Big Game and Roadway Mitigation Strategy

Highway 120 Meeteetse to Cody

Prepared For:
The Wyoming Department of Transportation

The Wyoming Game and Fish Department

Prepared By:
Hall Sawyer, Western Ecosystems Technology

Funded By:
The Beyond Yellowstone Program

Table of Contents

Acknowledgements: Thanks to K. Barker, C. Class, A. Middleton, R. Merritt, T. Mong, and C. Riginos for project assistance and report review.

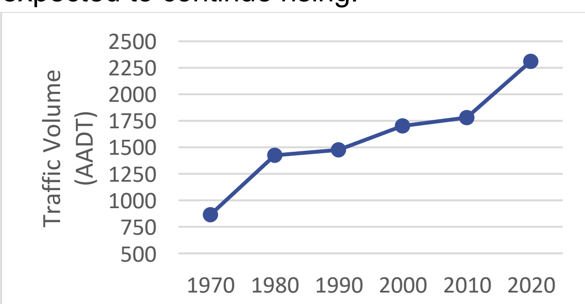
Suggestion Citation: Sawyer, H. 2024. Big Game Roadway and Mitigation Strategy – Wyoming Highway 120 Meeteetse to Cody. Western EcoSystems Technology, Inc., Laramie, WY, USA.

1.0 Introduction

Roadways where wildlife-vehicle collisions (WVC) occur are dangerous for motorists and can be a significant source of mortality for wildlife populations (Clevenger et al. 2001, Sawyer et al. 2012). On average, more than 7,600 ungulates are killed each year on Wyoming roadways (Riginos 2022), with an average cost annual cost exceeding 200 million dollars (Paul et al. 2023). Migratory ungulates can present particularly acute challenges because large numbers of animals move across roadways seasonally (Sawyer et al. 2016). Further, some population segments may move more heavily at night – when motorist visibility is limited – to avoid higher levels of human disturbance (e.g., hunting pressure, traffic) during daylight hours (Gaynor et al. 2018). Independent of WVCs, roadways can have detrimental effects on big game simply by blocking movements, reducing landscape connectivity and limiting available habitat (Clevenger and Waltho 2000, Bissonette and Adair 2008, Sawyer et al. 2016, Passoni et al. 2021). Migratory big game are especially vulnerable to movement barriers like roads, because they rely on movement to access forage, respond to weather conditions and human disturbance, find mates, and avoid predation (Mueller and Fagan 2008, Teitelbaum and Mueller 2019). Compared with species like deer and elk that can readily jump over most right-of-way fences, pronghorn are especially vulnerable to roadway impacts because they must move underneath right-of-way fencing, rather than simply jumping over (DeVoe et al. 2022, Jones et al. 2022). With expanded roadways and higher traffic volumes, WVCs continue to increase and roadway permeability decrease (Jacobson et al. 2016). The purpose of this study was to evaluate the needs and opportunities along Highway 120 between Meeteetse and Cody, to reduce WVCs and improve roadway permeability for affected big game populations.

2.0 Study Area

The study area was defined by the Wyoming Highway 120 corridor between Meeteetse and Cody. This roadway sits on the east side of the Greater Yellowstone Ecosystem and bisects the Bighorn Basin. This portion of Wyoming harbors six ungulates species and five large carnivores which are often associated with their migrations and seasonal ranges (Middleton et al. 2020). A recent study of the pronghorn shows long-distance migration and reliance of seasonal ranges on opposite sides of Highway 120 (Sawyer and Telander 2022). We divided the study area into 4 sections, beginning at milepost 52.0 and ending at milepost 79.4 (Fig. 1). The study area has been identified as a wildlife-vehicle collision (WVC) hotspot by multiple sources (Riginos 2022, Paul et al. 2023). The average annual daily traffic (AADT) volume continues to increase and recently exceeded the 2,000 AADT threshold (Fig. 1), where big game road crossings become especially dangerous for wildlife (Riginos et al. 2018*b*). Given local population growth and rising annual visitation to nearby Yellowstone National Park, the AADT is expected to continue rising.



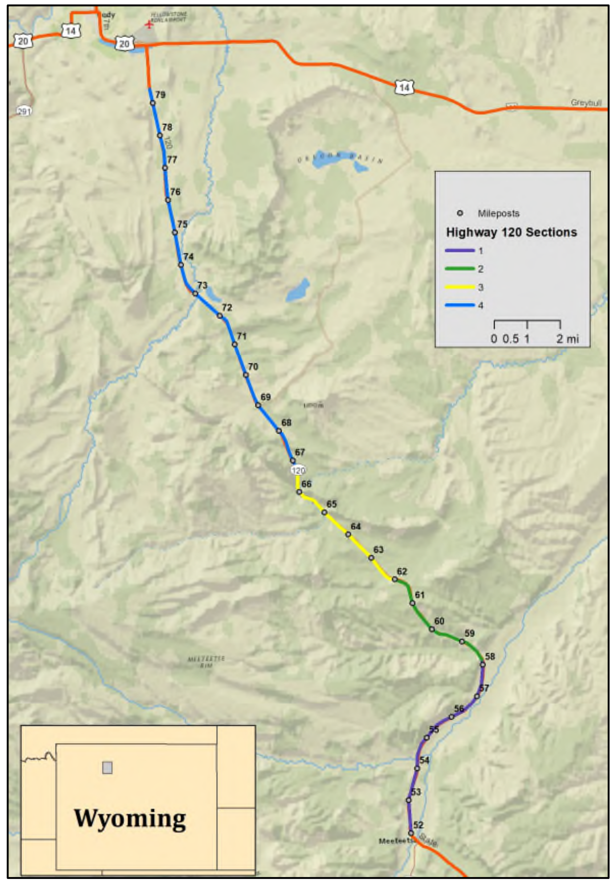


Figure 1. Study area and four highway sections along Highway 120 between Meeteetse and Cody, Wyoming (right). Annual average daily traffic (AADT) trends, 1970-2020 (left).

