WILDLIFE ASSESSMENT

FOR

US 20
JUNCTION OF STATE HIGHWAY 87 TO THE MONTANA STATE LINE

TARGHEE PASS PROJECT 14054 and 19913

MILEPOST 402.269

TO

MILEPOST 406.300

Prepared for the Idaho Transportation Department

2018

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This report was reviewed by Marcel Huijser, PhD, Research Ecologist at the Western Transportation Institute, for accuracy and validity.

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Note: Transportation agencies do not always distinguish between wild and domestic animal-vehicle collisions and hence they often report these as animal-vehicle collisions or "AVCs." Since the vast majority of AVCs are with wildlife and since it is the conventional term of road ecology, this report uses wildlife-vehicle collisions (WVCs) instead of AVCs to describe collisions between vehicles and animals. Data on WVCs were collected from two general sources for this report: 1) crash data reported by law enforcement and 2) carcass data reported by Idaho Department of Fish and Game and Idaho Transportation Department staff as well as by the public. Combined, these data are referred to as WVC data.

Photo by Lisa Ridenour

US 20 Corridor and the Targhee Pass Project

The Idaho Transportation Department (ITD) is continuing planning efforts on the US Highway 20 (US 20) Corridor from Chester, Idaho to the Montana State Line to improve the roadway. This includes improving road structural integrity, easing seasonally congested traffic and addressing environmental conditions in order to help reduce collisions and improve safety while enhancing wildlife movement across the road. US 20 is part of the Federal Highway Administration's road system, and is subject to the Zero Deaths vision described by the US Department of Transportation. The Zero Deaths vision uses a combination of strategies to achieve its goal and an interdisciplinary approach is one of the keystone tactics. ITD has also adopted a Toward Zero Deaths goal and prioritizes motorist safety in planning.

The Idaho Department of Fish and Game (IDFG) partners with ITD on these efforts under the guidance of a Memorandum of Understanding (MOU) and a Cooperative Agreement to provide information and recommendations regarding how roads and traffic affect wildlife populations and movements. As ITD plans highway improvement projects on the US 20 Corridor, IDFG provides support as a wildlife expert. The next such project being planned is the Targhee Pass project (Figure 1).

The Targhee Pass project is currently being analyzed in an Environmental Assessment under the National Environmental Policy Act (Targhee Pass Environmental Assessment). This project will replace the road's pavement and subsurface, improve drainage under the highway, add a climbing lane to the entire length of the project area, add turning lanes into a local subdivision and widen the shoulders of the road. Wildlife-vehicle collisions are included as a safety concern in the project's Purpose and Need statement. Reducing WVCs will help improve driver safety and reduce wildlife mortality. One of the Goals of the project, as written in the Purpose and Need statement, is to also enhance wildlife movement across US 20 since the highway and its associated traffic can impede migratory, dispersal and daily movements of wildlife (Forman et al. 2003, Huijser et al. 2008, van der Ree et al. 2015).

The Targhee Pass highway segment is part of the greater 53-mile US 20 Corridor which runs through the city of Island Park and Fremont County, Idaho (Figure 2). This highway corridor crosses the eastern edge of the Island Park Volcanic Caldera and is within the Greater Yellowstone Ecosystem (GYE), one of the largest intact temperate ecosystems that remains in the world (Barbee and Varley 1984). The Island Park area is also considered to be part of the High Divide, a region that connects the GYE to the Crown of the Continent Ecosystem through a series of mountains and valleys that harbor some of the continent's most iconic large mammal species (Figure 2). The Targhee Pass project (ITD's projects 14054 and 19913) consists of the northern-most four-mile segment of this corridor between the junction with State Highway 87 and the Montana state line (mile markers ~402.3-406.3; Figure 1).

The Targhee Pass project area is split between two ecological sections as defined by the Idaho State Wildlife Action Plan (SWAP; IDFG 2017). These are the Beaverhead Mountains Section

(BMS) and the Yellowstone Highlands Section (YHS; Figure 3). The BMS is noted for its vast roadless areas which provide refugia and important movement corridors for migrating ungulates, forest carnivores and other species which require large, intact expanses of habitat to survive (e.g., grizzly bears, wolverine). Where the BMS overlaps the US 20 Corridor, small headwater streams of Henry's Lake drain from the Centennial and Henry's Lake Mountains and support water and riparian associated species such as American beaver, moose, diverse avian communities and native Yellowstone cutthroat trout. The alpine highlands parts of this section, which also overlaps the US 20 Corridor and Targhee Pass project area, support species adapted to the harsh conditions of a high mountain landscape such as black rosy-finch, hoary marmot, mountain goat and wolverine (IDFG 2017). The YHS contains the Island Park, Henry's Fork and Yellowstone volcanic calderas (IDFG 2017; Figure 3). Sixty-six percent of the lands in this section are managed by the Caribou-Targhee National Forest. In the Targhee Pass project area, approximately one-half of the land surrounding US 20 is privately owned. The northern half of US20 along Targhee Pass project area is owned predominately by the US Forest Service; a small portion is owned by the Bureau of Land Management (Figure 4).

The YHS is a major component of the Greater Yellowstone Ecosystem. Most bird and mammal species that were present prior to European settlement are still present in the GYE, including one of the largest elk herds in North America (the northern Yellowstone elk herd), one of the few grizzly populations in the lower 48 United States and rare species such as wolverine, trumpeter swan and common loon (IDFG 2017). Lower elevations in the GYE have some of the most productive habitats of this ecosystem but are also vulnerable because much of this land is private property vulnerable to development. In fact, the number of single family homes in the YHS has tripled in the last 50 years and most of these have been built in rural areas (Headwaters Economics 2014). Fremont County has seen the most significant growth in this region (IDFG 2017). These types of growth patterns inevitably bring more traffic to the local road systems (Figure 5). Increased traffic leads to increased safety concerns for motorists and wildlife alike and leads to barrier-effects to wildlife movement (Seiler 2003).

The wildlife in this area have been studied extensively, resulting in a broad understanding of the ecology of the area's wildlife and how wildlife movements and migrations tie together the resources of Yellowstone National Park (YNP) and the GYE to those areas north and west that provide seasonal and annual ranges and habitats (Andreasen et al. 2014, Cramer 2016, Interagency Grizzly Bear Study Team, Wildlife Conservation Society, J. Cunningham, S. Roberts and P. Atwood personal communication) and areas to the south that provide expanded range for dispersing carnivores such as wolverine and grizzly bears (Schwarz et al. 2009, Schwarz et al. 2010, Inman 2013). This technical report assimilates information from such reports, from observational and road mortality data from the Idaho Fish and Wildlife Information System (IFWIS), from law enforcement reports of wildlife collisions and from articles published in peer-reviewed journals regarding the topics of wildlife, roads and highway design elements to provide recommendations for reducing WVCs and increasing landscape permeability. These components are presented as they relate to the proposed Targhee Pass highway project.

Economy of Fremont County

Fremont County, Idaho boasts being the sole county in Idaho that contains part of YNP. In fact, US 20 is the Idaho gateway to YNP, nicknamed the "Yellowstone Highway." Wildlife found in this area are similar to those found in YNP and the area is considered to have the full suite of native mega-fauna (NPS 2017). Travel and tourism make up a significant portion of this small county's economy mainly in the form of accommodation and food services (Headwaters Economics 2014). Travel and tourism to this region are predominantly made up of anglers, hunters, wildlife watchers and other recreationists, including hikers and off-highway recreation vehicle users (Loomis 2005, Headwaters Economics 2014). Many people pass through Island Park and Fremont County on their way to visit the nearby national parks, YNP and Grand Teton National Park, especially in the summer months (Loomis 2005). US 20 leads to the west entrance of YNP, the most frequented entrance to YNP with ~1.9 million visitors annually from around the globe. In the winter, Island Park is known as a premier destination for snowmobilers with over 400 miles of groomed snowmobiling trails. One-fifth of all snowmobile registrations in Idaho are made in Fremont County (10,127 snowmobiles were registered in 2006; Fremont County Comprehensive Plan 2008).

The Fremont County Comprehensive Plan (2008) "recognizes that fish and wildlife are a cornerstone element of Fremont County's economy, image, heritage and reputation as an international recreational destination. The County also recognizes that fish and wildlife resources offer recreation and sporting opportunities, which depend on abundant open space, clean water, and healthy ecosystems with intact fish and wildlife resources and habitat."

In the Fremont County Planning and Building economic development strategy, wildlife viewing was listed as the top activity desired by off-season visitors (Gardner 2008). The vision statement for Island Park begins by recognizing the "the thriving wildlife, aesthetic natural beauty, healthy environment and visitor attractions of the caldera" (Gardner 2008). The Action Strategy in this document outlines development and enhancement of tourist facilities and services to increase wildlife viewing opportunities.

Hunting and angling in the High Divide counties of Idaho (Butte, Clark, Custer, Fremont and Lemhi counties) bring in $153 million annually (Headwaters Economics 2014). In the Upper Snake Region, hunting brings in over $22 million annually. More than 4,000 elk, 5,000 mule deer and 700 moose winter in Fremont County and big game hunters spend over 64,000 hunter-days in this county (C. Hendricks personal communication).

Anglers in Fremont County spent over $50.8 million in 2003 on fishing and fishing related expenses, making this world-class fishery the top county in Idaho for angler expenditures (Idaho Sport Fishing Economic Report 2003, Loomis 2005). In 2005, Loomis estimated that fishing-related jobs on the Henry's Fork River alone created at least 851 jobs and generated $29 million in income annually (including direct, indirect and induced income). The Henry's Fork River in

Fremont County generates more spending than any other waterbody in the Upper Snake Region (Idaho Sport Fishing Economic Report 2003).

In 2001, 82 million people participated in wildlife-related recreational activities in the US (Henderson 2005). Of those, 66 million people spent $38 billion wildlife watching. Idaho has one of the highest per capita spending rates in the wildlife industry and rural businesses are the primary beneficiary of this spending (Henderson 2005). A 2016 report from the National Park Service (Thomas and Koontz) showed that 4.2 million visitors to YNP generated a cumulative economic benefit to the local surrounding communities, including Island Park, of $680.2 million and supported 7,737 jobs in the local area.

Local Wildlife Resources

Ungulate migration routes in and out of YNP traverse US 20 as animals make their way to winter range on the Sand Creek Desert in Idaho (southwest of YNP) and the Madison Valley in Montana (northwest of YNP) during fall and return across US 20 in the spring to access summer range and calving/fawning areas in YNP and Island Park (Figure 2). These movements may be as far as 70 kilometers in one season (Andreasen et al. 2014). For moose migrating out of the Island Park and YNP areas in fall, they arrive on winter range in some of the largest concentrations of migratory moose known. Long-distance migrations like these are declining world-wide and scientists urge the protection of these legacies and the ecosystem services they provide (Berger 2004, Wilcove and Wikelski 2008, Seidler et al. 2014). Seventy-five percent of migration routes for elk, bison and pronghorn have already been lost in the GYE (Berger 2003). Not only is the loss of migration a loss of natural heritage in a region defined by charismatic wildlife species, but it results in the truncation of basic ecological processes such as nutrient cycling, the limitation of recreational opportunities such as hunting and wildlife watching and can impact economic opportunities for local communities that rely on the value of hunting, fishing and wildlife watching (Kie et al. 2003). Spectacular herds of bison, moose, elk, pronghorn and deer reside in and around YNP and migration is a crucial piece of their life history that allows them to return to winter ranges which have less-severe winter conditions and better access to forage (Fryxell and Sinclair 1988, Alerstam et al. 2003). Some of these migrations cross US 20 in the Targhee Pass project area.

Non-migratory moose also live year-round along US 20 in the Targhee Pass project area, sometimes crossing the highway multiple times a day (Andreasen et al. 2014). Wolverine and grizzly bears cross US 20 in the Targhee Pass project area as part of their daily movements and during once-in-a-lifetime dispersals away from natal ranges (Schwarz et al. 2009, Inman 2013, IGBST 2013 personal communication). Yellowstone cutthroat trout (YCT) live in the Henry's Lake watershed and spawn in tributaries adjacent to the Targhee Pass project area feeding into this world-class fishery.

Wildlife and the Targhee Pass Project Area

Within the SWAP (IDFG 2017), there are several species and guilds called out as highest priorities with special conservation needs in the BMS and YHS ecological sections. Of these, wolverine, grizzly bear and migratory ungulates—pronghorn, mule deer, whitetail deer, elk, moose and bison— all utilize the Targhee Pass project area and, hence, are of consideration in this project. Current and increasing levels of traffic (Burke 2015; Fig. 2) and road infrastructure leave these animals susceptible to wildlife-vehicle collisions (WVCs), un-navigable culverts along streams, habitat loss and stress (Seiler 2001, Frid and Dill 2002, Forman et al. 2003, Gavin and Komers 2006, Huijser et al. 2008). Road surface widening and increasing traffic make traversing the road more difficult for wildlife (Seiler 2001, van der Ree et al. 2015).

