report prepared for Arizona Department of Transportation Phoenix, Arizona, USA.

Benn, B. & S. Herrero. 2002. Grizzly bear mortality and human access in Banff and Yoho National Parks, 1971-98. Ursus 13: 213-221.

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.

Dodd, N.L., J.W. Gagnon, S. Boe & R.E. Schweinsburg. 2007a. Role of fencing in promoting wildlife underpass use and highway permeability. In: Irwin, C.L., D. Nelson & K.P. McDermott, K.P. (Eds.), Proceedings of the 2007 International Conference on Ecology and Transportation. Center for Transportation and the Environment, North Carolina State University, Raleigh, North Carolina, USA, pp. 475-487.

Dodd, N., J. Gagnon, S. Boe & R. Schweinsburg. 2007b. Assessment of elk highway permeability by using global positioning system telemetry. Journal of Wildlife Management 71: 1107-1117.

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.

FHWA. 2001. Second revised Record of Decision. Improvement of U.S. Highway 93 Evaro through Polson, Missoula and Lake Counties, Montana. Project F 5-1(9)6. Final Environmental Impact Statement. Final Section 4(f) Evaluation FHWA-MT-EIS-95-01-F. Federal Highway Administration. Helena, Montana, USA. http://www.peopleswaywildlifecrossings.org/images/abouthwy93/background_outreach_docs/US93ROD_2001.pdf

Ford, A.T., M. Barrueto & A.P. Clevenger. 2017. Road mitigation is a demographic filter for grizzly bears. Wildlife Society Bulletin 41(4): 712-719; 2017; DOI: 10.1002/wsb.828

Ford, A.T., M. Huijser & A.P. Clevenger. 2022. Long-term responses of an ecological community to highway mitigation. Report No. 701-18-803 TO 7. Transportation Pooled-Fund Project TPF-5(358), Administered by the Nevada Department of Transportation. Western Transportation Institute, Montana State University, Bozeman, Montana, USA.

Forman, R.T.T., D. Sperling, J.A. Bissonette, A.P. Clevenger, C.D. Cutshall, V.H. Dale, L. Fahrig, R. France, C.R. Goldman, K. Heanue, J.A. Jones, F.J. Swanson, T. Turrentine & T.C. Winter. 2003. Road Ecology: Science and Solutions. Island Press: Washington, DC.

Gagnon, J.W., N.L. Dodd, S.C. Sprague, K. Ogren, R.E. Schweinsburg. 2010. Preacher Canyon wildlife fence and crosswalk enhancement project evaluation. State Route 260. Final Report — Project JPA 04-088. Arizona Game and Fish Department, Phoenix, Arizona, USA.

Gibeau, M.L., A.P. Clevenger, S. Herrero & J. Wierzchowski. 2002. Grizzly bear response to human development and activities in the Bow River Watershed, Alberta, Canada. Biological Conservation 103: 227-236.

Graves, T.A., K.C. Kendall, J.A. Royle, J.B. Stetz & A.C. Macleod. 2011. Linking landscape characteristics to local grizzly bear abundance using multiple detection methods in a hierarchical model. Animal Conservation14: 652-664.

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., 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., A.V. Kociolek, T.D.H. Allen, P. McGowen, P.C. Cramer & M. Venner. 2015. Construction guidelines for wildlife fencing and associated escape and lateral access control measures. NCHRP Project 25-25, Task 84, National Cooperative Highway Research Program, Transportation Research Board of the National Academies, Washington D.C., USA.

Huijser, M.P., W. Camel-Means, E.R. Fairbank, J.P. Purdum, T.D.H. Allen, A.R. Hardy, J. Graham, J.S. Begley, P. Basting & D. Becker. 2016a. US 93 North post-construction wildlife-vehicle collision and wildlife crossing monitoring on the Flathead Indian Reservation between Evaro and Polson, Montana. FHWA/MT-16-009/8208. Western Transportation Institute – Montana State University, Bozeman, Montana, USA.

Huijser, M.P., E.R. Fairbank, W. Camel-Means, J. Graham, V. Watson, P. Basting & D. Becker. 2016b. 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. & J.S. Begley. 2019. Large mammal-vehicle collision hot spot analyses, California, USA. Report 4W6693. Western Transportation Institute, Montana State University, Bozeman, Montana, USA.