2.1 Section 1

Section 1 extends from the outskirts of Meeteetse at mile post 52 for approximately 6 miles and ends at the junction of Highway 120 and the Lower Greybull Road at mile post 58.4. This section is characterized by private croplands and several steeper ravines and sagebrush draws in the northwest portion. Both white-tailed deer and mule deer commonly feed in the irrigated croplands and highway right-of-way. Most WVCs involving white-tailed deer and mule deer occur in this section (See WVC chapter). Mule deer tend to move in between the sagebrush draws on the west side of the highway and agricultural fields on the east side of the highway (Fig. 2). Right-of-way fencing is mixed through the section and includes 4 and 5-strand wire, and short sections of woven wire. The section includes two existing structures with the potential to move big game underneath the roadway, including a double box culvert along Spring Creek at mile post 52.5 (Fig. 3) and a span bridge over Meeteetse Creek at mile post 54.3 (Fig. 4).

Figure 2. Section 1 (view south), where mule deer commonly move from sagebrush draws (right) to feed in irrigated croplands (left).

Figure 3. Double-box culvert along Spring Creek (view west). The left tunnel is lower for water flow and the right tunnel is higher for livestock movement. With some modifications, the dry tunnel could potentially be used by deer to cross underneath Highway 120.

Figure 4. Span bridge over Meeteetse Creek (view north) includes some upland habitat with potential to move mule and white-tailed deer underneath Highway 120.

2.2 Section 2

Section 2 extends from the Lower Greybull Road at mile post 58.4 approximately 4 miles and ends at the bottom of Meeteetse Rim at mile post 62.0 (Fig. 1). This section is generally characterized by rolling sagebrush ridges and draws administered by the Bureau of Land Management. Although some mule deer can be found here, elk are the primary concern in this section (Fig. 5.) and most WVCs with elk occur in this section. In a recent incident in October 2023, 7 elk were killed by one vehicle (Fig. 6). This section includes an existing double box culvert along Cottonwood Creek at mile post 58.4 but is not maintained for wildlife use (Figs 7,8). Between mileposts 60 and 61, approximately 0.3 mi of right-of-way fence has been modified with wooden top-rail to facilitate elk movements across the highway (Fig. 9). The remaining right-of-way fences are 4 strand wire fences.

Figure 5. Signage at the Lower Greybull Road warns motorists of elk crossings in Section 2.

Figure 6. Several elk carcasses in Section 2 following elk-vehicle collision in October 2023. Other wounded elk had to be euthanized by the Wyoming Game and Fish Department.

Figure 7. Double-box culvert along Cottonwood Creek (view north).

Figure 8. Double-box culvert along Cottonwood Creek (view east). The right tunnel is lower for water flow and the left tunnel is higher for potential livestock movement. With some modifications, the dry tunnel could potentially be used by deer or elk to move underneath Highway 120.

Figure 9. Top rail fence modifications designed to facilitate elk movements and minimize fence damage in Section 2.

2.3 Section 3

Section 3 extends from the bottom of Meeteetse Rim at mile post 62 approximately 5 miles and ends just north of the Stage Station (South Fork of Dry Creek) at County Road 3FK near mile post 67.0. This section is generally characterized by open and rolling sagebrush, with a prominent ridge bisecting the north end of the section. Thousands of pronghorn from the Carter Mountain Herd cross Highway 120 in this section between mile posts 63 and 65 – an area locally referred to as the “Antelope Alley Crossing” (Fig. 10). Wildlife-vehicle collisions in the section are dominated by pronghorn. The section is primarily BLM lands, interspersed with smaller sections of private land. The right-of-way fencing is 4-strand wire built to wildlife-friendly specifications. The section has a double-box culvert at milepost 62.4 along Sage Creek, but has low potential for big game use because of water and undesirable approach characteristics (Fig. 11).

Figure 10. Trails from pronghorn crossing Highway 120 near mile post 63. The staples from bottom wire have been ripped out and fence stays bent, from pronghorn moving underneath. This highway crossing is in the middle of a high-use migration corridor that pronghorn rely on to access seasonal ranges.

Figure 11. Double-box culvert at milepost 62.4 is large enough to move big game underneath roadway, but the drainage and site characteristics have low potential for big game movements.

2.4 Section 4

Section 4 extends from County Road 3FK near mile post 67 approximately 12 miles and ends just south of Cody at the Highway 120 Closure Gate. This section is generally characterized by open and rolling sagebrush, with a mix of private, state, and federal lands. Wildlife-vehicle collisions in the section predominately involve pronghorn. Most of the right-of-way fencing is 4-strand wire built to wildlife-friendly specifications, but there is approximately 0.8 mi of woven wire immediately south of Sage Creek, between mileposts 72 and 73. The existing open-span bridge over Sage Creek may provide opportunity for funneling deer, elk, and pronghorn underneath the highway, especially on the south side (Fig. 12).

Figure 12. Span bridge over Sage Creek at mile post 72.9 includes some upland habitat with potential to move big game underneath Highway 120 (view north).

3.0 Wildlife-Vehicle Collisions

Highway 120 between Meeteetse and Cody is widely recognized as a wildlife-vehicle collision (WVC) “hotspot” (Riginos 2022), with approximately 100 documented carcasses per year. It is important to note that WYDOT carcass counts are only an index to the actual number of animals killed each year, which are typically 2-3x higher (Lee et al. 2021). A recent report covering the western US identified this section of Highway 120 as a WVC and Ecological Connectivity Hotspot, where the construction of overpasses and/or underpasses met specific economic and ecological criteria (Paul et al. 2023). Consistent with other regions in Wyoming (Riginos 2022), mule deer comprised the largest proportion of WVCs (63%), followed by pronghorn (16%), white-tailed deer (15%), and elk (6%), respectively (Fig. 13a). However, the proportion of pronghorn WVCs were more than 2x the state average of 7% (Riginos 2022). Of particular concern is that WVC rates along Highway 120 do not track population trends (Table 3.1). For example, the number of mule deer WVCs was consistent each year, despite a declining deer population. Relatedly, the number of pronghorn and white-tailed deer WVCs are increasing, yet their overall populations are not growing. Based on WYDOT data from the last 10 years, WVCs along Highway 120 are increasing at a rate of 6% per year (Fig. 13b). This annual increase is exacerbated because WVC rates do not appear to track population trends, so that the proportion of mortality from WVCs continues to rise.