Targhee Pass is an important linkage for dispersing carnivores as their North American ranges expand. Grizzly bear and wolverine have both been documented traveling through this area (Figure 6; IFWIS observational data, IGBST data) and recent data show a radio-collared male wolverine home range overlapping US 20 in the Targhee Pass project area and a female wolverine home range directly adjacent to it (Heinemeyer et al. 2017). Major blocks of suitable wolverine habitat are present in the mountains around Island Park and wolverine movement models developed using global positioning system (GPS) radio-transmitter data show that this narrow connection on the edge of the Greater Yellowstone Ecosystem is a priority area to protect for connectivity with ecosystems to the north and west (Figure 7; Schwarz et al. 2009, Inman 2013). For wolverine specifically, the IDFG SWAP (2017) poses these strategic actions:

- Continue the partnership with Idaho Transportation Department (ITD) and Federal Highway Administration (FHWA) to develop and monitor traffic volume, wildlife-vehicle collisions, and other metrics needed to identify connectivity and high risk areas for road mortality or road crossing avoidance.
- Work with ITD to design connectivity and crossing mitigation consistent with FHWA Handbook for Design and Evaluation of Wildlife Crossing Structures in North America.
- Work with ITD to avoid and reduce barriers or impediments to connectivity and crossings.

(IDFG 2017, page 297)

The SWAP also states that US 20 is currently a substantial regional concern to wildlife connectivity (e.g., ungulate migration) and that expansions to the highway could decrease permeability of the landscape for wildlife (Andreasen et al. 2014, IDFG 2017). The major objective of the SWAP for migrating ungulates along US 20 is to increase the permeability of the highway by collaborating with ITD and other partners to develop best practices that can be incorporated into the planning and implementation steps of highway projects (IDFG 2017).

Migratory elk and mule deer move across US 20 on Targhee Pass to reach winter range in the Madison Valley, as shown by Montana Fish Wildlife and Parks GPS radio-collar and IDFG observational data (Figure 8 and Figure 9; unpublished data). Global positioning system (GPS) radio-collar data from elk and non-migratory moose show that these large ungulates not only pose a safety hazard to motorists but also suggest that key sections of Targhee Pass are a substantial barrier to these animals (Figure 8 and Figure 10). Where these animals cross the road, they are vulnerable to WVCs. Where these animals are not able to cross the road due to traffic volumes and road design (Seiler 2003), the resulting reduction in access to forage, mates, seasonal ranges, and breeding grounds can compromise individual and population fitness of herds that travel in and out of YNP and the Island Park Caldera (Frid and Dill 2002, Gavin and Komers 2006). As traffic increases—as projected in the ITD traffic report (Burke 2015)—the highway will become less permeable to wildlife (Seiler 2003).

Howard Creek flows adjacent to and crosses under US 20 in the Targhee Pass area. It provides spawning and rearing habitat for YCT up to the lower impassable culvert, under the US Forest Service road to the Targhee Creek Trailhead. Previous work to protect YCT in the area has included miles of bank restoration along Henry's Lake and tributary streams as well as the replacement of eight culverts and a bridge on State Highway 87 at the lower reach of Howard Creek (J-U-B Engineers, Inc. 2006). However, two culverts on Targhee Pass remain a barrier to fish passage at the Targhee Creek Trail access road and at Howard Springs (Damon Keen, IDFG, personal communication).

Wildlife-Vehicle Collisions

Wildlife-vehicle collisions (WVCs) are the second-leading cause of reported vehicular collisions on the US 20 Corridor in Island Park (Figure 11; US 20 Corridor Plan). The US 20 Corridor Plan reports that from 2010 - 2014, 441 crashes occurred costing over $49 million dollars. Almost 50 (11%) of these crashes were due to WVCs (WebCARS 2017). These statistics are remarkable because US 20 is a major freight corridor which brings high-levels of heavy semi-truck traffic to the area (e.g., half of all produce freight from southern California travels US 20 through Island Park; Ben Burke, Traffic Engineer, ITD, personal communication). Wildlife collisions with heavy trucks are less likely to be reported to law enforcement due to reduced human injury and lower vehicular damage rates. Because of this, WVC rates are likely actually higher than reported.

There are two types of data important when analyzing wildlife-vehicle collisions. The first is reported roadkill, such as those animals reported by citizens and IDFG employees to the IFWIS system or another carcass observation database. In Idaho, ITD reports to a separate system, the ITD Transportation Asset Management System (TAMS). These data are then transferred to the IFWIS site regularly (Cramer et al. 2014).

The second type of data that are important to understanding road impacts to wildlife are crash data. These are the vehicle collisions that are reported to law enforcement by motorists involved in a collision. Collisions estimated to cost more than $1,500 are reported to the state crash reporting system, WebCARS. Collisions that cost less than $1,500 and do not cause harm to humans are not reported to WebCARS, but if law enforcement was to the scene of the accident, data on these collisions are generally available from the local Sheriff's office i.e., Fremont County Sheriff. These reports go into a separate data system that law enforcement and transportation agencies have access to (some of the information is sensitive so it is not fully available to the general public). For this study, we used data from both WebCARS and the Fremont County Sheriff's office (collectively termed "law enforcement data") as well as carcass data reported to IFWIS to inform our process. Altogether, these are WVC data.

For data consistency and because WebCARS data were not yet reported for 2016, we used statistics reported over the five-year period from 2011-2015 for WVC calculations for Targhee Pass (Table 1**Error! Reference source not found.**). In order to estimate the number of WVCs in the Targhee Pass project area, we combined reported crash data that involved wildlife (WebCARS 2017, Fremont County Sheriff, personal communication) with roadkill data from IFWIS, then removed duplicates. Duplicates were defined as reports of a carcass or crash with the same species reported within seven days of another carcass or crash and within 0.5 mile of that carcass or crash location. In the case of law enforcement data, some duplicate reports were over one mile from each other because the Sheriff's reports were reported to an estimated mile marker while the WebCARS reports were reported to a waypoint. These duplicates were also removed (Table 1).

These methods assessed 32 large mammal-vehicle collisions reported to law enforcement between January 2011 and December 2015 (WebCARS 2017, Fremont County Sheriff's office; Table 2). Note that data from the Fremont County Sheriff's office were provided for the years 2012-2015 only. In this same time period, 11 carcass observations were made (IFWIS 2017**Error! Reference source not found.**), 13 of these reports were duplicates, for a total of 30 reported WVCs and road killed animals over the five-year period (average 6/year; Table 2). Perhaps a reflection on the consistency of reporting to IFWIS, no roadkill observations were made in the Targhee Pass project area between 2008 and 2011, while eight WVCs were reported in the WebCARS database over this same time period. From 2011-2015, WebCARS data from the Targhee Pass project area demonstrated that 36% of all collisions were due to WVCs (20 out of 56 reported crashes were due to collisions with wildlife). We did not include carcass counts in this calculation because they do not represent reported crashes and we did not include any Sheriff's reports because these reports were only WVC reports, i.e., they did not provide a comparison with other types of crashes that cost less than $1,500. This WVC rate on Targhee Pass is much higher than the average 4.6% rate of WVCs in the nation (General Estimates System data, Huijser et al. 2008), despite the fact that WVC data are frequently under-reported (Conover et al. 1995, Huijser et al. 2008), especially along the US 20 Corridor (Cramer et al. 2014).

We also explored the WVC data available in 2017. These data included carcass reports to IFWIS and reports from the Fremont County Sheriff's office (WebCARS data have not yet been reported for 2017). The number of reported WVCs in 2017 increased dramatically from previous years, by almost 300% (the average number of WVCs between 2013-2016 was 5.5; the number of WVCs reported in 2017 was 16; Figure 12). This is equivalent to 4 large mammal-vehicle collisions per mile per year. The increased number of reports could be due to increased road mortality associated with the severe winter experienced in 2017, possibly putting animals on the road at unfamiliar times of the year or leading animals to spend more time on the road surface, since it is plowed clear of snow. However, it is more likely this change in the level of reporting is due to an increased awareness by local agencies, organizations and citizens for the need for rigorous data to provide a deeper understanding of the wildlife-road relationship in this area. We treated the 2017 data the same as previous years and removed all duplicates accordingly. The significant change in reports was only found in the IFWIS data and not in the data from the Fremont County Sheriff's office (Figure 13). This supports the idea that motorists along Targhee Pass were more likely to record and report carcass data in 2017.

Cost Benefit Analysis

Wildlife are a major economic driver in Fremont County and Island Park as well as a flagship that defines the community's image (Headwaters Economics 2014, Gardner 2008, Fremont County Comprehensive Plan 2008). The need for healthy ecosystems where wildlife can move unimpeded across the roaded landscape is a key element in retaining this heritage. Because of this, protecting wildlife resources is critical to the sustainability of the small communities in this area (Fremont County Comprehensive Plan 2008). In order to understand what benefits might be gained by reducing WVCs on the Targhee Pass project area, we compared the costs of a highway design that reduces large mammal-vehicle collisions by 83-87% with the value of the local wildlife (Huijser et al. 2009, Rytwinski 2016). This analysis compiled crash statistics and reported roadside carcasses to determine how long it would take for such a design to pay for itself, i.e., it calculated a cost-benefit ratio.

In a previous report, cost-benefit ratios were calculated using both Idaho and national (US Department of Transportation) crash values (these values generally include medical costs, vehicle towing and repair, emergency services, lost productivity and increased insurance costs) plus carcass values derived from the State of Idaho Penal Code i.e., the value of a poached animal. These ratios were calculated to estimate the cost-effectiveness of various methods of reducing WVCs in the Targhee Pass project area (Cramer 2016). We modified these methods to include statewide crash severity rates and estimates of unreported roadkill. Using a long-term, larger-scale average crash severity rate (such as a state or national crash severity rate) is recommended for short stretches of road because data from short road sections are less likely to correctly capture the statistical risk for human injury and WVCs (Huijser et al. 2009).

For Targhee Pass, we used Idaho data in order to estimate crash severity rates, because national crash severity rates do not reflect the same rates of severity that collisions with elk, moose, bison and grizzly bears do. Crash reporting standards are different state-by-state and most states do not have the large megafauna that are found in the Targhee Pass project area. For instance, in Illinois and Minnesota, over 90% of the reported WVCs are deer collisions.

Wildlife-vehicle collisions reported to law enforcement on the Targhee Pass project area from 2011-2015, were 43% deer, 27% elk, 10% moose, 7% bear and 13% with an unknown animal. In 2017, an adult male bison (mass ranging from 700-1,200 pounds; Meagher 1986) was also hit and killed in a WVC. For these reasons, we used Idaho WVC crash severity rates which can better approximate the rate of crash types on Targhee Pass (Table 4) to calculate cost-benefit ratios of recommended wildlife-specific highway design elements (see Wildlife Passage Recommendations below) and to estimate the number of years until such elements would pay for themselves.

We used the most recent wildlife monetary values from the 2017 Idaho Statute Title 36, Chapter 14, Section 36-1404 to assign a value to vehicle-killed wildlife (Table 1**Error! Reference source not found.**). Huijser et al. (2008) report that WVCs with large animals (animals capable of causing substantial property damage) are likely underreported by as much as 70-85%. Using data from the IFWIS Roadkill Database and those law enforcement reports that noted the species of wildlife involved in the collision between 2011-2015 and a conservative correction factor of 50% underreporting (Conover et al. 1995), we then calculated a total annual average wildlife loss value of $12,345 for the four-mile stretch of the Targhee Pass project area (Table 5). This value was combined with the weighted annual average cost of a WVC reported to law enforcement multiplied by 6 WVCs/year ($174,541) resulting in a total annual cost of WVCs on Targhee Pass of $186,886 (Table 5).

Of important note, these calculations do not reflect the intrinsic value of an animal to the larger population (such as its reproductive capacity) or the ecosystem (such as its value in cycling nutrients via migration or its value as a prey species) nor the value of that animal to non-consumptive users. Such values are based on subjective human perceptions and are difficult to quantify. Some reports create wildlife values based on wildlife watching expenditures (such as money spent on viewing equipment, travel costs and lodging; Huijser et al. 2008), but this still does not place a value on an individual animal and the economic loss that the death of that animal incurs. This report includes none of these estimates.

We analyzed cost-benefit ratios for the construction of three wildlife overpasses connected with wildlife-proof fence as a design element to prevent animals from crossing on the road's surface and to funnel animals to the overpasses. This design has the best possibility of reducing WVCs while maintaining or increasing wildlife connectivity on Targhee Pass and while allowing improvement of the highway's level of service to motorists (Huijser et al. 2009, Rytwinski et al. 2016). Other elements of this treatment such as human access gates and cattle guards at access roads are included in cost estimates. An underpass for recreationists to help prevent human use of wildlife overpasses while maintaining human access across the road was recommended by IDFG for this project, but is not included in the cost-benefit analysis here because it is not part of the final Environmental Assessment alternatives under consideration. The estimated cost for this treatment is $8.5 million when calculated over a 50-year life of the treatment. This includes two installations of fence, since the estimated life of fence is 25 years. This treatment is the highway design recommended by IDFG for wildlife, not including a human-access underpass (see below section on Wildlife Passage Recommendations).