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., E.R. Fairbank & K.S. Paul. 2022a. 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.

Huijser, M.P. & S.C. Getty. 2022b. The effectiveness of electrified barriers to keep large mammals out of fenced road corridors. Report No. 701-18-803 TO 6 Part 2. Transportation Pooled-Fund Project TPF-5(358), Administered by the Nevada Department of Transportation. Western Transportation Institute, Montana State University, Bozeman, Montana, USA.Parsons, B.M., N.C. Coops, G.B. Stenhouse, A.C. Burton & T.A. Nelson. 2020. Building a perceptual zone of influence for wildlife: delineating the effects of roads on grizzly bear movement. European Journal of Wildlife Research (2020) 66: 53. https://doi.org/10.1007/s10344-020-01390-1

Huijser, M.P., J.W. Duffield, C. Neher, A.P. Clevenger & T. McGuire. 2022c. 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.

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.

Lamb, C.T., G. Mowat, A. Reid, L. Smit, M. Proctor, B.N. McLellan, S.E. Nielsen & S. Boutin. 2018. Effects of habitat quality and access management on the density of a recovering grizzly bear population. Journal of Applied Ecology 55: 1406-1417.

Mace, R.D., J.S. Waller, T.L. Manley, L.J. Lyon & H. Zuuring. 1996. Relationships among grizzly bears, roads and habitat in the Swan Mountains Montana. Journal of Applied Ecology 33(6): 1395-1404.

MDT. 2023a. 2021 Traffic by sections report: On system. Montana Department of Transportation, Helena, Montana, USA. https://www.mdt.mt.gov/other/webdata/external/Planning/traffic_reports/TBS_ONSYSTEM.pdf?v=1

MDT. 2023b. 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

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.

Parsons, B.M., N.C. Coops, G.B. Stenhouse, A.C. Burton & T.A. Nelson. 2020. Building a perceptual zone of influence for wildlife: delineating the effects of roads on grizzly bear movement. European Journal of Wildlife Research (2020) 66: 53. https://doi.org/10.1007/s10344-020-01390-1

Parsons, B.M., N.C. Coops, S.P. Kearney, A.C. Burton, T.A. Nelson & G.B. Stenhouse. 2021. Road visibility influences habitat selection by grizzly bears. (Ursus arctos horribilis). Canadian Journal of Zoology 99: 161-171.

Peccia, R. & Associates. 2015. US Highway 93 Road Safety Audit. Evaro to Polson, MT. Helena, Montana, USA.

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

Rytwinski T., K. Soanes, J.A.G Jaeger, L. Fahrig, C.S. Findlay, J. Houlahan, R, van der Ree & E.A. van der Grift. 2016. How effective is road mitigation at reducing road-kill? A meta-analysis. PLoSOne 2016; 11(11): e0166941.35 https://doi.org/10.1371/journal.pone.0166941PMID:27870889

Sawaya, M.A., S.T. Kalinowski & A.P. Clevenger. 2014. Genetic connectivity for two bear species at wildlife crossing structures in Banff National Park. Proceedings of the Royal Society B: Biological Sciences 281(1780): 20131705

Sawyer, H., C. Lebeau & T. Hart. 2012. Mitigating roadway impacts to migratory mule deer-A case study with underpasses and continuous fencing. Wildlife Society Bulletin 36: 492-498.

Schwartz, C.C., M.A. Haroldson & G.C. White. 2010. Hazards affecting grizzly bear survival in the Greater Yellowstone Ecosystem. Journal of Wildlife Management 74(4): 654-667.
U.S. Fish and Wildlife Service. 2021. Biological report for the grizzly bear (Ursus arctos horribilis) in the Lower-48 States. Version 1.1, January 31, 2021. Missoula, Montana. 370 pp. https://ecos.fws.gov/ServCat/DownloadFile/196991