Given the rising level of traffic along Highway 120 (Fig. 1), we should expect WVC rates to initially increase as the "gap" or time in between consecutive vehicles is reduced (Jacobson et al. 2016). However, once a certain threshold is reached, the traffic volume then becomes a complete (or near-complete) barrier to ungulate movement (Jacobson et al. 2016). Research from Wyoming suggests deer can safely cross roadways when vehicle gaps are >60 seconds, however once gaps are reduced to 30 seconds or less deer no longer attempt to cross (Riginos et al. 2018*b*). We expect pronghorn need even larger gaps because they tend to cross in larger groups and have more difficulty negotiating right-of-way fencing. We do not know what specific traffic volume (AADT) will block elk, deer, or pronghorn movements across Highway 120, but the ability of ungulates to cross will continue to deteriorate as traffic volumes increase.

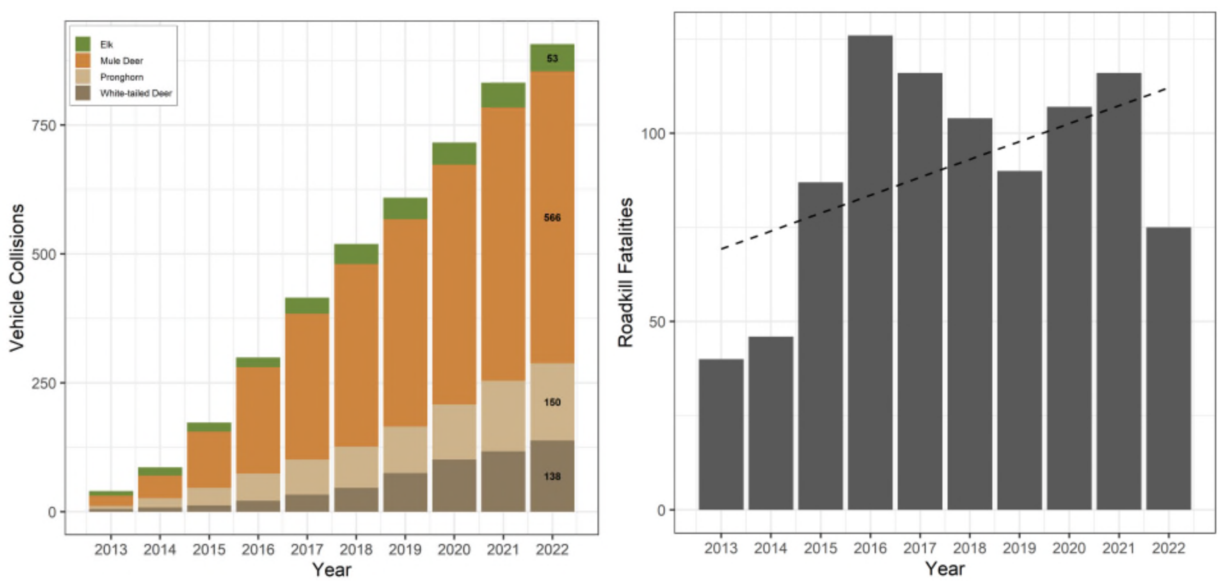


Figure 13. A) Left panel shows cumulative wildlife-vehicle collisions for elk, mule deer, pronghorn, and white-tailed deer along Highway 120, 2013-2022. Approximately 1,000 carcasses were detected in that 10-year period. B) Right panel shows wildlife-vehicle collisions are increasing along Highway 120 at rate of 6% per year (dashed line is regression trend).

Table 3.1 Population and wildlife-vehicle collision (WVC) trends for elk, mule deer, pronghorn, and white-tailed deer along the Highway 120 corridor from Meeteetse to Cody.

Species	5-Year Population Trend	Highway 120 WVC Trend
Elk	Stable	Stable/consistent
Mule Deer	Declining	Stable/consistent
Pronghorn	Stable	Increasing
White-tailed Deer	Stable	Increasing
Overall	n/a	Increasing at 6% per year

4.0 Big Game Population Trends and Movement Patterns

4.1 Elk

The study area bisects the Cody Elk Herd Unit, which is currently 10% below its population objective of 4,400, but generally considered a stable population over the last five years (Wyoming Game and Fish Department 2022). Most elk reside west of Highway 120, however seasonal movements east of the highway have increased in recent years and can vary depending on harvest levels east of Highway 120. The Wyoming Game and Fish Department maintains liberal elk hunting seasons east of the highway to minimize the number of elk and reduce damage to private property. Importantly, the health or size of the broader Cody Elk Herd does not rely on seasonal movements or migrations east of Highway 120. The GPS elk movement data that are currently available show most highway crossings between mileposts 66.0 and 70.5 (Fig. 14). However, most WVCs occur in Section #2 between mileposts 58 and 62 (Figs. 16,17). Over the last 10 years, elk have comprised 6% of WVCs. Although elk comprise a small percentage of overall WVCs, their collisions can be more damaging than deer and pronghorn.

4.2 Mule Deer

The Highway 120 corridor overlaps with three different mule deer herd units, including the Upper Shoshone, Greybull River, and Owl Creek/Meeteetse. These herds are 34%, 82%, and 71% below objective, respectively and generally declining (Wyoming Game and Fish Department 2022). Although an abundance of GPS mule deer data are available in surrounding areas (e.g., South Fork of the Shoshone River), data are currently limited along the Highway 120 corridor (Fig. 14). Records of two individual deer were available and showed short migratory movements to Carter Mountain. Most mule deer mortality occurs in Section #1 (Figs 16,17).