Reflecting on the average reported WVCs per year in the Targhee Pass project area corrected for 50% underreported collisions, 12 collisions/year can be reduced by 85% with fencing and three wildlife overpasses to provide for wildlife movement (Huijser et al. 2009, Rytwinski et al. 2016) resulting in a savings of $317,712/year (Effectiveness × Average Cost of a single WVC; 10.2 × $31,148; Table 6). Wildlife crossing structures are estimated to have a 70-80-year life span (Huijser et al. 2009). However, ITD uses an estimated structure life of 50 years. Using a 50-year life span and a treatment cost of $8.5 million, it will take 27 years for the treatment to pay for itself with a Benefit:Cost ratio of 1.87 (Project Savings Over 50 Years ÷ 50-Year Treatment Cost; $15,885,583 ÷ $8,483,410; Table 6).

If correction factors are not used, i.e., if we use 6 WVC/year to calculate cost-benefit ratios, the resulting annual savings are $158,856 and it will take 53 years for the treatment to pay for itself with a Benefit:Cost ratio of 0.94 (Table 7).

Finally, we calculated cost-benefit ratios using only 2017 data since these are the most recent data available and since motorists were more likely to report carcasses on the roadside in 2017 than in previous years. Using 16 WVC/year, the resulting annual savings of installing the IDFG recommended wildlife highway design elements are $423,616 and it will take 20 years for the treatment to pay for itself with a Benefit:Cost ratio of 2.50 (Table 8).

These methods were verified by Marcel Huijser, PhD, Research Ecologist at the Western Transportation Institute.

Wildlife Passage Recommendations

When considering wildlife highway design elements for the Targhee Pass project area and the accompanying Environmental Assessment, Cumulative Effects that influence wildlife and habitat need to be included. Current data suggest that parts of US 20 through Targhee Pass are avoided by wildlife (Figure 8), while other areas contribute to WVCs with large mammals (Figure 6, Figure 8, Figure 10). Targhee Pass project area provides habitat for many species, passage for migratory ungulates and connectivity for dispersing carnivores. These critical elements are not limited to the Targhee Pass project area and many animals moving across US 20 on Targhee Pass must also move across the US 20 Corridor south of Targhee Pass and SH 87 to the west (Andreasen et al. 2014, Cramer 2016). Targhee Pass and these adjacent highways and associated developments contribute to habitat loss and fragmentation that impact the Targhee Pass area. Declines in mammal species abundance due to wide-ranging effects of roads can be up to 17 km from roads (Benítez-López et al. 2010). While it is challenging to assess possible impacts of road improvements beyond the described project area, this must be done as part of a Cumulative Effects Assessment. Beyond the Targhee Pass project area, US 20 and SH 87 already impact wildlife movements and contribute to significant WVCs and wildlife loss that should be considered as part of the cumulative impact of Targhee Pass (Andreasen et al. 2014, Cramer 2016). In addition, other highway improvement projects are planned just beyond the Targhee Pass project area which will include added passing lanes and the cumulative impacts of these projects will contribute to a measurable future impact on wildlife crossing Targhee Pass.

The decline of wildlife populations is difficult to detect before they reach a threshold that may eventually contribute to local population extirpation or to metapopulation losses (Jaeger 2015). If populations have so far survived all road construction in a landscape, this does not mean that populations will survive further road construction (Jaeger 2015). Sometimes these impacts are not detected or evident until decades beyond road expansion. Maintaining ecological corridor networks is less costly than paying for their restoration at a later date and this fact must be taken into consideration when reviewing impacts from expansion of US 20 in the Targhee Pass project area. This could be especially true for species such as wolverine that exist in a tenuous metapopulation that is linked by corridors characterized by contiguous protected areas with persistent spring snow at high elevation, similar to the habitat around US 20 on Targhee Pass (Squires et al. 2006, Schwartz et al. 2009).

The uncertainty associated with wildlife population thresholds related to roads requires a proactive approach to protect wildlife. This is supported by the concept that it is better to mistakenly detect or predict environmental impacts (i.e., commit a Type I error) rather than failing to detect true, significant environmental impacts (i.e., commit a Type II error; Kriebel et al. 2001, Jaeger 2015).

The wildlife highway design elements recommended here not only improve safety for motorists by significantly reducing a major source of collisions on US 20, but also maintain connectivity for wildlife and help to maintain the integrity of the ecosystem. No other highway design elements have been shown to do both of these things as effectively as crossing structures combined with wildlife fencing because fences not only serve to prevent wildlife from crossing the road surface, but they also funnel wildlife to crossing structures (Dodd et al. 2007, Gagnon et al. 2010, Huijser et al. 2016). Because of this, these elements also help to preserve natural heritage, hunting, fishing and recreational opportunities.

There are many options to reduce WVCs on a highway. Each of these highway design elements have been tested to some degree in past research demonstrating different levels of effectiveness at reducing WVCs (Table 9). Of these, the best performing tools to reduce WVCs include wildlife crossing structures (e.g., underpasses, overpasses) accompanied by fence that is impermeable to the target species (Huijser et al. 2009). The fence serves dual purposes of preventing animals from accessing the road surface and funneling animals onto the crossing structures. These design elements have been shown to successfully reduce WVCs by 83-87% (Huijser and McGowen 2010, Clevenger and Huijser 2011, Rytwinski 2016). A recent study on the length of mitigation required to be effective for reducing WVCs with large mammals combined results from 21 studies, primarily in North America. This meta-analysis showed that mitigated road sections that were at least five-kilometers long reduced collisions with large mammals by 84% on average. Mitigated road sections that were less than five-kilometers long only reduced WVCs by 53% on average (Huijser et al. 2016).

Other options for reducing WVCs that show some promise include animal detection systems (ADS), in-vehicle ADS (e.g., Volvo's cars), variable message signs and seasonal warning signs (Huijser et al. 2008, Huijser and McGowen 2010, Rytwinski et al. 2016, Huijser et al. 2017; Table 9). However, none of these options have demonstrated consistent effectiveness at reducing WVCs like the combination of wildlife crossing structures and fence. Animal detection systems can be similar in effectiveness to fences in combination with underpasses and overpasses, however the range of effectiveness is much wider and lower than fences combined with crossing structures—33-97% effective (Huijser et al. 2015)—and many ADS systems fail before effectiveness can even be measured because the systems are not yet robust enough for many settings and, hence, are a high risk investment (Huijser et al. 2017). Importantly, only crossing structures with fences have demonstrated an ability to increase landscape permeability (animal rate of movement across roads, Alexander et al. 2005) for wildlife across roads (Huijser et al. 2016). Highways can impede animal movements, fragmenting important habitat and leading to population isolation that impacts genetic connectivity, dispersal of young and other population processes that can result in extirpation of local and regional populations (Dodd et al. 2011). In Fremont County, it is critical to maintain ungulate migrations and large carnivore habitat integrity. Since traffic volumes at certain times of the day and year in the Targhee Pass project area are theoretically past a critical threshold for being a barrier to wildlife movement (300-500 vehicles/day for carnivores and 500-5,000/day for ungulates; Seiler 2003, Alexander et al. 2005, Clevenger and Huijser 2011, and see Figure 5) and since this area is a key linkage for grizzly bears, wolverine and migrating ungulates to preserve genetic integrity of populations and to enable movement to winter range, it is imperative to account for landscape permeability while designing highway elements. To date, no highway design elements can increase wildlife connectivity except crossing structures (various types of overpasses and underpasses) with fences (Huijser et al. 2016).

The recommendations from IDFG include a combination of elements that will change both wildlife and human behaviors in the Targhee Pass project area. In order to discourage animals from crossing US 20 on its road surface, to reduce WVCs and to maintain landscape permeability for animals crossing the highway, IDFG recommends three wildlife crossing overpasses with wildlife fencing between the crossing structures for the length of the project area. Overpasses are able to accommodate all target species of interest (elk, moose, deer, wolverine, grizzly bear, and pronghorn) whereas underpasses would severely limit use by pronghorn and female grizzly bears with cubs, and would have to be overspan bridges to accommodate substantial use by elk and moose and would potentially create logistical challenges to build sufficient openness to encourage use by both ungulates and carnivores (Clevenger and Waltho 2000, Huijser et al. 2008, Clevenger and Huijser 2011, Sawyer et al. 2016, Ford et al. 2017).

Using telemetry data, GPS-based models, wildlife-vehicle collision locations, observational data and expert consultation (Andreasen et al. 2014, Bergen et al. 2016, Schwarz et al. 2009, Schwarz et al. 2010, and others) IDFG verified that the crossing structure types and locations recommended in Cramer 2016 are suitable and ideal locations for wildlife passage. These structures are recommended to be located at these approximate locations (minor modifications in the recommended location of structures are allowable since target species are large mammals that will likely move large distances to seek passage): mile markers 403.2, 404.9 and 406.0. Wildlife overpasses must minimally be 50 m wide (Pfister et al. 1999, Evink 2002, Clevenger and Huijser 2011; Figure 14) with dirt berms or other structures on the sides to reduce highway sounds and sights. Bottomless box culverts or a small simple span bridge are recommended to replace existing small culverts on Howard Creek at mile markers 404.5 and 405.5 in order to improve fish passage. These culverts will not accommodate the larger target species, but can provide increased health for the surrounding aquatic habitats and provide safe passage for small mammals that contribute to the overall health of the ecosystem. Culverts should be at least 3 m wide and include terrestrial passage for small, non-target mammals, reptiles and amphibians (Clevenger and Huijser 2011). These culverts should allow at least 150% bankfull width (Damon Keen, IDFG, personal communication). All crossing and passage structures should include appropriate vegetation at the ends and on the crossing structures (Clevenger and Barrueto 2014).

An impermeable fence 2.4 – 3.0 m high made of galvanized woven wire (12.5 gauge, 4 x 4” mesh size) with steel or treated wood posts, escape ramps and a buried mesh apron should run the full length of the project on both sides of the road (Huijser et al. 2015; Huijser et al. 2016). This fence must be checked regularly (more than once/year) for integrity (e.g., fallen trees, animals digging under, vegetation maintenance; Huijser et al. 2015). Consideration of fence replacement should occur at ~25 years (Rob Ament, Western Transportation Institute, personal communication; Huijser et al. 2009). The fence should include raised swing gates for hiking, fishing and hunting access (Huijser et al. 2015). At vehicle access points, Texas gates (e.g., cattle guards) and electric mats should be used to prevent wildlife from accessing the highway at these points (Texas gates alone will not be an effective deterrent for large carnivores; Clevenger and Barrueto 2014, Allen 2011). Fence end treatments (e.g., wildlife guards, electric mats, fence end returns, boulder fields, driver awareness signs; Huijser et al. 2015) should be used where the fences end in order to prevent a concentration of WVCs at fence ends and in order to reduce the likelihood that animals will venture into the right-of-way between the fences. In order to address both concerns, multiple fence end treatments should be used in conjunction, such as angling fences both toward (to reduce animals in the right-of-way) and away from the road (to reduce animals crossing the road surface outside the fence end) accompanied by electric mats embedded in the pavement and right-of-way. Carefully determining where fences should end, considering habitat and topographic changes and locations of crossing structures, will also help reduce increased concentrations of WVCs at fence ends. Montana Department of Transportation should be requested to consider installation of fencing along US 20 in Montana adjacent to the Targhee Pass project area. This will help prevent wildlife from crossing the road surface in Montana if the fence were to end at the state line, ¼ mile from the northern-most overpass. Huijser et al. (2016) conducted a meta-analysis of the effectiveness of various mitigation lengths. They found that total mitigation lengths should cover at least five kilometers of highway in order to reduce WVCs by 84% on average. Mitigation less than five kilometers only reduced collisions by 53%. Surety that fences will cover collision hotspots plus adjacent buffer zones will provide the most effective reduction in WVCs. Little research has been done to determine species-specific lengths of fencing that help prevent animals from traversing around mitigation. Target species for mitigation on Targhee Pass are high-mobility species and could easily cover distances of a mile to seek a route across the highway. Given this, IDFG recommends a mile of fencing be installed beyond the northern-most recommended wildlife overpass. Near this same structure, a culvert or other underpass-type structure for snowmobile, all-terrain vehicle and hiker crossing near the Continental Divide Trail should be installed to prevent recreationists from utilizing wildlife crossing structures to cross the road because this is a high-use area for humans seasonally (Clevenger and Huijser 2011, Barrueto et al. 2014). Co-use wildlife crossing structures can effectively accommodate species habituated to human disturbance, like those that successfully live proximal to urban development, but for many species co-use structures will decrease or prevent wildlife use (van der Ree et al. 2015). On the southern end of the Targhee Pass project area, approximately one mile of fencing can be installed between the southern-most structure and the junction with SH 87. Future highway projects will need to consider wildlife movement and WVCs along SH 87 and on US 20 south of the junction with SH 87 in order to address possible increases in wildlife movement on these road sections in response to crossing structures and fences on Targhee Pass. Wildlife overpasses should be able to accommodate sufficient soil depths to support native vegetation that mimics the surrounding environment. In some cases, vegetation will need to be watered in summer months until native plants establish themselves. Slope angles to and on the overpasses should not exceed 10% (Marcel Huijser, personal communication).