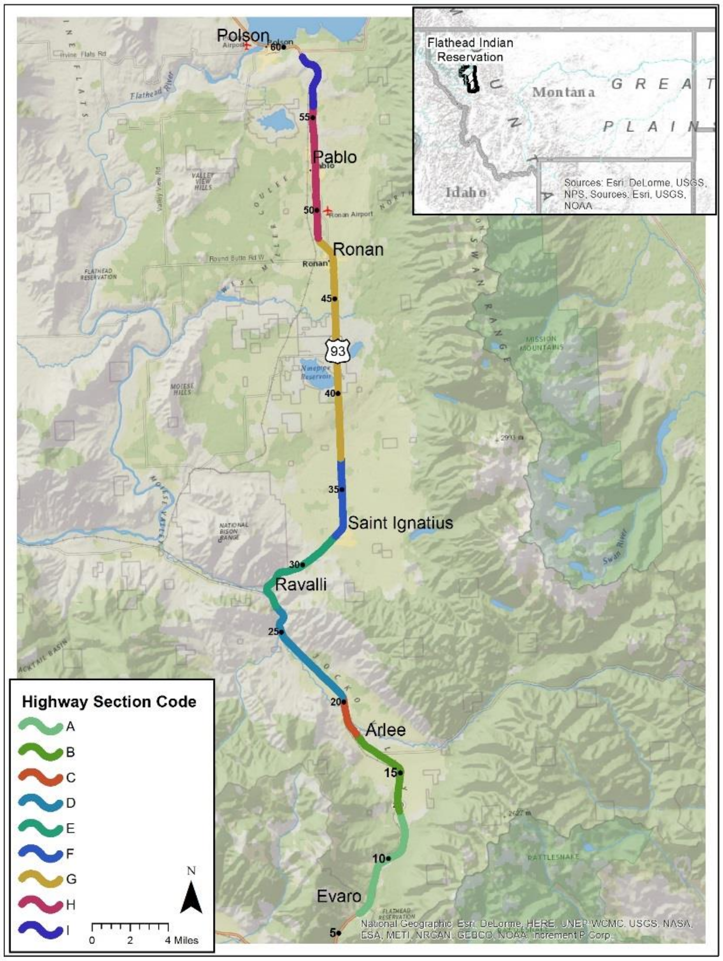
Van der Ree, R., D.J. Smith & C. Grilo (eds). 2015. Handbook of road ecology. Wiley Blackwell, New Jersey, USA.

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.

12 APPENDIX A

The reconstruction time period for the different road sections along US Highway 93 North (based on Peccia & Associates 2015).



Highway section code on map	Name road section	Mile reference post	Reconstruction period
A	Evaro-McClure Road	6.5-12.9	10 Sep 2008 - 8 Oct 2010
B	McClure Rd-N of Arlee Couplet	12.9-18.1	27 Oct 2008 - 21 Jul 2011
C	N of Arlee-Vic White Coyote Rd	18.1-20.2	15 Nov 2004 - 15 Nov 2006
D	Vic White Coyote Rd - S of Ravalli	20.2-26.7	6 Mar 2006 - 24 Oct 2007
E	S of Ravalli-Medicine Tree	26.7-31.4	24 Apr 2006 - 1 Dec 2008
F	Medicine Tree-Vic Red Horn Rd	31.4-36.8	20 Apr 2006 - 9 Jun 2009
G	Ninepipe wetland area	36.8-48.4	Not reconstructed yet
H	Spring Creek Rd-Minesinger TRL	48.4-55.7	7 Sep 2007 - 25 Jun 2009
I	Minesinger Trail-MT 35	55.7 58.7	19 Apr 2005 - 12 Oct 2006

13 APPENDIX B

The 39 wildlife crossing structures along US Highway 93 North considered suitable for medium sized or large mammals.