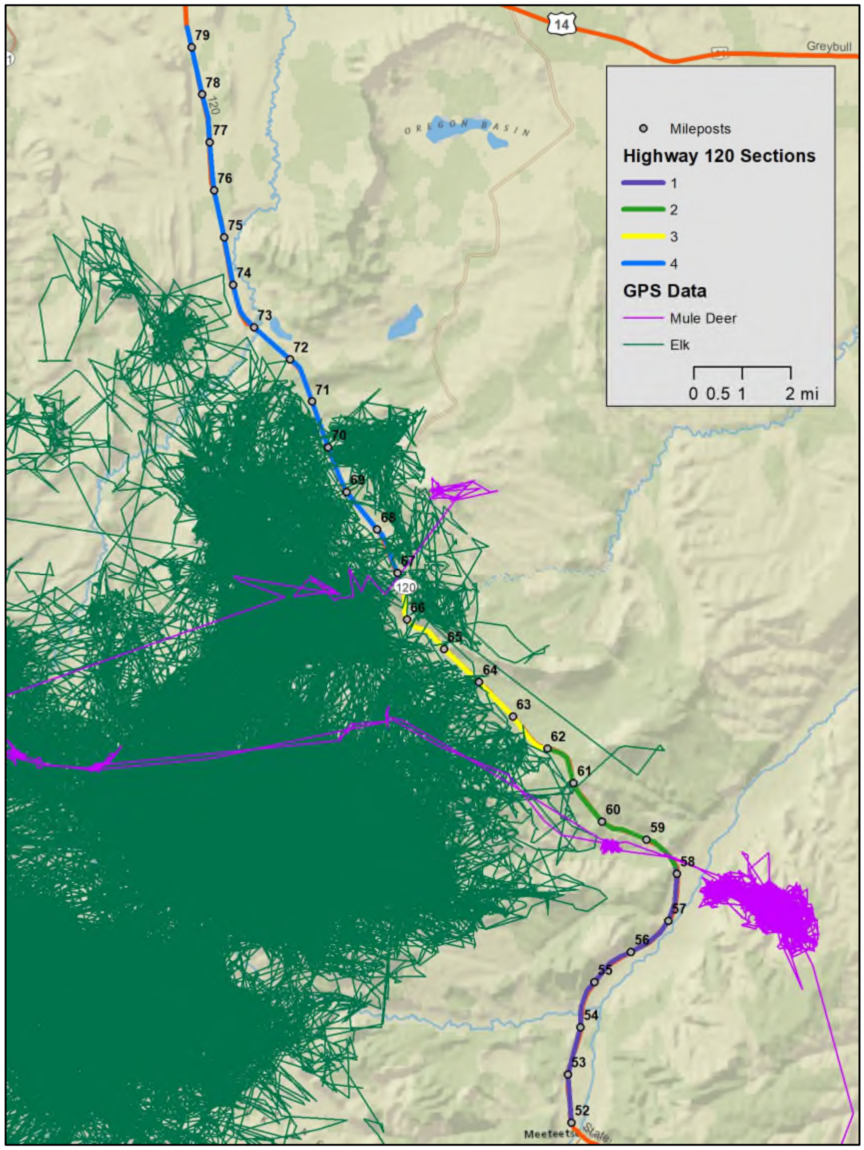


Figure 14. Available movement data collected along the Highway 120 corridor from GPS-collared elk (green) and mule deer (purple). Data provided by Wyoming Game and Fish Department, University of Wyoming, and UC Berkeley.

4.3 Pronghorn

The study area bisects the Carter Mountain Pronghorn Herd Unit which is currently stable at a population objective of 7,000. The WGFD recently completed a GPS study to document the seasonal movement and distribution patterns of this herd (Sawyer and Telander 2022), so excellent movement data is available along the Highway 120 corridor (Fig. 15). Pronghorn in the Carter Mountain Herd Unit include both resident and migratory animals. Compared to the resident population, the migratory pronghorn tend to be more productive and successfully recruit more fawns each year (Wyoming Game and Fish Department 2022). The migratory animals number in the thousands and generally move west of Highway 120 in the spring (March-April) and migrate back to the Bighorn Basin in the fall (October). The timing and duration of the spring migration is more variable than the fall migration (Sawyer and Telander 2022). Most pronghorn crossed the highway between mileposts 63 and 64, along a well-defined, high-use migration corridor. Many pronghorn also crossed between mileposts 71 and 72 along a moderate-use corridor. This is believed to be the largest pronghorn migration across any roadway in North America. Pronghorn mortality was more concentrated in Section #3 and more dispersed Section #4 (Figs. 16,17).