The above ecological design criteria are the minimum recommendations to provide for maintenance of wildlife movement, reduced WVCs and motorist safety. The main drivers of these recommendations are: 1) the level of WVCs in the area which compromise motorist and wildlife lives and which dictate safety improvements for drivers, 2) the traffic volumes, which are well above those that can create a barrier to wildlife movement, 3) the likelihood of increasing traffic in the future and 4) the importance of this area to sustaining healthy wildlife populations and ecosystems in the Northern Rockies.

These recommendations speak to a larger ecological need to mitigate the costs to wildlife in addition to protecting citizens, motorists, and the local economy in the greater Island Park area and beyond. Because reported crashes and roadkill are gross underestimates on almost any roadway (Conover et al. 1995, Huijser et al. 2008) and especially on the US 20 Corridor (Cramer 2016), we note that the numbers reported here are conservative estimates of true WVC occurrences. Accidents are often not reported if vehicle damage is minimal, such as with large trucks. Additionally, if an animal moves off the road and out of site before it dies it likely won't be reported to a database where its loss can be included in area statistics. For these reasons, the safety risk to drivers and wildlife traveling through the Targhee Pass project area is likely higher than described here.

In addition to the safety risk to drivers and wildlife, substantial consideration must go into protecting wildlife and their daily, seasonal and dispersal movements. Without the ability to migrate out of the Island Park area in the fall, many migratory ungulates would suffer and possibly perish struggling to survive with limited access to forage. This area is also particularly important for large carnivore dispersal, providing genetic connection between ecosystems important to grizzly bear and wolverine meta-populations (Schwarz et al. 2009, Schwarz et al. 2010, Inman 2013). If these ecosystems were to become isolated by roads and traffic, it would be devastating to the local economies of the area which rely on the visitors to subsidize income and economic growth in the region.

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Figures

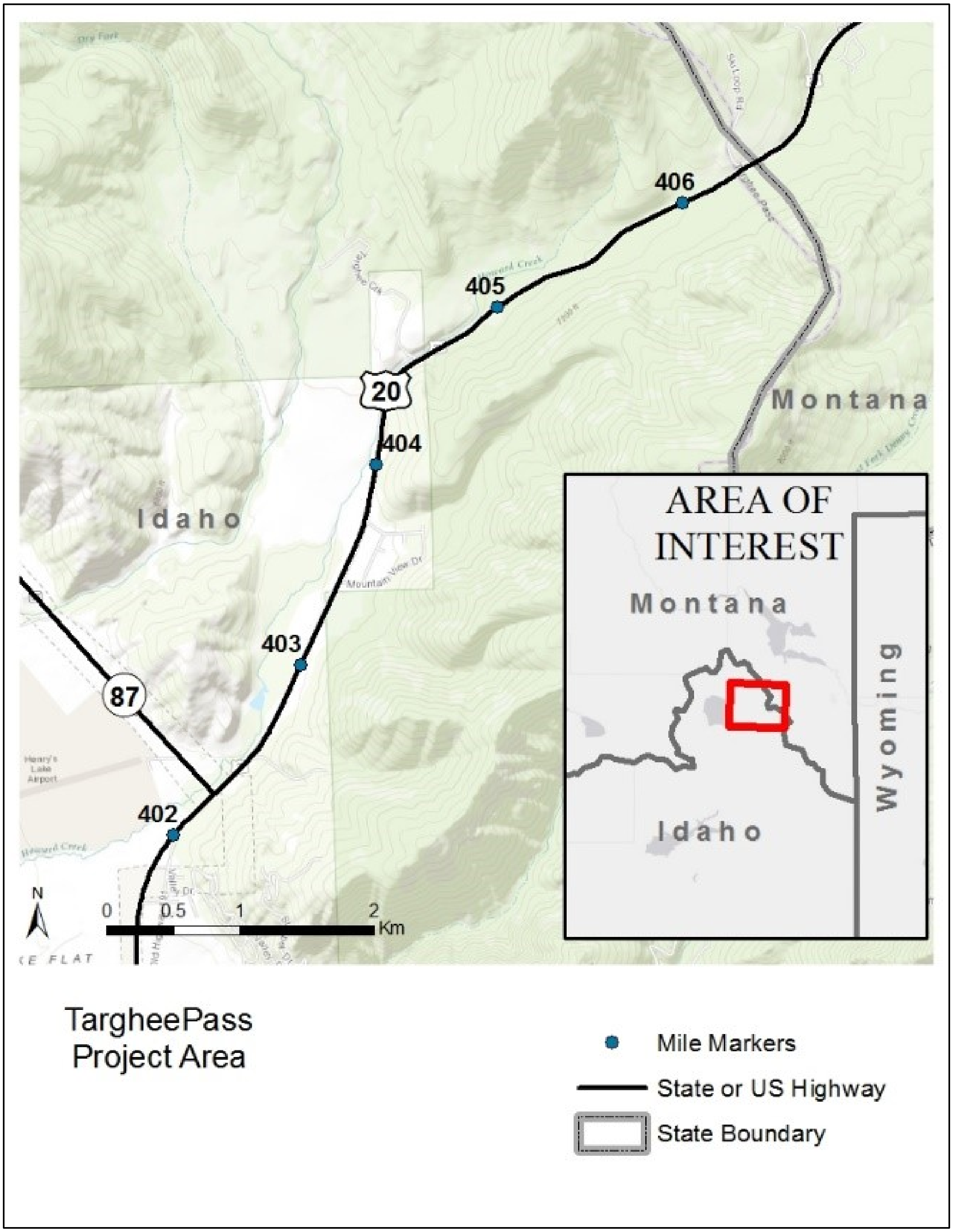

Figure 1. Overview of the Targhee Pass project area on US 20 between the intersection with State Highway 87 and the Montana state line (mile markers 402.3-406.3) is shown in relation to the tri-state area of Idaho, Montana and Wyoming.

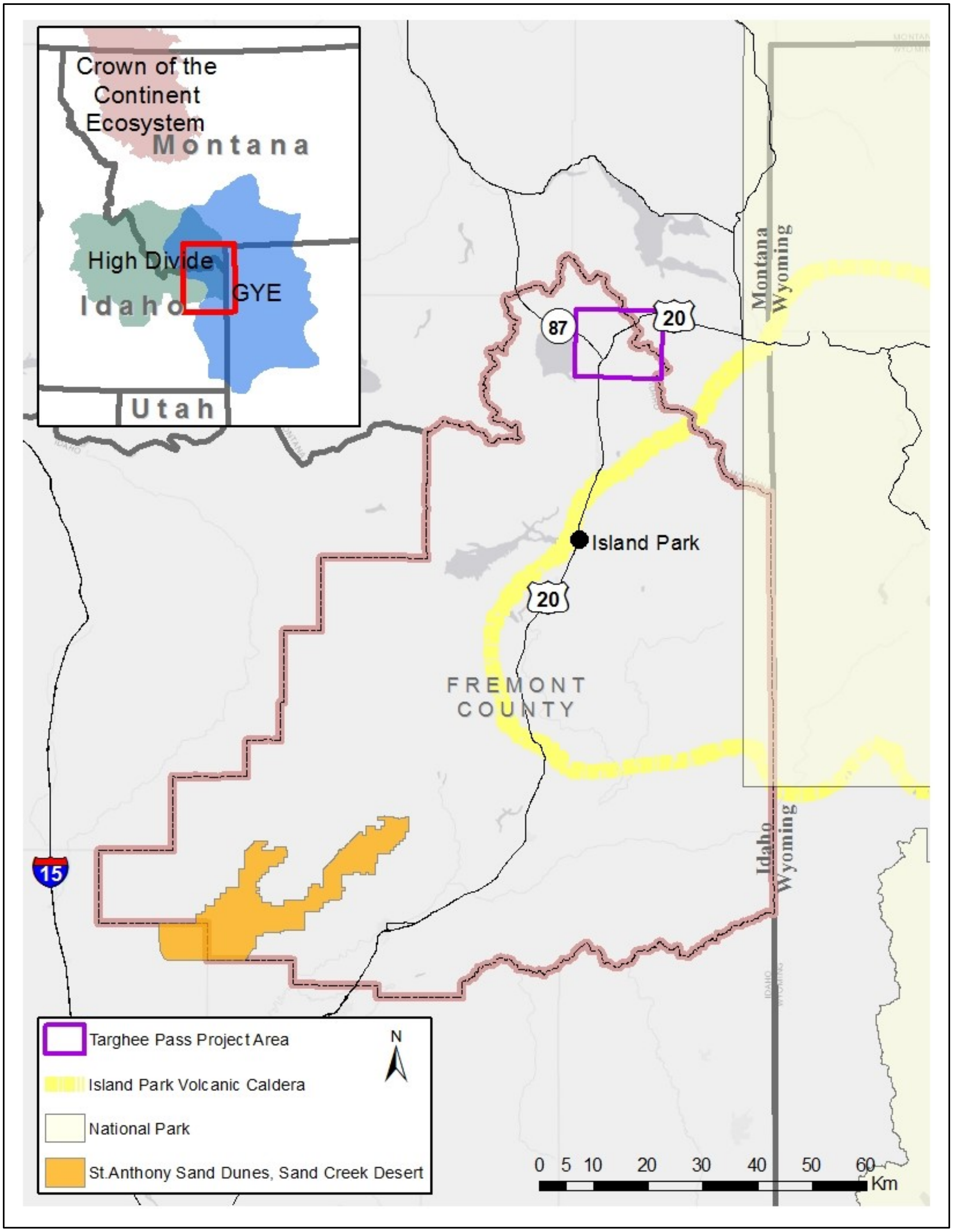

Figure 2. Targhee Pass project area is shown in relation to the High Divide, Greater Yellowstone and Crown of the Continent Ecosystems, Fremont County, the city of Island Park, the Island Park Volcanic Caldera, Yellowstone and Grand Teton National Parks and the Sand Creek Desert.

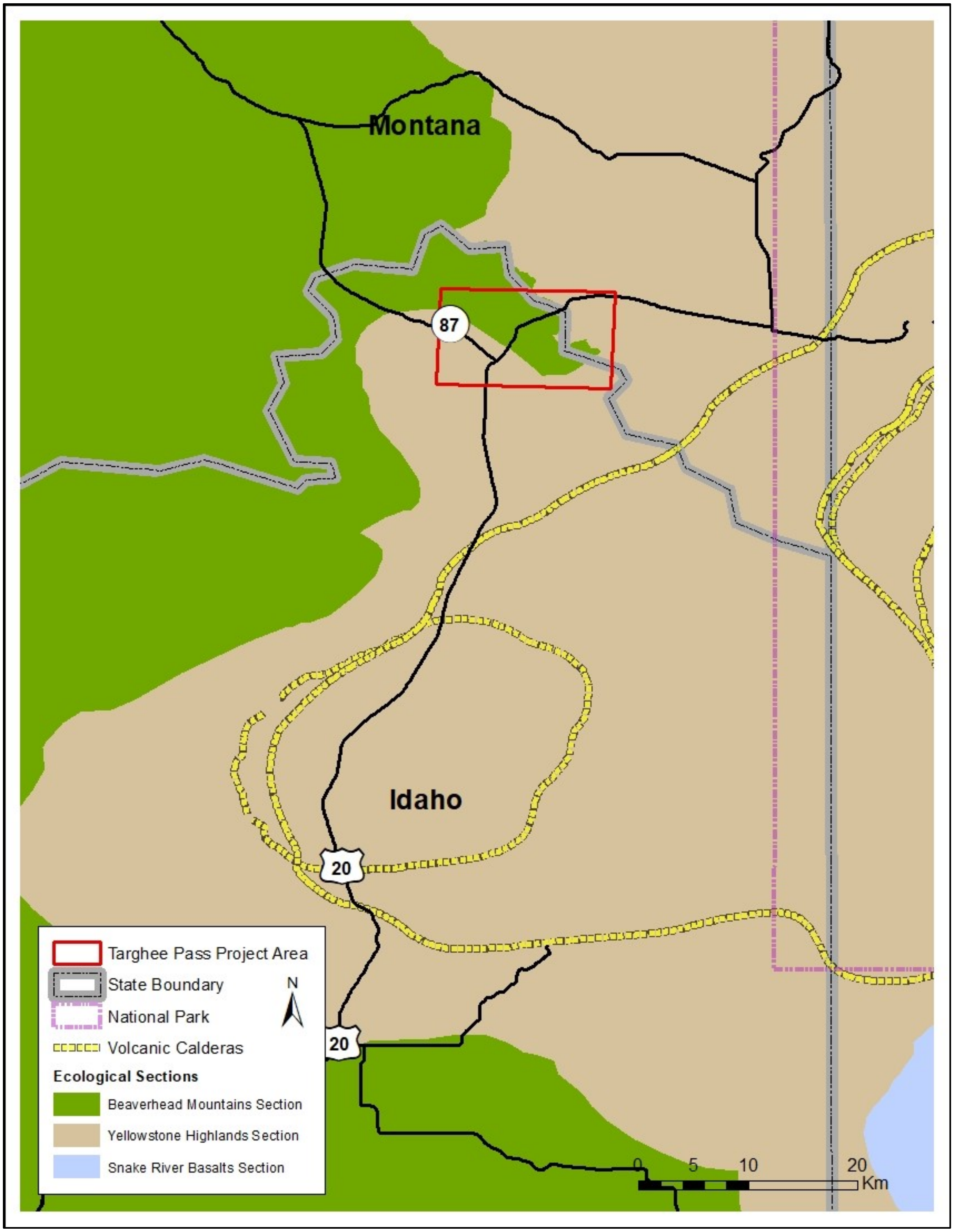

Figure 3. Bailey's Ecological Sections in the Targhee Pass Project Area.