Area	# in Fig. 1	Ref. post	Structure name	Structure type	Dimensions (W x H x L) (ft)*[1]	Dimensions (W x H x L) (m)*[1]	Construction period	Fenced road length (mi)*[2]	Coordinates (latitude, longitude)
	1	8.77	North Evaro	Large culvert	25.4 x 16.7 x 84.6	7.75 x 5.1 x 25.8	2009-2010	No	47° 3'32.62"N, 114° 4'32.19"W
Evaro	2	9.68	Railroad bridge	Over span bridge	339.6 x 31.8 x 39.4	103.5 x 9.7 x 12.0	2009-2010	1.67	47° 4'12.07"N, 114° 3'58.15"W
	3	10.04	Finley Creek 1	Large culvert	26.1 x 18.2 x 105.0	7.95 x 5.55 x 32.0	2009-2010	1.67	47° 4'20.48"N, 114° 3'34.37"W
	4	10.28	Finley Creek 2	Large culvert	26.1 x 18.2 x 71.9	7.95 x 5.55 x 21.9	2009-2010	1.67	47° 4'25.96"N, 114° 3'18.08"W
	5	10.34	Overpass	Overpass	196.9 x n/a x 206.7	60 x n/a x 63.0	2009-2010	1.67	47° 4'27.21"N, 114° 3'13.87"W
	6	10.53	Finley Creek 3	Large culvert	25.4 x 16.7 x 81.0	7.75 x 5.1 x 24.7	2009-2010	1.67	47° 4'31.27"N, 114° 3'0.98"W
	7	10.82	Finley Creek 4	Large culvert	26.1 x 18.2 x 83.0	7.95 x 5.55 x 25.3	2009-2010	1.67	47° 4'41.20"N, 114° 2'43.70"W
	8	11.90	Schley Creek	Large culvert	25.4 x 16.7 x 98.4	7.75 x 5.1 x 30	2009-2010	0.14*[3]	47° 5'35.03"N, 114° 2'26.26"W
	9	12.24	E. Fork Finley Creek	Large culvert	25.4 x 16.7 x 79.7	7.75 x 5.1 x 24.3	2009-2010	No	47° 5'53.01"N, 114° 2'31.96"W
Jocko River	10	18.83	Jocko River 1	Box culvert	6.9 x 6.9 x 147.6	2.1 x 2.1 x 45	2005-2006	0.38	47°10'31.34"N, 114° 5'54.11"W
	11	18.86	Jocko River 2	Box culvert	6.9 x 6.9 x 141.1	2.1 x 2.1 x 43	2005-2006	0.38	47°10'33.43"N, 114° 5'55.52"W
	12	18.90	Jocko River 3	Box culvert	6.9 x 6.9 x 131.2	2.1 x 2.1 x 40	2005-2006	0.38	47°10'35.48"N, 114° 5'56.71"W
	13	18.98	Jocko River bridge	Over span bridge	54.5 x 17.1 x 393.7	16.6 x 5.2 x 120	2005-2006	0.38	47°10'39.21"N, 114° 5'58.73"W
Ravalli Curves	14	22.97	RC 377	Box culvert	7.9 x 7.9 x 122.0	2.4 x 2.4 x 37.2	2006-2007	3.74	47°13'30.37"N, 114° 8'34.49"W
	15	23.21	RC 381 (Spring Cr.)	Over span bridge	98.4 x 15.1 x 39.4	30 x 4.6 x 12	2006-2007	3.74	47°13'39.78"N, 114° 8'47.95"W
	16	24.20	RC 396	Large culvert	22.5 x 15.7 x 72.2	6.86 x 4.78 x 22	2006-2007	3.74	47°14'17.77"N, 114° 9'39.89"W
	17	24.82	RC 406	Large culvert	22.5 x 15.7 x 84.0	6.86 x 4.78 x 25.6	2006-2007	3.74	47°14'41.89"N, 114°10'8.12"W
	18	25.77	RC 422 (Side Channel)	Over span bridge	98.4 x 17.1 x 39.4	30 x 5.2 x 12	2006-2007	3.74	47°15'27.43"N, 114°10'5.20"W