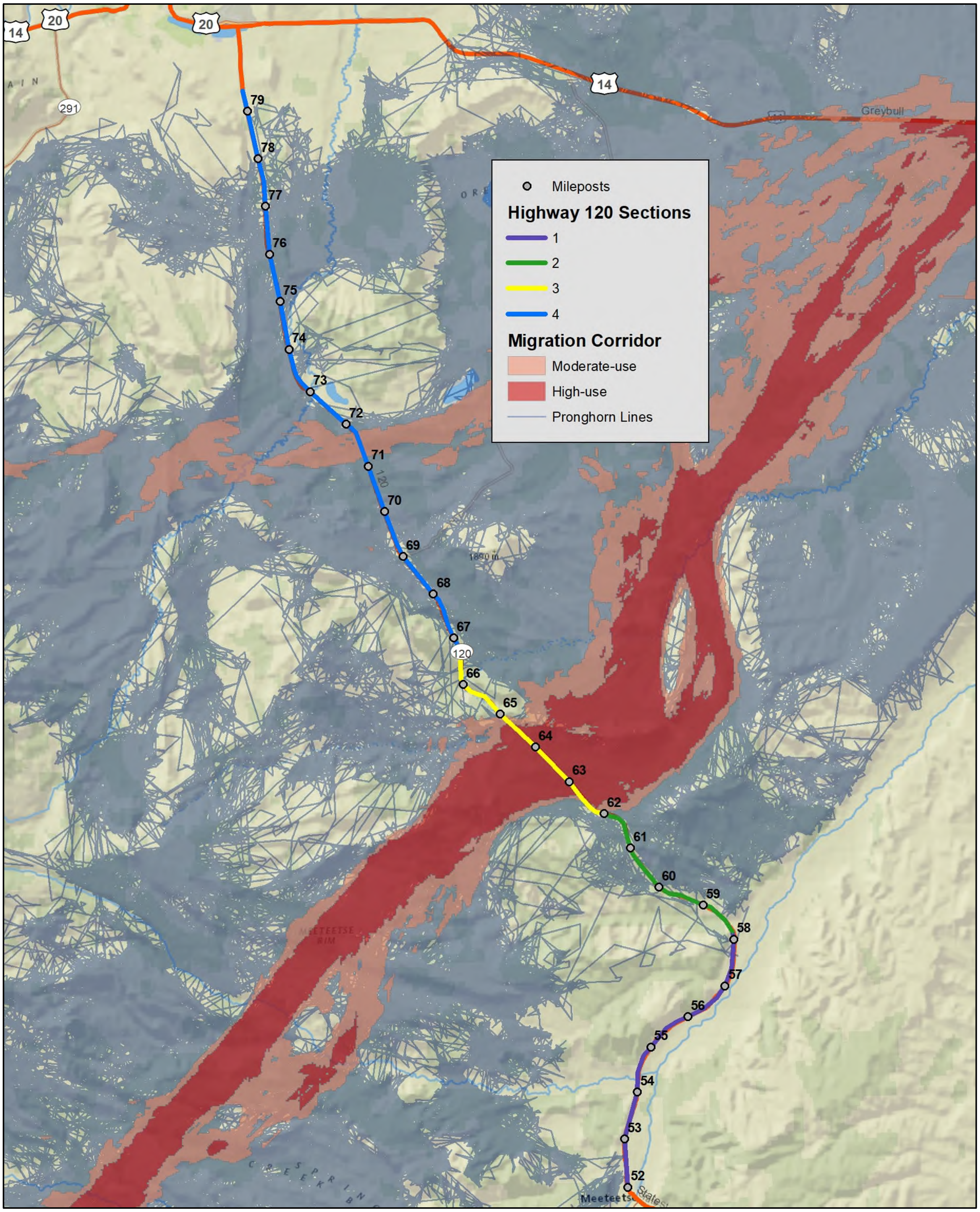


Figure 15. Movement and migration routes of GPS-collared pronghorn along the Highway 120 corridor (Sawyer and Telander 2022).

4.5 White-tailed Deer

White-tailed deer are not part of a larger herd unit, but their numbers are stable despite recent disease outbreaks and rising chronic wasting disease (CWD) prevalence (Wyoming Game and Fish Department 2022). Most white-tailed deer are restricted to riparian corridors and agricultural fields adjacent to Section #1, between mile posts 52 and 58.

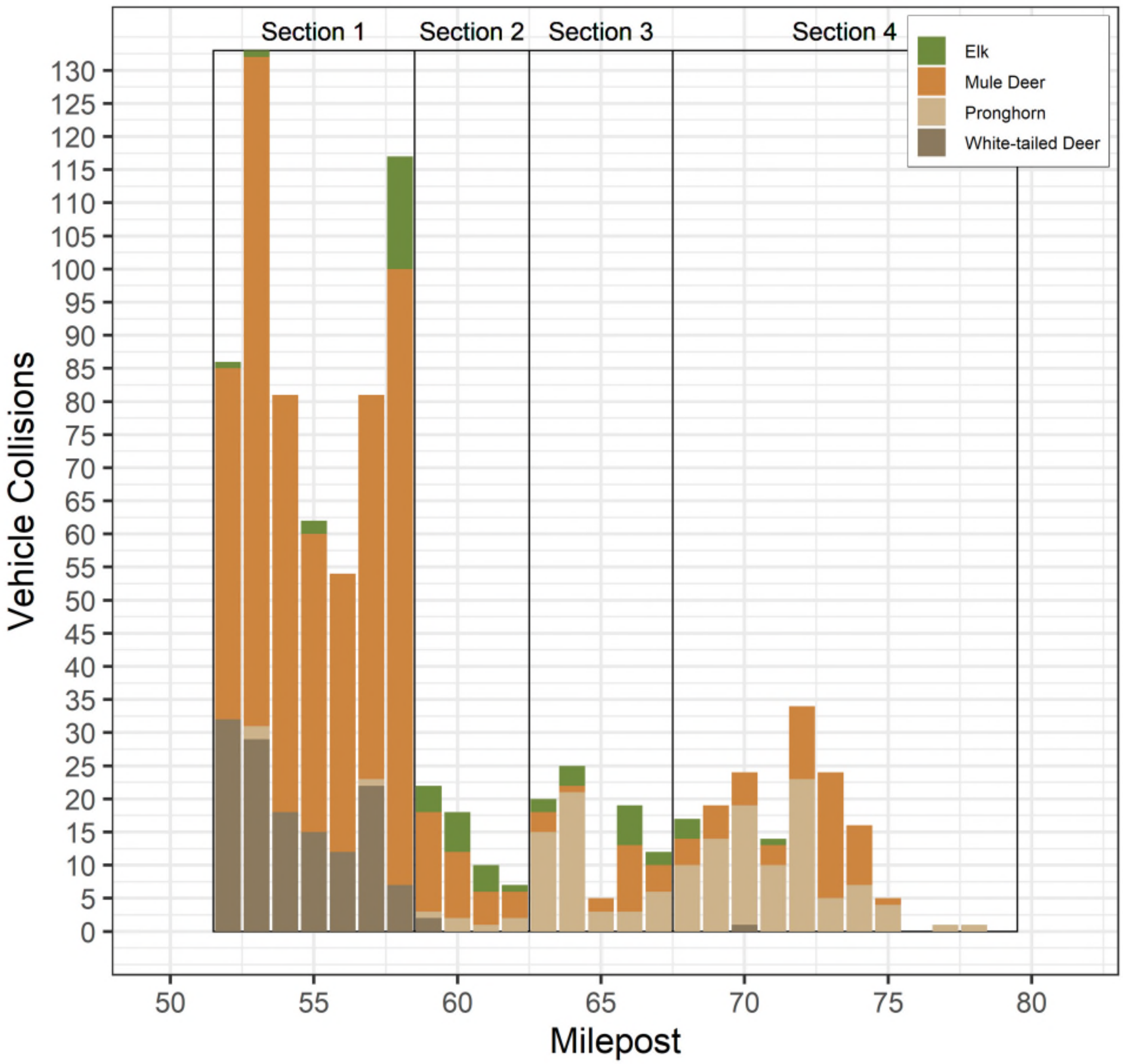


Figure 16. Number of wildlife-vehicle collisions along Highway 120 at each mile post, 2013-2022.