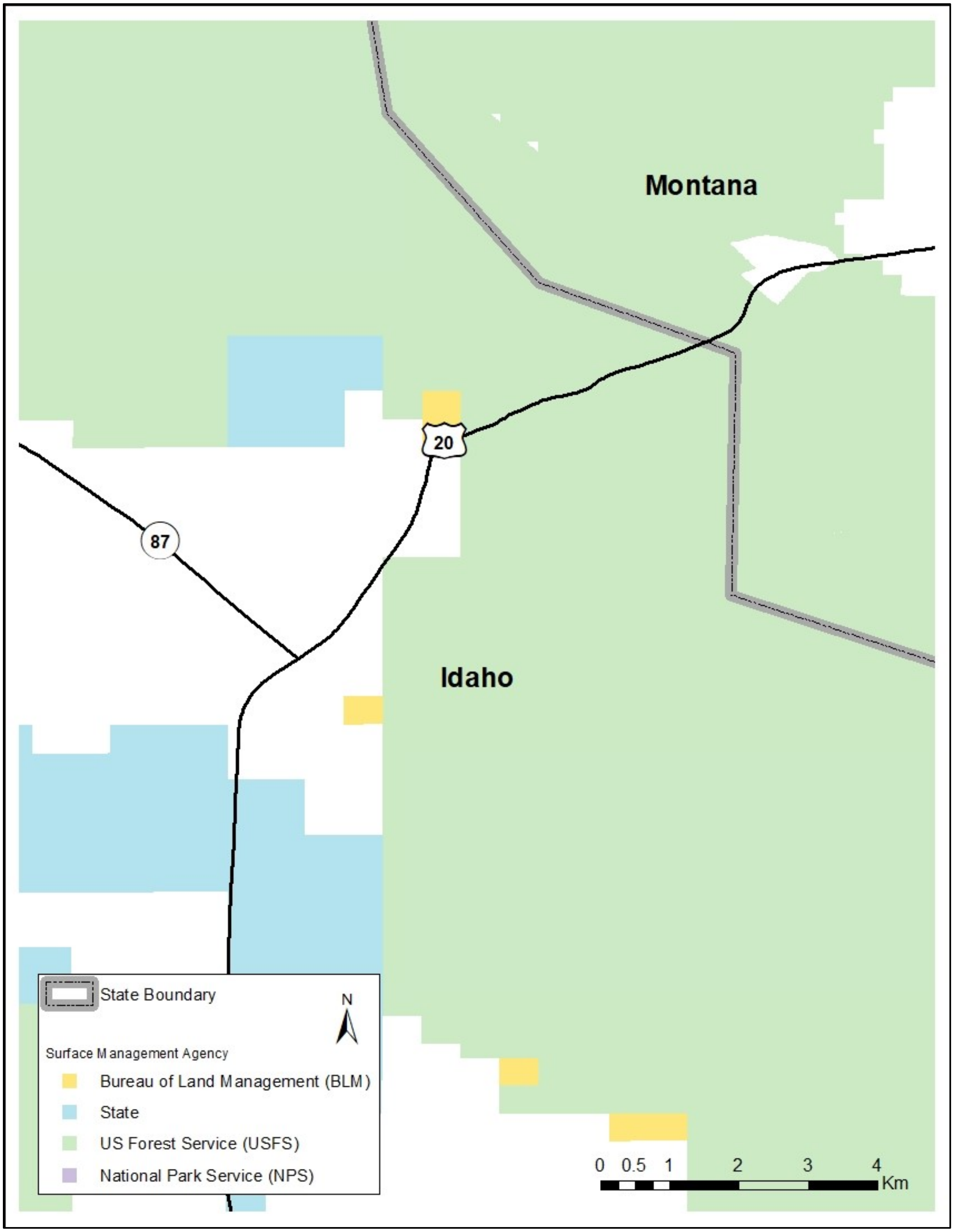

Figure 4. Land ownership surrounding Targhee Pass Project area. Privately owned lands are white.

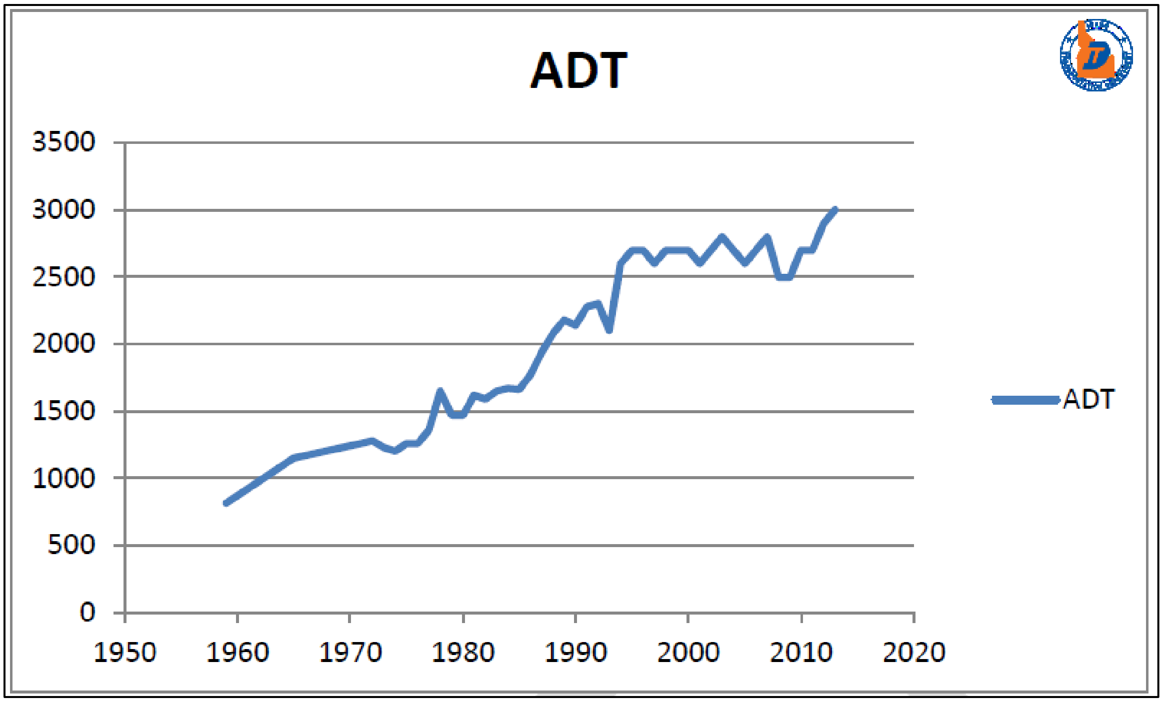

Figure 5. Average daily traffic (ADT) growth over the last 40 years rose to 3,000 on Targhee Pass in 2013 (Burke 2015).

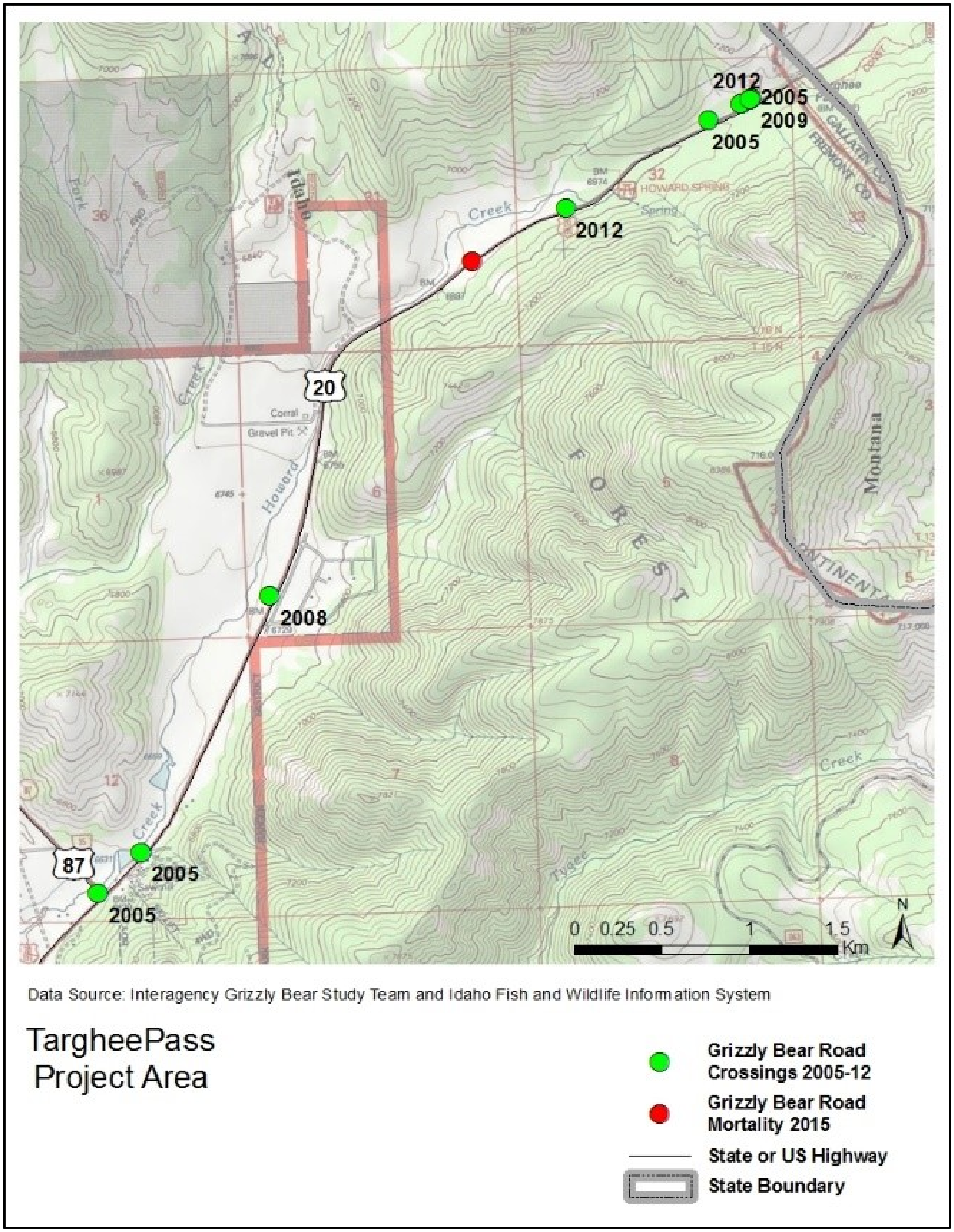

Figure 6. Grizzly bear crossing locations were created by the Interagency Grizzly Bear Study Team using global positioning system (GPS) radio-collar data (green dots). A grizzly bear-vehicle collision (collision occurred in 2015; sourced from IFWIS) that resulted in the mortality of the bear in the Targhee Pass project area is shown as a red dot.