	19	26.07	RC 426	Box culvert	3.9 x 5.9 x 89.9	1.2 x 1.8 x 27.4	2006-2007	3.74	47°15'42.00"N, 114°10'6.72"W
	20	26.13	RC 427	Small culvert	6.7 x 4.9 x 82.0	2.05 x 1.5 x 25	2006-2007	3.74	47°15'44.58"N, 114°10'9.73"W
	21	26.28	RC 431	Box culvert	5.9 x 3.9 x 80.1	1.8 x 1.2 x 24.4	2006-2007	3.74	47°15'50.55"N, 114°10'17.00"W
	22	26.39	RC 432 (Copper Cr.)	Large culvert	25.4 x 16.7 x 60.0	7.75 x 5.1 x 18.3	2006-2007	3.74	47°15'54.98"N, 114°10'22.65"W
Ravalli Hill	23	28.11	RH 1	Large culvert	24.0 x 17.1 x 128.0	7.3 x 5.2 x 39	2006-2007	1.09	47°17'7.75"N, 114°10'42.99"W
	24	28.38	RH 2	Large culvert	24.0 x 17.1 x 102.4	7.3 x 5.2 x 31.2	2006-2007	1.09	47°17'17.82"N, 114°10'29.37"W
	25	30.48	Pistol Creek 1	Large culvert	24.0 x 17.1 x 131.2	7.3 x 5.2 x 40	2006-2007	No	47°18'6.74"N, 114° 8'7.23"W
	26	30.68	Pistol Creek 2	Large culvert	24.0 x 17.1 x 131.2	7.3 x 5.2 x 40	2006-2007	No	47°18'12.50"N, 114° 7'55.51"W
	27	31.77	Sabine Creek	Large culvert	24.0 x 12.0 x 47.9	7.32 x 3.65 x 14.6	2006-2007	0.12	47°18'46.26"N, 114° 6'56.42"W
	28	32.45	Mission Creek	Over span bridge	54.5 x 16.1 x 131.2	16.6 x 4.9 x 40	2006-2007	0.22	47°19'10.80"N, 114° 6'19.75"W
	29	33.81	Post Creek 1	Large culvert	24.0 x 15.6 x 94.5	7.32 x 4.75 x 28.8	2006-2007	0.07	47°20'13.97"N, 114° 5'48.82"W
	30	34.09	Post Creek 2	Large culvert	24.0 x 15.6 x 72.2	7.32 x 4.75 x 22	2006-2007	0.07	47°20'28.51"N, 114° 5'48.43"W
	31	34.40	Post Creek 3	Large culvert	24.0 x 15.6 x 64.0	7.32 x 3.9 x 19.5	2006-2007	0.11	47°20'44.42"N, 114° 5'48.30"W
	32	34.51	Post Creek 4	Small culvert	5.9 x 3.9 x 129.9	1.8 x 1.2 x 39.6	2006-2007	No	47°20'50.48"N, 114° 5'48.40"W
	33	34.75	Post Creek 5	Small culvert	7.9 x 7.9 x 104.0	2.4 x 2.4 x 31.7	2006-2007	No	47°21'2.55"N, 114° 5'48.63"W
	34	36.40	Post Creek 6	Small culvert	5.9 x 3.9 x 96.1	1.8 x 1.2 x 29.3	2006-2007	No	47°22'28.68"N, 114° 5'48.05"W
	35	36.73	Post Creek 7	Small culvert	5.9 x 3.9 x 104.0	1.8 x 1.2 x 31.7	2006-2007	No	47°22'46.17"N, 114° 5'48.46"W
	36	48.75	Spring Creek 1	Large culvert	27.9 x 9.8 x 145.7	8.5 x 3.0 x 44.4	2007-2008	0.15	47°32'57.89"N, 114° 6'47.20"W
	37	49.27	Spring Creek 2	Large culvert	27.9 x 9.8 x 170.3	8.5 x 3.0 x 51.9	2007-2008	0.09	47°33'29.16"N, 114° 6'46.99"W
	38	50.96	Mud Creek	2 Large culverts	42.0 x 13.8 x 52.3	12.8 x 4.2 x 15.94	2007-2008	0.16	47°34'53.10"N, 114° 6'47.09"W
	39	57.76	Polson Hill	2 Large culverts	22.0 x 12.0 x 52.0	6.71 x 3.66 x 15.85	2004-2005	0.87	47°40'34.97"N, 114° 6'29.95"W