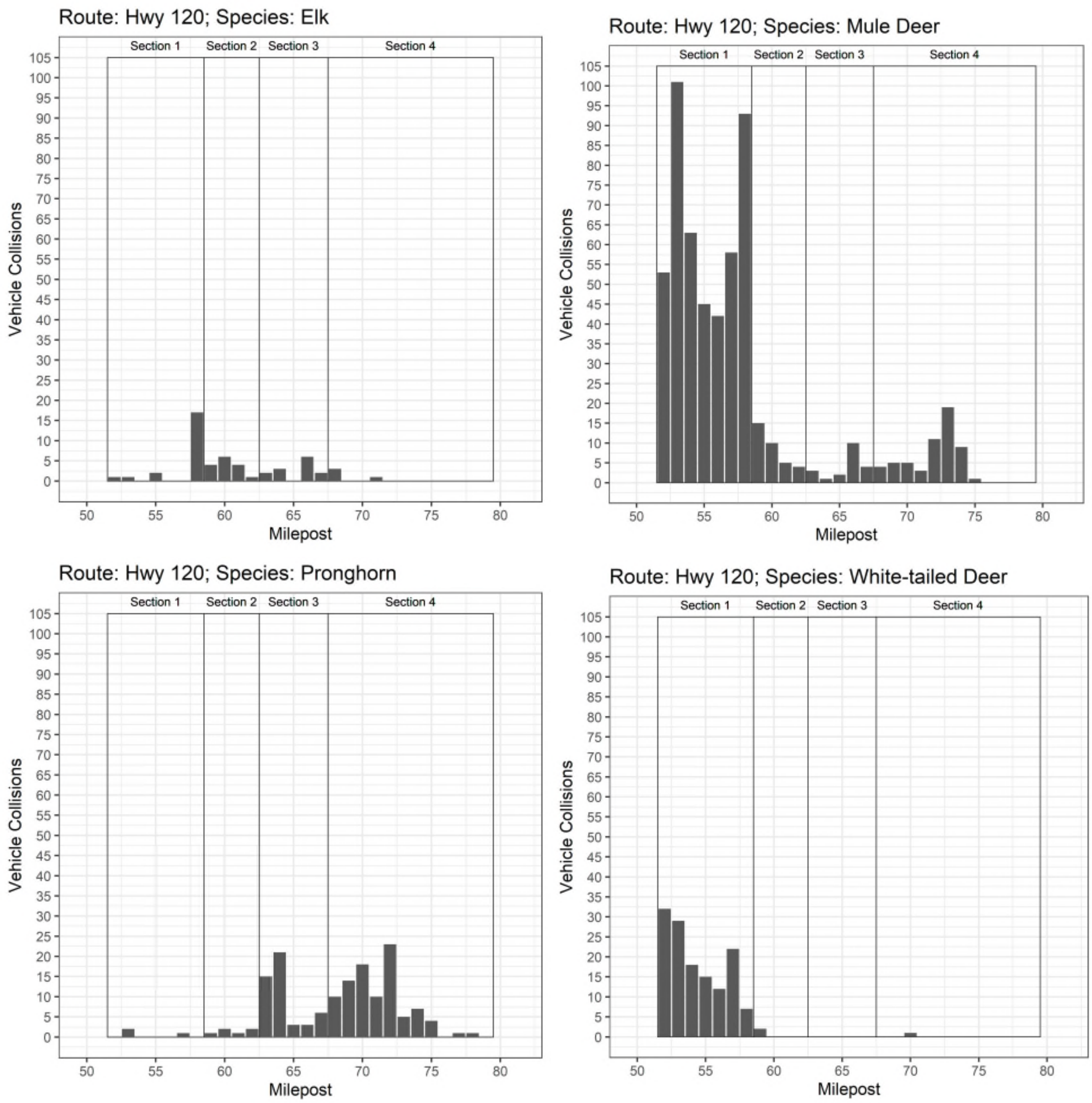


Figure 17. Number of wildlife-vehicle collisions along Highway 120 at each mile post for elk (top left), mule deer (top right), pronghorn (bottom left), and white-tailed deer (bottom right), 2013-2022.

5.0 Mitigation Strategies

Mitigation efforts aimed at reducing WVCs can range from simple signage to warn motorists of danger (Gordon et al. 2004), to exclusionary fencing that keeps wildlife off roads (Clevenger et al. 2001), to multi-million dollar crossing structures that improve motorist safety and allow animals to safely cross roadways (Brennan et al. 2022). In general, the most effective options are the most expensive. For example, reducing speed limits are not costly to implement, but have not helped reduce WVC with deer in Wyoming (Riginos et al. 2022). Relatedly, warning lights/signs and various detection systems can help modify motorist behavior, but results for reducing WVC risk have been mixed (Reeve and Anderson 1993, Gordon et al. 2004, Riginos et al. 2018*a*, 2022) - including a detection system installed at Trapper's Point along Highway 191 near Pinedale that was unreliable and expensive to maintain. The modification of roadside vegetation, such as clearing certain areas to improve visibility for motorists, can be effective for reducing WVC risk (Montgomery et al. 2012, Meisingset et al. 2014) but is limited to areas with trees or tall shrubs. When paired with appropriate fencing, wildlife underpasses and overpasses are by far the most effective means for reducing WVCs and maintaining habitat connectivity for wildlife (Smith et al. 2015, Brennan et al. 2022), including those constructed in Wyoming (Sawyer et al. 2012, 2016). Such structures typically reduce WVCs by 80-90% (Sawyer et al. 2012, 2016, Simpson et al. 2016). Although underpasses and overpasses are expensive to build, the cost-savings they trigger from reducing WVCs – which now carry an estimated cost of $19,089 per deer (Huijser et al. 2022) – can be significant, and pay for the investment in years rather than decades (e.g., Sawyer et al. 2016). Further, the benefits of overpass and underpasses extend to a wide range of species and can also simplify livestock movement (Sawyer et al. 2016). Below we list potential several mitigation options for each section of Highway 120.

5.1 Section 1

- Continue mowing efforts and consider increased vegetation removal on west side of highway, where shrub and tree encroachment is occurring.
- Remove or treat palatable vegetation species (e.g., clover, alfalfa) growing in right-of-way.
- Coordinate with landowners on potential to increase white-tailed deer harvest.
- Coordinate with landowners and consider options (e.g., fence modification, vegetation removal, earthwork, etc.) that would allow deer to move underneath Highway 120 via existing structures at mile posts 52.5 (double box culvert at Spring Creek) and 54.3 (span bridge over Meeteetse Creek).

5.2 Section 2

- Continue to operate moving warning signs and try to coordinate signage with elk movements.

- Consider how effective (or not) elk harvest and hunting seasons on the east side of Highway 120 are at minimizing elk movement from across Highway 120. It may be possible to manage the growing number of elk-vehicle collisions through harvest level and allocation.

- Coordinate with landowners and consider options (e.g., fence modification, vegetation removal, etc.) that would allow deer and elk to move underneath Highway 120 through the existing double box culvert at mile posts 58.4. Given that most elk-vehicle collisions occur nearby (Figs. 6, 16), this may be a good site to consider replacing box culvert with an underpass and wing fencing that could funnel nearby elk and deer movements. Alternatively, the cut banks on the Cody side of the guardrails near mile post 59 may provide a practical location for overpass construction.