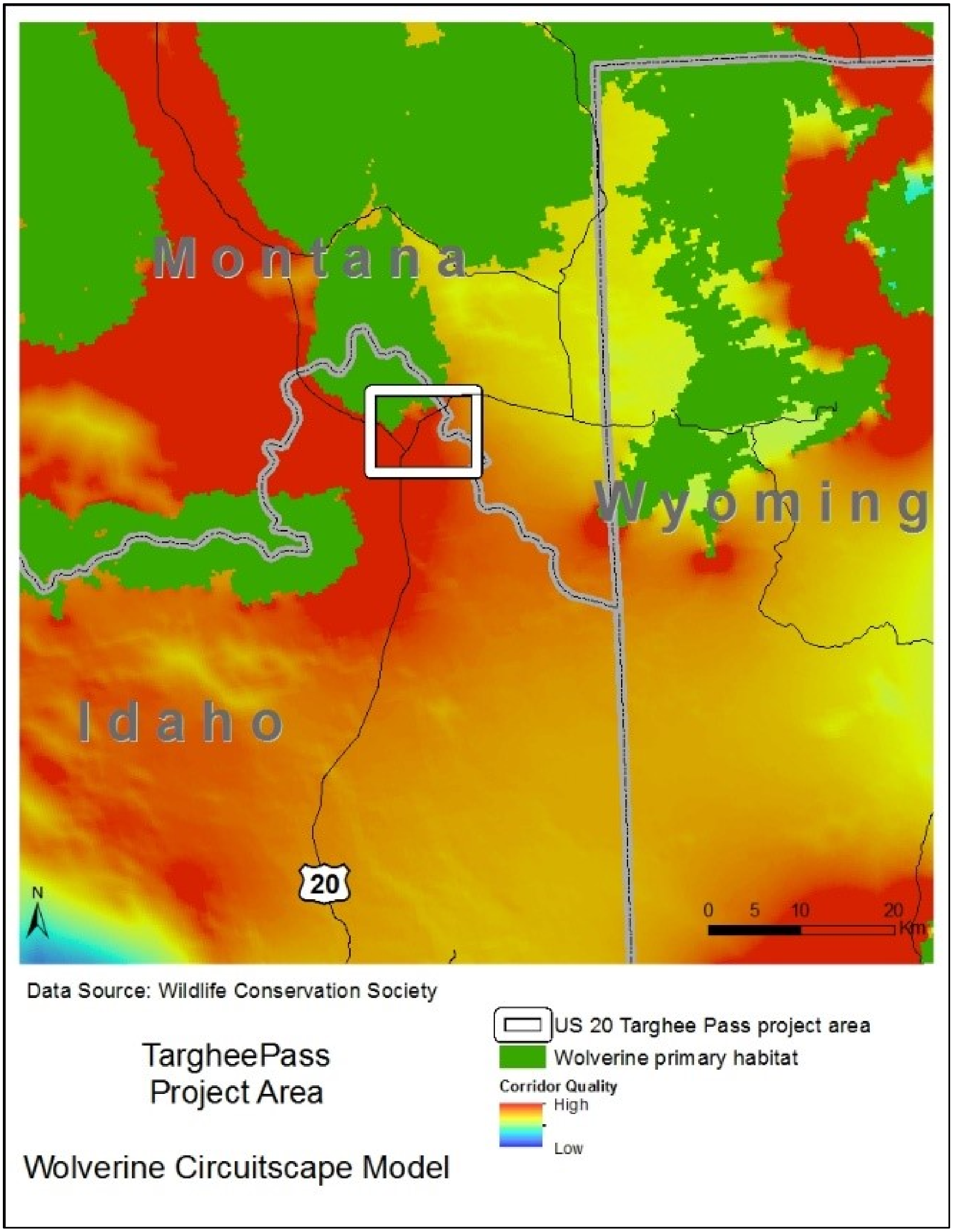

Figure 7. This Wolverine Circuitscape Model shows a high probability dispersal corridor on the Targhee Pass project area. Green areas on the map are wolverine primary habitat used as initiation and termination points of dispersal in the model. Other colors on the map represent the likelihood of a wolverine moving across the landscape. Blue areas show a low probability of use; red areas show a high probability of use. This model was created by the Wildlife Conservation Society using global positioning system (GPS) data from implanted and radio collared wolverines.

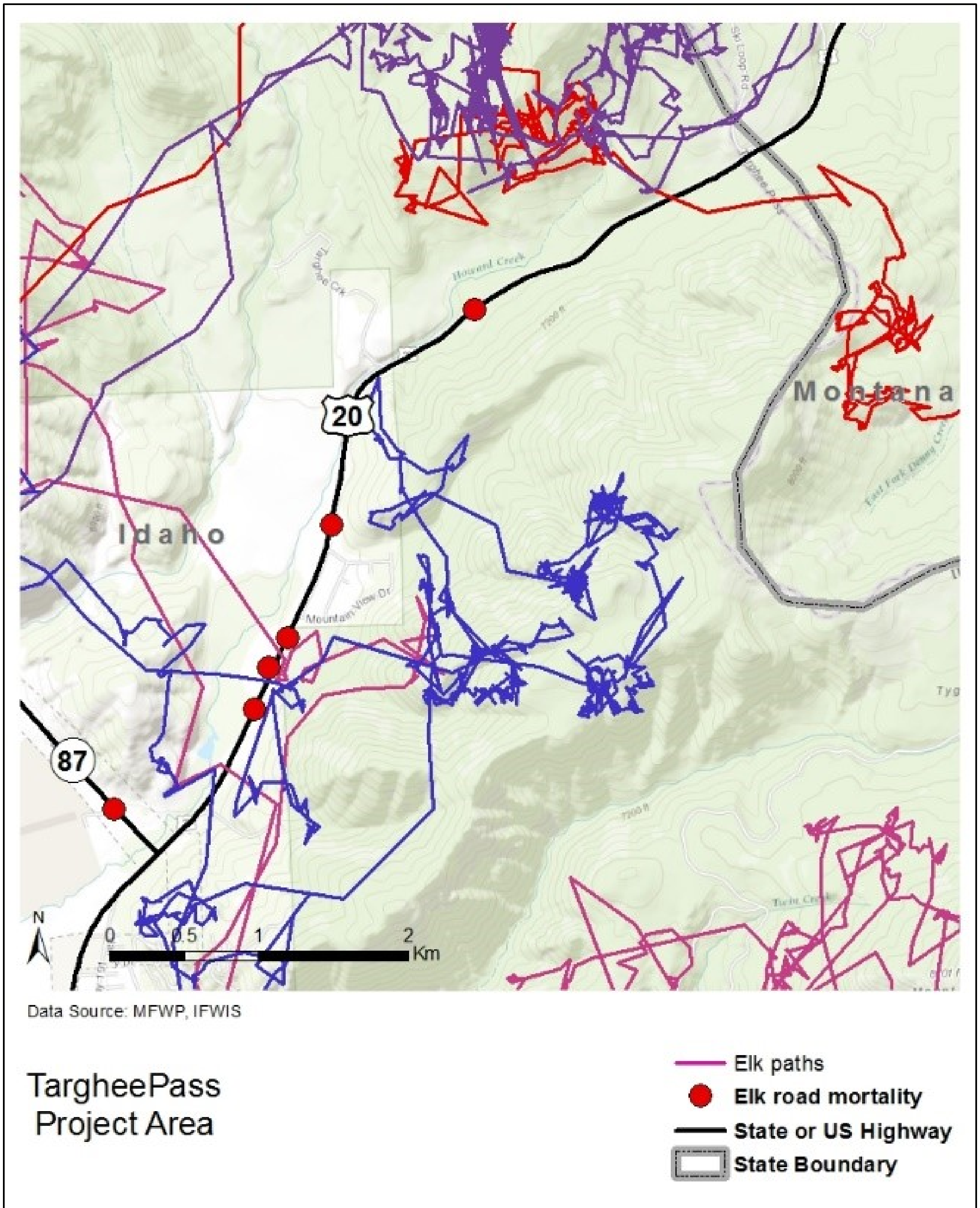

Figure 8. Elk movement paths were created in ArcGIS using radio-collar data from Montana Fish Wildlife and Parks and elk road mortalities in the Targhee Pass project area were downloaded from the IFWIS. Note that while many movement paths show elk crossing US 20, several paths also show elk approaching and then leaving US 20 without crossing.

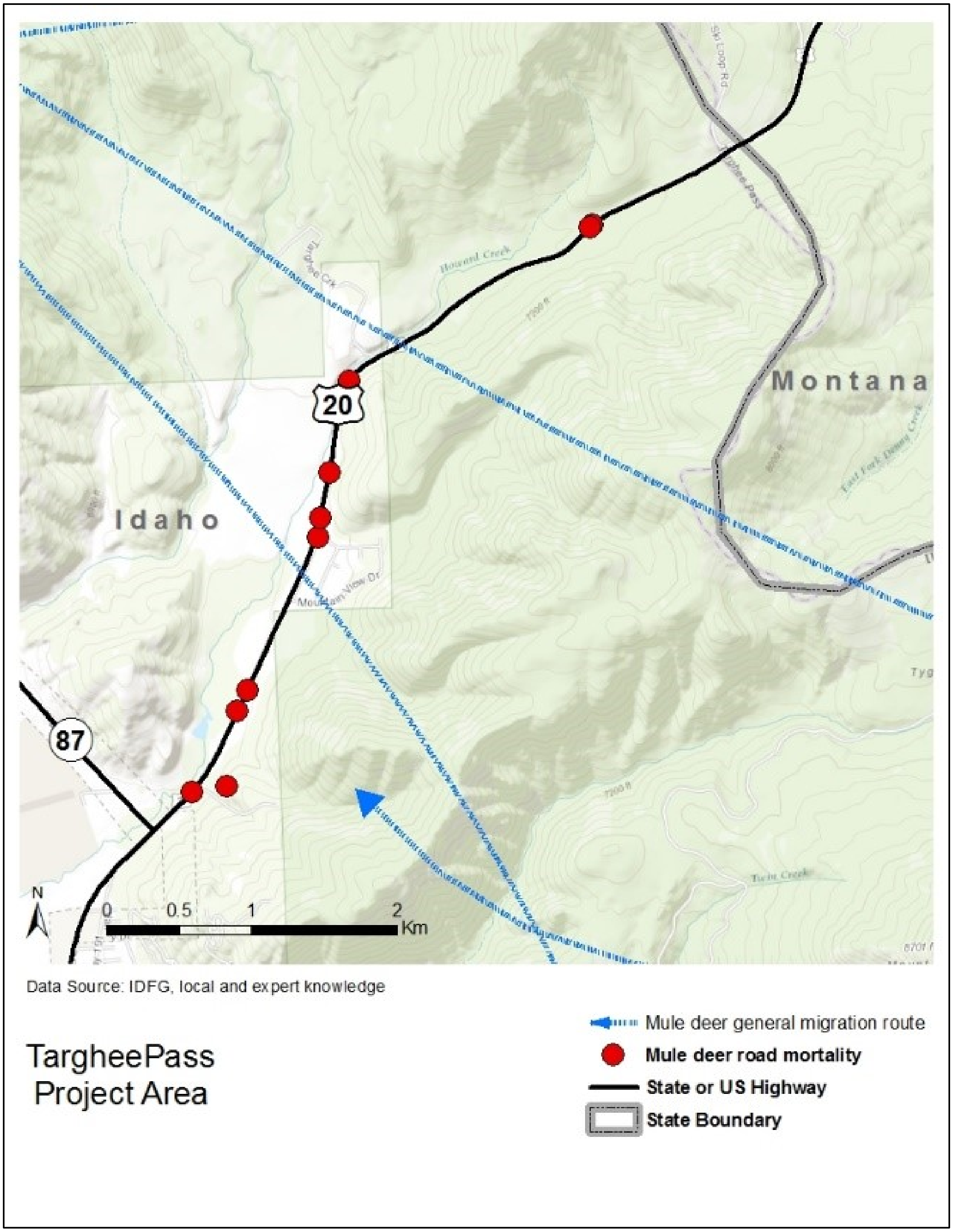

Figure 9. Estimated mule deer migration routes were created using IDFG expert and other local knowledge (blue lines). Mule deer road mortality locations were downloaded from the IFWIS (red dots).