*[1] As seen by the animals, *[2] Wildlife fence, *[3] West side highway only

14 APPENDIX C

The length of the fenced road sections, measured as "road length fenced". This ignores additional fence length as a result of the fences not always running perfectly parallel to the highway.

Name fenced section		Mi reference post		Length (mi)			Road length with wildlife fences on both sides
		west	east	west	east		
Evaro	start	9.33	9.30	1.70	1.70		1.67
	end	11.03	11.00				
Schley	start	11.86	no fence	0.14	0.00		0.00
	end	12.00	no fence				
Jocko	start	18.72	18.75	0.41	0.38		0.38
	end	19.13	19.13				
Ravalli Curves	start	22.93	22.93	3.74	3.75		3.74
	end	26.67	26.68				
Ravalli Hill	start	27.53	27.56	1.12	1.09		1.09
	end	28.65	28.65				
Sabine Creek	start	31.73	31.74	0.13	0.15		0.12
	end	31.86	31.89				
Mission Creek	start	32.32	32.32	0.21	0.22		0.22
	end	32.53	32.53				
Post Creek 1	start	32.77	32.75	0.09	0.07		0.07
	end	32.86	32.82				
Post Creek 2	start	34.04	34.03	0.07	0.08		0.07
	end	34.11	34.11				
Post Creek 3	start	34.32	34.32	0.13	0.11		0.11
	end	34.45	34.42				
Spring Creek 1	start	48.66	48.66	0.15	0.17		0.15
	end	48.81	48.83				
Spring Creek 2	start	49.22	49.25	0.12	0.09		0.09
	end	49.34	49.34				
Mud Creek	start	50.84	50.85	0.16	0.18		0.16
	end	51.00	51.03				
Polson Hill	start	57.22	57.19	1.03	0.90		0.87
	end	58.25	58.09				
Total road length fenced (mi)				9.18	8.87		8.71

15 APPENDIX D

Grizzly bear mortality along US Highway 93 North on the Flathead Indian Reservation

Reported road mortality of grizzly bears along US Highway 93 North on the Flathead Indian Reservation (1998-2022) (Source: Payton Adams, Wildlife Biologist, CSKT Wildlife Management Program).

Year	**Discovery or report date**	**US Highway 93 mile reference post**	**Location description**	**Species**	**Sex**	**Age**	**Comment**
1998	UNK	41.5	Canal across US93, access/canal road	Grizzly Bear	Female	2-year old female	
2001	UNK	37	Post Creek: right before guard rail on northbound lane	Grizzly Bear	Female	Subadult	
2002	UNK	37	Post Creek: right before guard rail on northbound lane	Grizzly Bear	Female	Adult	
2010	5-May-10	41.3	Canal across US93, access/canal road.	Grizzly Bear	Male	Yearling	
2010	21-Jun-10	40	Gunlock	Grizzly Bear	Male	Adult	
2012	20-Sep-12	31.8		Grizzly Bear	Male	Cub of the year	
2012	5-May-12	34.8	South of Lemery Road, approx. 150 yrds north of crossing structure	Grizzly Bear	Male	Adult	
2013	2-Oct-13	37	Post Creek	Grizzly Bear	Unknown	Unknown	Skeleton
2015	13-Oct-15	46	Beaverhead Road/Scenic Turnout south of Ronan	Grizzly Bear	Male	Cub of the year	
2018	29-May-18	35	Interection of Lemery Road/Pinsonault Rd	Grizzly Bear	Female	Unknown	
2018	27-Jul-18	44.75	Vicinity Crow Creek/Bev's Bloomers	Grizzly Bear	Female	Adult	
2018	27-Jul-18	44.75	Vicinity Crow Creek/Bev's Bloomers	Grizzly Bear	Female	Cub of the year	
2018	27-Jul-18	44.75	Vicinity Crow Creek/Bev's Bloomers	Grizzly Bear	Male	Cub of the year	

2018	27-Jul-18	44.75	Vicinity Crow Creek/Bev's Bloomers	Grizzly Bear	Male	Cub of the year	Euthanized due to loss of mother and no location to send animal
2018	24-Aug-18	44.1	Crow Creek	Grizzly Bear	Male	Adult	
2018	18-Oct-18	35	Vincinty interection of Lemery Road/Pinsonault Rd	Grizzly Bear	Unknown	Unknown	
2018	18-Oct-18	35	Vincinty interection of Lemery Road/Pinsonault Rd	Grizzly Bear	Unknown	Unknown	
2019	7-Nov-19	35.4	North of Lemery Road	Grizzly Bear	Male	Cub of the year	
2019	24-Sep-19	41.3	West side of highway north of 9-pipe lodge	Grizzly Bear	Female	Adult	
2019	7-Dec-19	34.4	Wheeler property	Grizzly Bear	Female	Cub of the year	
2020	4-Sep-20	40.9	9 pipe bridge	Grizzly Bear	Female	Adult	
2021	27-Jul-21	41.5	FWP pond pullout, south of irrigation canal	Grizzly Bear	Unknown	Cub of the year	

16 APPENDIX E

Survey

Grizzly bears and US Hwy 93 on the Flathead Indian Reservation

This survey is part of a project through the Confederated Salish and Kootenai Tribes, and it is funded by US Fish and Wildlife Service.