5.3 Section 3

- Consider warning signs between mile posts 62 and 65 (Antelope Alley) to flash or operate during spring and fall pronghorn migration periods. The sight distances in this section can be short for motorists to respond to wildlife on the road.

- Consider right-of-way fence panels or sections that can be dropped in Antelope Alley during spring and fall migrations to facilitate roadway crossings for pronghorn. If drop fences are not feasible because of cattle grazing, then fixed pipe fence gaps (e.g. 10'-wide) could be installed (see example here) so that bottom pipe allows plenty of room (≥18") for pronghorn to move underneath. There are several existing pronghorn trails that could be targeted.

- The pronghorn migration route receives intense hunting pressure on BLM lands where it crosses Highway 120. Anecdotal observations suggest hunting pressure and associated human activity disrupt pronghorn movements and make it difficult for them to cross the highway during daylight hours of the fall migration. Given the relatively poor sight distances along this stretch of highway, pronghorn crossing at night are likely more susceptible to WVCs. Efforts should be made to evaluate how pronghorn hunting season structure or regulations might be modified to limit disturbance to migratory pronghorn attempting to cross Highway 120. For example, hunting could be restricted some distance from the highway, as the Wyoming Game and Fish Commission did at Trapper's Point to discourage hunting within a ½-mile of the pronghorn crossing on US Highway 191. In the case of Highway 120, we know these pronghorn continue migrating northeast along a well-defined corridor beyond the highway on public lands (Fig. 15), so hunter opportunity would unlikely be diminished if some sort of restriction were applied near the highway.

- Unlike deer and elk herds in the study area, a large and highly productive segment of the Carter Mountain Pronghorn Herd relies on summer ranges west of Highway 120 and winter ranges east of Highway 120. Absent the ability to cross the highway, the viability of this herd numbering ~7,000 animals is at risk. And, unlike deer and elk that can easily jump most right-of-way fencing, pronghorn need to move underneath fences, which can be difficult in stretches with low bottom wires, or periods with snowpack, or high traffic volumes. Traffic volumes along Highway 120 have exceeded 2,000 average annual daily traffic (AADT) – a level at which ungulate roadway crossings tend to become more dangerous and difficult (Riginos et al. 2018*b*). This is especially true for pronghorn because they move in larger groups require more time to negotiate right-of-way fences. Given traffic volumes are only going to increase, the section between mile post 63 and 64 would be a desirable location for a wildlife overpass, as it would fully accommodate the high-use migration route of pronghorn across Highway 120 (Fig. 15) and ensure connectivity between the Bighorn Basin and Absaroka Front. In Wyoming, the benefits of overpass installation extend to a wide range of species and can also expedite livestock movement (Sawyer et al. 2016).

5.4 Section 4

- Consider warning signs between mile posts 71 and 72 to flash or operate during spring and fall pronghorn migration periods.

- Consider right-of-way fence panels or sections that can be dropped during spring and fall migrations to facilitate roadway crossings for pronghorn. If drop fences are not feasible because of cattle grazing, then fixed pipe fence gaps (e.g. 10’-wide) could be installed (see example here) so that bottom pipe allows plenty of room (≥18”) for pronghorn to move underneath. There are several existing pronghorn trails that could be targeted.

- Coordinate with landowners and consider options (e.g., fence modification, vegetation removal, etc.) that would allow deer, pronghorn, and possibly elk to move underneath Highway 120 through the existing bridge over Sage Creek at mile post 72.9.

- The section between mile post 71 and 72 marks another desirable location for a wildlife overpass to accommodate the pronghorn migration route across Highway 120 (Fig. 15) and ensure connectivity between the Bighorn Basin and Absaroka Front. In Wyoming, the benefits of overpass installation extend to a wide range of species and can also expedite livestock movement (Sawyer et al. 2016).

6.0 Summary

Highway 120 between Meeteetse and Cody is widely recognized as a wildlife-vehicle collision (WVC) hotspot (Riginos 2022, Paul et al. 2023), where wildlife overpass or underpass construction meets specific economic and ecological criteria (Paul et al. 2023). The number of WVCs is increasing 6% each year and incrementally accounting for a larger proportion of mortality in big game herds that are declining or stable. Like other parts of the state, most (63%) WVCs here involve mule deer (Fig. 18), yet the proportion of pronghorn WVCs is more than 2x the state average (Riginos 2022). Because thousands of pronghorn from the Carter Mountain Herd rely on seasonal migrations that cross Highway 120 (Fig. 15), the persistence of this population is closely linked to their ability to access summer ranges west of the highway and winter ranges east of the highway (Fig. 18), and likely represents the largest pronghorn migration across any roadway in North America. Compared with deer or elk that can easily jump fences, roadway crossings tend to be more difficult for pronghorn because they must move underneath right-of-way fencing, which can be challenging in sections with low bottom wires, or when snowpack reduces space underneath bottom wire, or during periods of high traffic volume when groups do not have sufficient time to crossing (sensu Jacobson et al. 2016). The ability for deer, elk, or pronghorn to cross Highway 120 will become more difficult and dangerous as traffic volume continues to increase (Fig. 1). We identify several areas where improvement of existing structures and construction of new underpasses or overpasses could improve motorist safety and permeability of Highway 120 to deer, elk, and pronghorn populations.

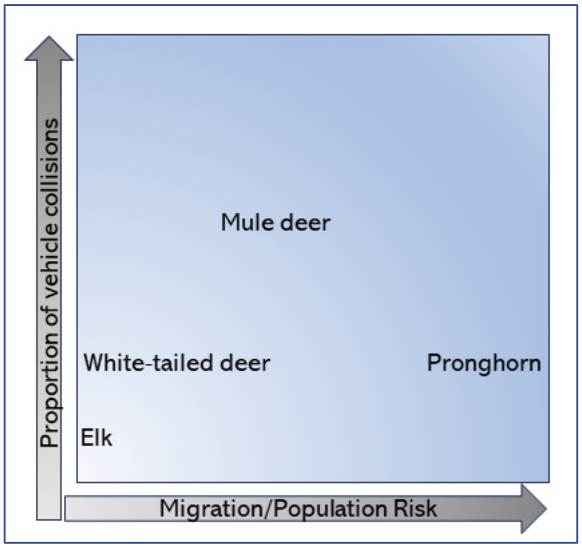


Figure 18. Elk, mule deer, pronghorn, and white-tailed deer differ relative to their wildlife-vehicle collisions rates (y axis) and risk of population-level effects from loss of migration across Highway 120 (x axis). Mule deer have the largest proportion of wildlife-vehicle collisions, but pronghorn have the highest risk of migratory loss and associated impacts to the larger herd.