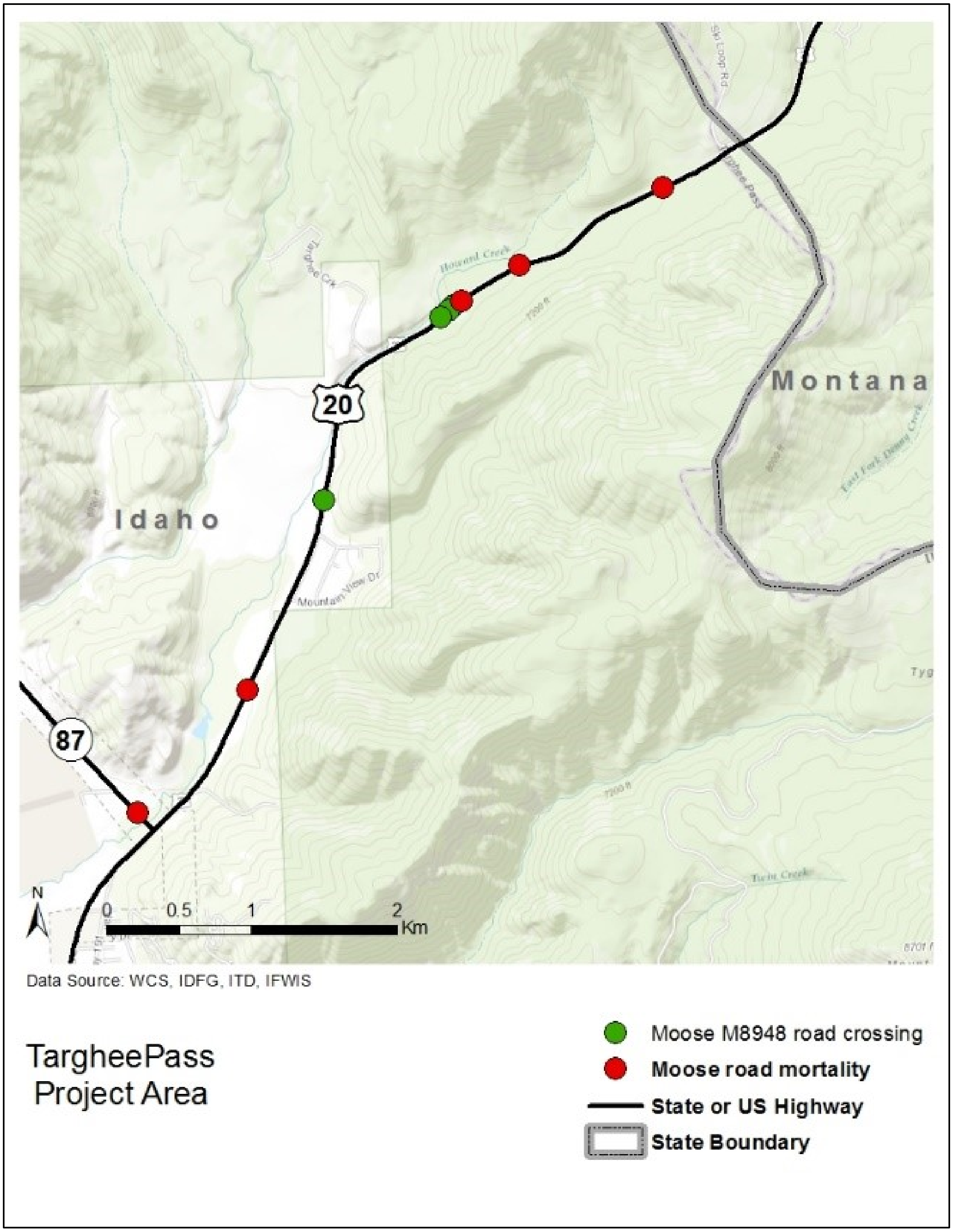

Figure 10. A non-migratory moose's US 20 crossing locations during spring and fall on the Targhee Pass project area are shown as green dots (Wildlife Conservation Society, IDFG, ITD). Road mortalities of other moose are shown in red (IFWIS).

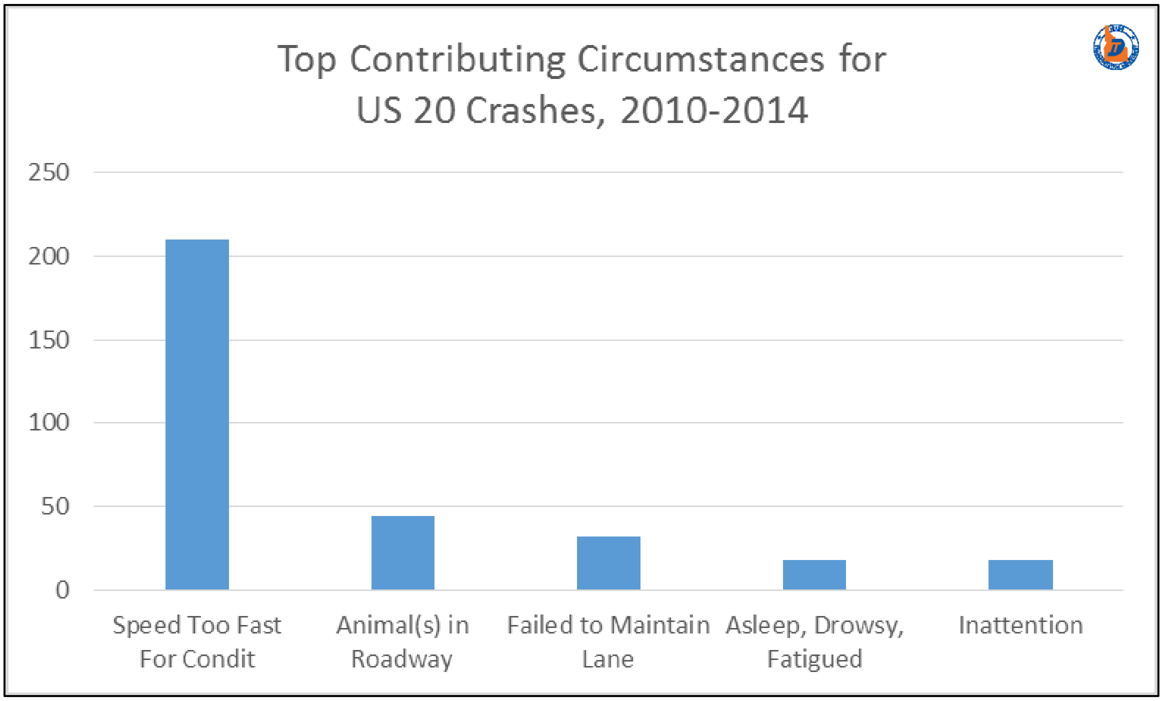

Figure 11. Animals in the roadway are the second leading cause of crashes on the US 20 Corridor ([US 20 Corridor Plan](#)).

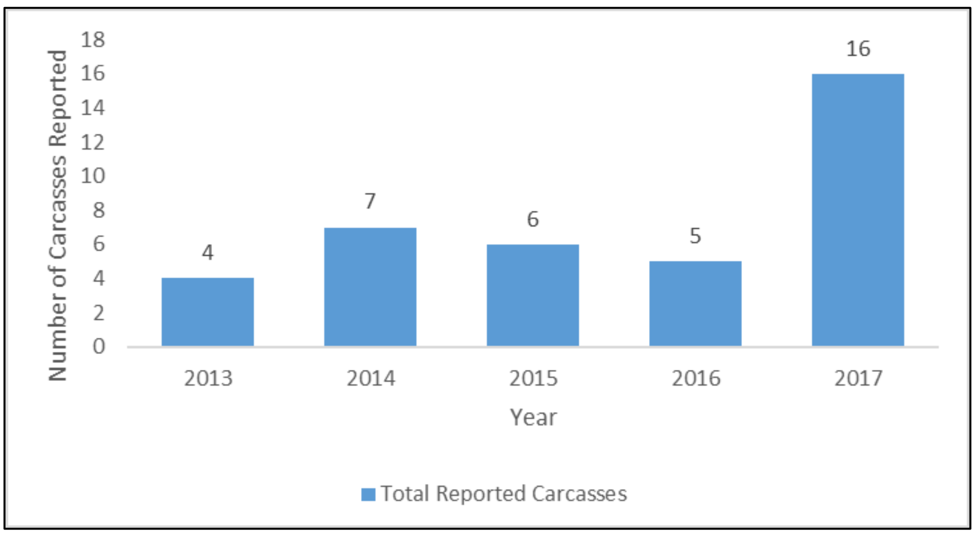

Figure 12. The number of WVCs reported to IFWIS and law enforcement increased almost 300% in 2017 compared to the previous 4 years.

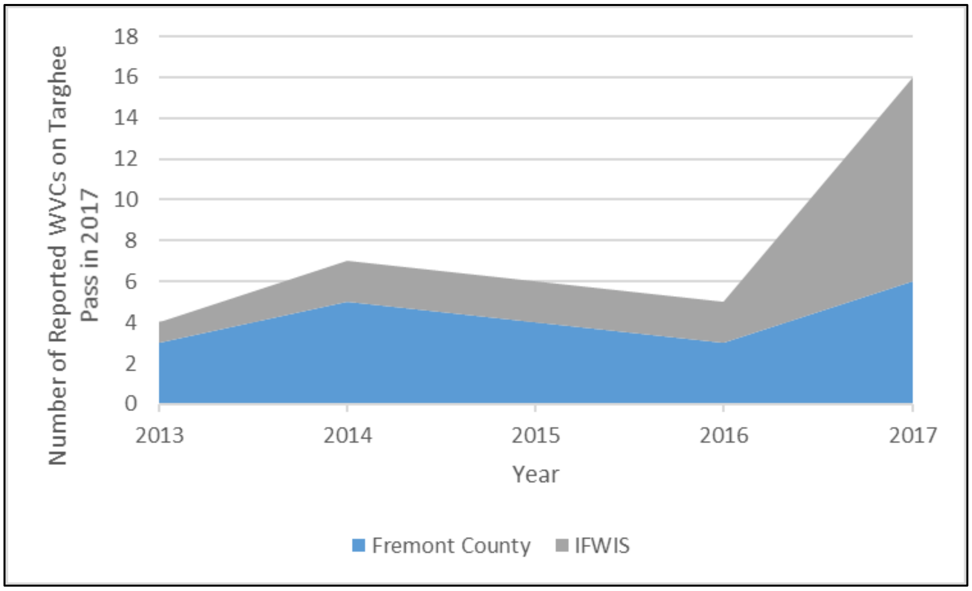

Figure 13. The increase in reported WVCs on Targhee Pass in 2017 is due to increased reporting of carcasses to Idaho's IFWIS site.

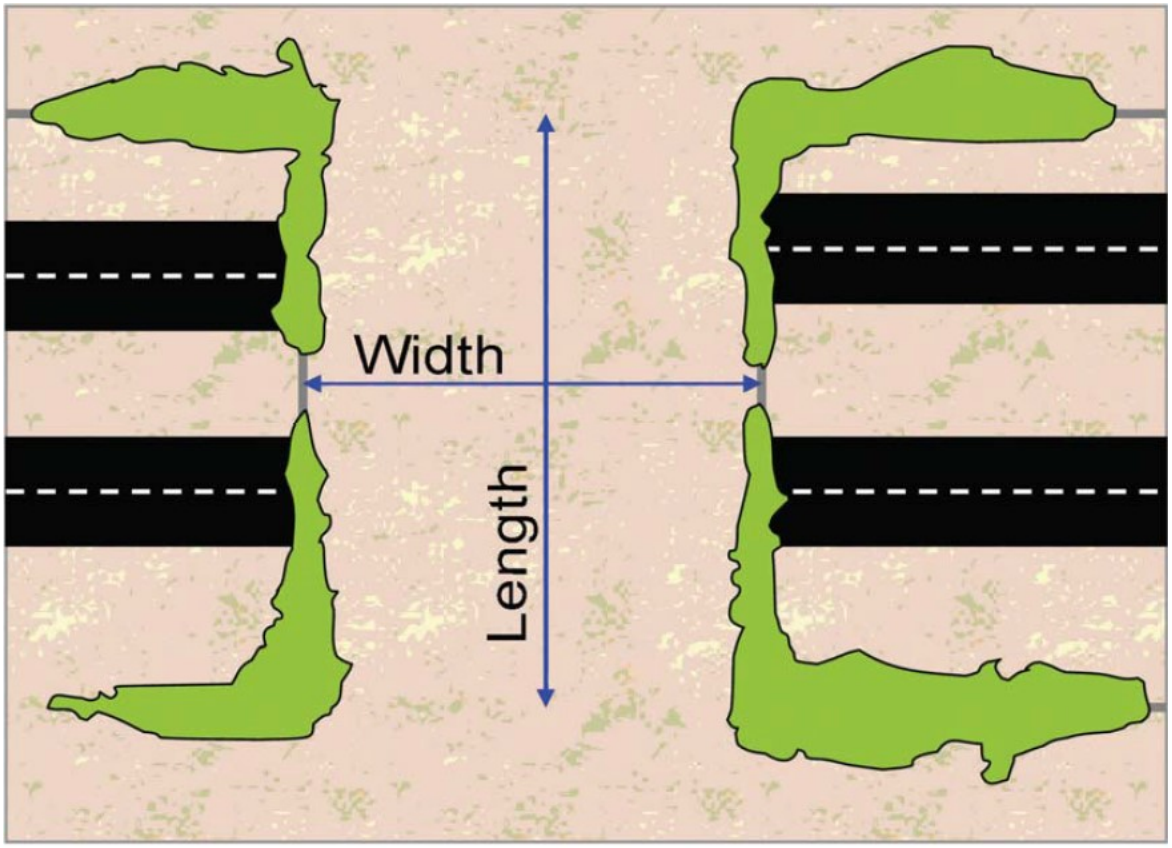

Figure 14. Width and length of a wildlife overpass (Clevenger and Huijser 2011).

Tables

Table 1. We estimated the value of road killed wildlife that were reported to the IFWIS and to WebCARS on the Targhee Pass project area between January 2011 and December 2015 using Idaho Statute Title 36, Chapter 14, Section 36-1404, which is based on the value of an animal that was illegally killed. A conservative correction factor of 50% (Conover et al. 1995) was applied to calculate the total annual value of killed wildlife. Duplicates include any roadkill reported to IFWIS within one month of a WebCARS crash date and within two kilometers of a crash location. These were subsequently removed from the data.