If you can and want to, please complete this survey. In addition, please forward the link to this survey to others who are familiar with grizzly bears and US Hwy 93 on the Flathead Indian Reservation, as long as they are affiliated with one of the following organizations:
1. Confederated Salish and Kootenai Tribes.
2. Montana Department of Transportation.
3. Federal Highway Administration.
4. US Fish and Wildlife Service.

The survey is short (6 questions) and should only take a few minutes to complete.

The purpose of this survey is to document the potentially different perspectives of the 4 organizations regarding:
1. Direct road mortality of grizzly bears and the barrier effect of US Hwy 93 on grizzly bears.
2. The "desirable" potential future situation.
3. What measures are supported to reach that "desirable" potential future situation.

The questions relate to US Hwy 93 on the Flathead Indian Reservation in general. They relate to the road sections that are already upgraded and (partially) mitigated, as well as the road section through the Ninepipe wetland area that has not been upgraded or mitigated yet.

This survey is voluntary; you are under no obligation to participate in this survey. If you do not want to answer a question, please skip it and proceed to the next one. While we do not collect personal data, we do ask you to identify the organization you are affiliated with. However, if you are not comfortable identifying the organization you are affiliated with, please skip this question.

Please complete the survey by end of day **Mon 16 January 2023**.

Definition "Direct road mortality of wildlife": Wildlife mortality caused by vehicle collisions. Depending on the species, direct road mortality does not only result in the death of the individual animal, but it can also reduce the population viability of a species in an area.

Definition "Barrier effect": Many animal species are less likely to cross an unmitigated highway compared to moving through a landscape without roads. Traffic and other disturbance associated with a highway can keep animals from crossing a transportation corridor; highways are a barrier, or a partial barrier, to their movements. The types of movements that may be impacted include daily movements between areas on either side of a road, seasonal migration, and "once-in-a-lifetime" dispersal that may allow for recolonization or the strengthening of small and isolated populations. No or reduced movement can affect individual survival, gene flow, ecological integrity, and population viability of a species in an area.

Once the report to US Fish and Wildlife Service is finalized and published, you will receive a link to the PDF.

For questions, please contact:
Dr. Marcel Huijser
marcelhuijser@mphetc.com
406-543-2377

1. Direct road mortality of grizzly bears along this road section is currently too high (select one)

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree
- Other (please specify)

2. The barrier effect for grizzly bears of this road section is currently too high (regardless of gender or age) (select one).

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree
- Other (please specify)

3. What do you see as a desirable future situation for this road section regarding direct road mortality? (select one)

- Direct road mortality for grizzly bears is (nearly) "eliminated"
- Direct road mortality for grizzly bears is "reduced" (but not nearly eliminated)
- Direct road mortality for grizzly bears does not need to be "reduced"
- Other (please specify)

4. What do you see as a desirable future situation for this road section regarding connectivity? (select one)

- Grizzly bears (both genders, any age category) "frequently" cross the road
- Grizzly bears (not necessarily both genders, not necessarily any age category) "sometimes" cross the road
- Grizzly bears do not need to cross the road
- Other (please specify)

5. What measures do you support should the objective be to reduce direct road mortality and increase connectivity for grizzly bears? (select all that apply)

- Fences over "short" distances (perhaps up to a few hundred yards or a few miles)
- Fences over "long" distances (longer than a few miles)
- Cattle or wildlife guards at access roads, driveways or agricultural access points
- Electrified barriers at access roads, driveways or agricultural access points
- "Narrow" underpasses (about 7 m wide, 4 or 5 m high)
- "Wide" underpasses (several dozens or hundreds of meters wide, 4 or 5 m high)
- "Narrow" overpasses (10-30 m wide)
- "Wide" overpasses (50-70 m wide)
- Other (please specify)

6. What organization are you affiliated with? (select one)

- Confederated Salish and Kootenai Tribes
- Montana Department of Transportation
- Federal Highway Administration
- United States Fish and Wildlife Service