7.0 References

Bissonette, J. A., and W. Adair. 2008. Restoring habitat permeability to roaded landscapes with isometrically-scaled wildlife crossings. Biological Conservation 141:482–488.

Brennan, L., E. Chow, and C. Lamb. 2022. Wildlife overpass structure size, distribution, effectiveness, and adherence to expert design recommendations. PeerJ 10:1–19.

Clevenger, A. P., B. Chruszcz, and K. E. Gunson. 2001. Highway mitigation fencing reduces wildlife-vehicle collisions. Wildlife Society Bulletin 29:646–653.

Clevenger, A. P., and N. Waltho. 2000. Factors influencing the effectiveness of wildlife underpasses in Banff National Park, Alberta, Canada. Conservation Biology 14:47–56.

DeVoe, J. D., K. M. Proffitt, and J. J. Millspaugh. 2022. Fence types influence pronghorn movement responses. Ecosphere 13:1–15.

Gaynor, K. M., C. E. Hojnowski, N. H. Carter, and J. S. Brashares. 2018. The influence of human disturbance on wildlife nocturnality. Science 360.

Gordon, K. M., M. C. McKinistry, and S. H. Anderson. 2004. Motorist response to a deer-sensing warning system. Wildilfe Society Bulletin 32:565–573.

Huijser, M. P., J. W. Duffield, C. Neher, A. P. Clevenger, and T. McGuire. 2022. Cost–benefit analyses of mitigation measures along highways for large animal species: An update and an expansion of the 2009 model. Transportation Pooled-Fund Project TPF-5(358). Nevada Department of Transportation. Carson City, NV.

Jacobson, S. L., L. L. Bliss-Ketchum, C. E. De Rivera, and W. P. Smith. 2016. A behavior-based framework for assessing barrier effects to wildlife from vehicle traffic volume. Ecosphere 7:1–15.

Jones, P. F., A. F. Jakes, S. E. Vegter, and M. S. Verhage. 2022. Is it the road or the fence? Influence of linear anthropogenic features on the movement and distribution of a partially migratory ungulate. Movement Ecology 10:1–13.

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

Meisingset, E. L., L. E. Loe, Ø. Brekkum, and A. Mysterud. 2014. Targeting mitigation efforts: The role of speed limit and road edge clearance for deer-vehicle collisions. Journal of Wildlife Management 78:679–688.

Middleton, A. D., H. Sawyer, J. A. Merkle, M. J. Kauffman, E. K. Cole, S. R. Dewey, J. A. Gude, D. D. Gustine, D. E. McWhirter, K. M. Proffitt, and P. J. White. 2020. Conserving transboundary wildlife migrations: recent insights from the Greater Yellowstone Ecosystem. Frontiers in Ecology and the Environment 18:83–91.

Montgomery, R. A., G. J. Roloff, and J. J. Millspaugh. 2012. Importance of visibility when evaluating animal response to roads. Wildlife Biology 18:393–405.

Mueller, T., and W. F. Fagan. 2008. Search and navigation in dynamic environments - from individual behaviors to population distributions. Oikos 117:654–664.

Passoni, G., T. Coulson, N. Ranc, A. Corradini, A. J. M. Hewison, S. Ciuti, B. Gehr, M. Heurich, F. Brieger, R. Sandfort, A. Mysterud, N. Balkenhol, and F. Cagnacci. 2021. Roads constrain movement across behavioural processes in a partially migratory ungulate. Movement Ecology 9:1–12.

Paul, K., J. Faselt, M. Bell, M. P. Huijser, D. Theobald, A. Keeley, and R. Ament. 2023. West-wide study to identify important highway locations for wildlife crossings. Bozeman, MT.

Reeve, A. F., and S. H. Anderson. 1993. Ineffectiveness of Swareflex Reflectors at reducing deer-vehicle collisions. Wildlife Society Bulletin 21:127–132.

Riginos, C. 2022. Impacts of roadways on wildlife in Wyoming: long-term and recent trends. Lander, WY.

Riginos, C., E. Fairbank, E. Hansen, J. Kolek, and M. P. Huijser. 2022. Reduced speed limit is ineffective for mitigating the effects of roads on ungulates. Conservation Science and Practice 4:1–13.

Riginos, C., M. W. Graham, M. J. Davis, A. B. Johnson, A. B. May, K. W. Ryer, and L. E. Hall. 2018*a*. Wildlife warning reflectors and white canvas reduce deer–vehicle collisions and risky road-crossing behavior. Wildlife Society Bulletin 42:119–130.

Riginos, C., C. Smith, C. Fairbank, E. Hansen, and P. Hallsten. 2018*b*. Traffic thresholds in deer road-crossing behavior: WY-1807F. Wyoming Department of Transportation. Cheyenne, WY, USA.

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

Sawyer, H., P. A. Rodgers, and T. Hart. 2016. Pronghorn and mule deer use of underpasses and overpasses along U.S. Highway 191. Wildlife Society Bulletin 40:211–216.

Sawyer, H., and A. Telander. 2022. Carter Mountain Pronghorn Study. Western Ecosystems Technology, Inc. Laramie, WY.

Simpson, N. O., K. M. Stewart, C. Schroeder, M. Cox, K. Huebner, and T. Wasley. 2016. Overpasses and underpasses: Effectiveness of crossing structures for migratory ungulates. Journal of Wildlife Management 80:1370–1378.

Smith, D. J., R. van der Ree, and C. Rosell. 2015. Wildlife Crossing Structures: An Effective Strategy To Restore or Maintain Wildlife Connectivity Across Roads. R. van der Ree, D. J. Smith, and C. Grilo, editors. Handbook of Road Ecology. John Wiley & Sons.

Teitelbaum, C. S., and T. Mueller. 2019. Beyond Migration: Causes and Consequences of Nomadic Animal Movements. Trends in Ecology and Evolution 34:569–581.

Wyoming Game and Fish Department. 2022. Cody Region Job Completion Report. Cheyenne, WY, USA.