Date	Source	Identifier	Species	Sex	Value[1,2]	Latitude	Longitude	Most Harmful Event	Primary Contributing Circumstance	Weather	Surface	Light	Crash Severity	Duplicate Record[3]
7/16/2011	WebCars	59	Deer		$1,200	44.658598	-111.310156	Animal - Wild	Animal(s) in Roadway	Clear	Dry	Dark, No Street Lights	Property Dmg Report	
1/6/2012	WebCars	22				44.639930	-111.320428	Guardrail Face	Animal(s) in Roadway	Clear	Ice	Dark, No Street Lights	Property Dmg Report	
6/1/2012	WebCars	37	Elk	Female	$750	44.646373	-111.315883	Animal - Wild	Animal(s) in Roadway	Clear	Dry	Dark, No Street Lights	Property Dmg Report	
7/21/2012	WebCars	43	Elk		$2,875	44.652950	-111.311795	Animal - Wild	Animal(s) in Roadway	Clear	Dry	Dark, No Street Lights	Property Dmg Report	
8/15/2012	WebCars	34	Elk	Male	$5,000	44.643796	-111.317703	Animal - Wild		Clear	Dry	Dark, No Street Lights	Property Dmg Report	✓
8/24/2012	WebCars	36	Elk	Female	$750	44.645086	-111.316796	Animal - Wild		Clear	Dry	Dark, No Street Lights	Property Dmg Report	
9/27/2012	WebCars	26	Deer		$1,200	44.642509	-111.318614	Animal - Wild	Animal(s) in Roadway	Clear	Dry	Dark, No Street Lights	Property Dmg Report	
10/2/2012	WebCars	72	Elk		$2,875	44.666827	-111.297228	Animal - Wild	Animal(s) in Roadway	Clear	Dry	Dark, No Street Lights	Property Dmg Report	
10/6/2012	WebCars	27	Unknown			44.642509	-111.318614	Animal - Wild	Animal(s) in Roadway	Clear	Dry	Dawn or Dusk	Property Dmg Report	
10/7/2012	WebCars	103	Moose	Male	$10,000	44.673213	-111.279351	Animal - Wild	Vision Obstruction	Clear	Dry	Dawn or Dusk	Property Dmg Report	✓
7/19/2013	Fremont Co Sheriff	FID 12	Moose		$5,750	476300	4945901							
8/1/2013	IFWIS	628631	Mule Deer	Female	$400	44.661327	-111.308885							
8/4/2013	Fremont Co Sheriff	FID 13	Bear		$400	476300	4945901							
9/8/2013	WebCars	25	Deer		$1,200	44.641220	-111.319523	Animal - Wild	Animal(s) in Roadway	Clear	Dry	Day	Property Dmg Report	
10/3/2013	WebCars	102	Elk	Female	$750	44.673520	-111.278157	Animal - Wild		Snow	Wet	Dark, No Street Lights	Property Dmg Report	✓
2/2/2014	IFWIS	665522	Moose	Female	$1,500	44.666078	-111.298952							
6/23/2014	WebCars	38	Deer		$1,200	44.647663	-111.314979	Animal - Wild		Clear	Dry	Day	Property Dmg Report	✓
7/26/2014	WebCars	5	Deer		$1,200	44.634329	-111.326638	Animal - Wild	Animal(s) in Roadway	Clear	Dry	Dawn or Dusk	Property Dmg Report	✓
8/28/2014	Fremont Co Sheriff	FID 1	Deer		$1,200	474732	4943289							
9/16/2014	WebCars	104	Deer		$1,200	44.673213	-111.279351	Animal - Wild	Animal(s) in Roadway	Clear	Dry	Day	Property Dmg Report	✓
10/25/2014	IFWIS	1334300	Elk		$2,875	44.644966	-111.317224							
11/7/2014	WebCars	75	Elk	Male	$5,000	44.666827	-111.297228	Animal - Wild		Clear	Dry	Dark, No Street Lights	Property Dmg Report	✓
7/17/2015	WebCars	18				44.635305	-111.325150	Animal - Wild		Clear	Dry	Dark, No Street Lights	B Injury Accident	
7/22/2015	IFWIS	1345517	Mule Deer	Female	$400	44.670339	-111.287602							✓
8/17/2015	WebCars	23	Deer		$1,200	44.639930	-111.320428	Animal - Wild	Animal(s) in Roadway	Clear	Dry	Dark, No Street Lights	Property Dmg Report	✓
9/5/2015	IFWIS	1346363	Mule Deer	Female	$400	44.651731	-111.312014							
9/9/2015	WebCars	79				44.667549	-111.295479	Animal - Wild	Animal(s) in Roadway	Clear	Dry	Dark, No Street Lights	Property Dmg Report	
9/13/2015	WebCars	92	Deer		$1,200	44.668989	-111.289786	Animal - Wild	Animal(s) in Roadway	Clear	Dry	Dark, No Street Lights	Property Dmg Report	✓
9/14/2015	Fremont Co Sheriff	FID 17	Deer		$1,200	476300	4945901							
9/27/2015	IFWIS	1346410	Grizzly Bear	Male	$10,000	44.666078	-111.298952							✓

[1]For unknown sex mule deer, elk and moose the average value of trophy and non-trophy was used.

[2]Not all WebCARS reports include the species involved (n = 3); in these cases, data were omitted from subsequent animal value calculations.

[3]Duplicates to the indicated records were removed from this table.

Table 2. After combining data from IFWIS, WebCARS and the Fremont County Sheriff's office between 2011 and 2015 and removing any duplicates, the average annual number of reported large mammal mortalities on Targhee Pass is six.

Number of IFWIS Reports	11
Fremont County Sheriff Reports	12
Number of WebCars Reports	20
Raw Large Mammal Mortality Count	43
DuplicatesRemoved	13
Total 5-Year Large Mammal Mortalities	30
Average Annual Large Mammal Mortalities	6.0

Table 3. Using WVC data reported to IFWIS, WebCARS and the Fremont County Sheriff, Idaho Statute Title 36, Chapter 14, Section 36-1404, we estimate the average value of a killed wild animal on Targhee Pass is $2,058.

5-year Value	$	61,725
Average annual value	$	12,345
Average per animal value	$	2,058

Table 4. Crashes reported in the state of Idaho between January 2011-December 2015 and their severity rates (WebCARS 2017). Percentages of each crash type were used to compute annual costs of WVCs in the Targhee Pass project area (table 4).

Year	A Injury Accident	B Injury Accident	C Injury Accident	Fatal Accident	Property Dmg Report	Total
2011	10	32	41	2	852	937
2012	10	33	57	3	916	1019
2013	7	37	63	1	881	989
2014	10	53	61	0	793	917
2015	8	61	68	1	1029	1167
Total	45	216	290	7	4471	5029
Percent	0.8948%	4.2951%	5.7666%	0.1392%	88.9044%	

Table 5. Crash type percentages (from table 3) and the cost per crash type as per ITD were used to calculate a weighted crash cost for each of five crash types (defined by their severity) involving wildlife in Idaho. This weighted cost of a WVC in Idaho was added to the annual value of roadkill in Idaho (table 1) to create an annual total cost of WVCs on Targhee Pass.

Crash Type[a]	Crash Type Percent in Idaho	Cost/CrashType[b]	Cost of Crash by Type in Idaho		Value of Roadkill on Targhee Pass		Total Cost of WVC on Targhee Pass
A	0.8948%	$454,281	$4,065				
B	4.2951%	$123,732	$5,314				
C	5.7666%	$63,181	$3,643				
PDO	88.9044%	$3,201	$2,846				
Fatal	0.1392%	$9,498,816	$13,222				
		Average Cost of a Single WVC on Targhee Pass:	$29,090	+	$2,058	=	$31,148
		Annual WVC Costs:	$174,541	+	$12,345	=	$186,886

[a]Crash types as defined by Idaho Transportation Department

[b]Idaho Transportation Department crash costs for 2014

Table 6. Calculations to determine a benefit:cost ratio of implementing the recommended wildlife highway design elements and the number of years to pay for implementation. Treatment costs are estimated over a 50-year period, including installation of fencing 2 times (fences have an estimated 25-year lifespan) and a single installation of overpasses (estimated life span of 70-80

years, Huijser et al. 2009). Estimated effectiveness of this treatment is 85% (Huijser et al. 2009, Rytwinski et al. 2016). A 50% correction factor for WVCs was used (Conover et al. 1995).

Calculation	Formula	Result
Corrected WVC/Year on Targhee Pass (50% correction)	(32 collisions, 11 carcasses, 13 duplicates) ÷ 5 years ÷ 0.5	12
Fence + overpass effectiveness (85%)	Corrected WVC/year * 0.85	10.2
Annual savings	Effectiveness * Average cost of single WVC	$317,712
Project savings over 50 yrs	Annual savings * 50 years	$15,885,583
Treatment cost (fence installed 2x over 50 years)	Estimated from other projects	$8,483,410
Benefit:Cost	50 year savings ÷ 50 year treatment cost	1.87
Years to Pay Off	Treatment cost ÷ Annual savings	27

Table 7. Calculations to determine a benefit:cost ratio of implementing the recommended wildlife highway design elements and the number of years to pay for implementation. Treatment costs are estimated over a 50-year period, including installation of fencing 2 times (fences have an estimated 25-year lifespan) and a single installation of overpasses (estimated life span of 70-80 years, Huijser et al. 2009). Estimated effectiveness of this treatment is 85% (Huijser et al. 2009, Rytwinski et al. 2016). No correction factors for unreported WVCs were used.

Calculation	Formula	Result
WVC/Year on Targhee Pass	(32 collisions, 11 carcasses, 13 duplicates) ÷ 5 years	6
Fence + overpass effectiveness (85%)	WVC/year * 0.85	5.1
Annual savings	Effectiveness * Average cost of single WVC	$158,856
Project savings over 50 yrs	Annual savings * 50 years	$7,942,791.72
Treatment cost (fence installed 2x over 50 years)	Estimated from other projects	$8,483,410
Benefit:Cost	75 year savings ÷ 75 year treatment cost	0.94
Years to Pay Off	Treatment cost ÷ Annual savings	53

Table 8. Calculations using data from 2017 only, including carcass reports to IFWIS and reports from the Fremont County Sheriff's office with duplicates removed, to determine a benefit:cost ratio of implementing the recommended wildlife highway design elements and the number of years to pay for implementation. Treatment costs are estimated over a 50-year period, including installation of fencing 2 times (fences have an estimated 25-year lifespan) and a single installation of overpasses (estimated life span of 70-80 years, Huijser et al. 2009). Estimated effectiveness of this treatment is 85% (Huijser et al. 2009, Rytwinski et al. 2016). No correction factors for unreported WVCs were used.

Calculation	Formula	Result
WVC/Year on Targhee Pass	IFWIS and Fremont County Sheriff data	16
Fence + overpass effectiveness (85%)	WVC/year * 0.85	13.6
Annual savings	Effectiveness * Average cost of single WVC	$423,616
Project savings over 50 yrs	Annual savings * 50 years	$21,180,777.92
Treatment cost (fence installed 2x over 50 years)	Estimated from other projects	$8,483,410
Benefit:Cost	75 year savings ÷ 75 year treatment cost	2.50
Years to Pay Off	Treatment cost ÷ Annual savings	20

Table 9. Some typical highway design elements used to reduce WVCs (Huijser et al. 2009, Huijser et al. 2015, Rytwinski et al. 2016). Effectiveness of these treatments is expressed in terms of reduction in WVCs only and does not include an estimate of changes in landscape permeability for wildlife that may be realized.

Highway Design Element	Target species	Reduction in WVC
Animal detection system	Large animals	33-97%
In-vehicle animal detection system	Large animals	Unknown
Standard warning sign	Any species	0%
Digital/variable message sign[1]	Any species	0%
Seasonal wildlife warning signs	Any species	0-51%
Vegetation removal[2]	Large to mid-size animals	20-38%
Fence + wildlife overpass (50-70 m wide)[3]	Any species	83-87%
Fence + multi-use overpass[3,4]	Any species	83-87%
Fence + large mammal underpass[3]	e.g., elk, deer, black bear, cougar, coyote, bobcat	83-87%
Fence + multi-use underpass[3,4]	e.g., elk, deer, black bear, cougar, coyote, bobcat	83-87%

[1]Digital/variable message signs have been shown to reduce driver speeds and reaction times, but have not been correlated with a reduction in WVCs (Huijser and McGowen 2010)

[2]Removal of plant canopy can increase forb and grass growth, increasing forage for animals and drawing them to the roadside (Huijser et al. 2008)

[3]Not effective without wildlife fencing (Rytwinski 2016)

[4]Human activity changes diel pattern use at crossing structures with potential for sublethal-effects on wildlife (Barrueto et al. 2014)