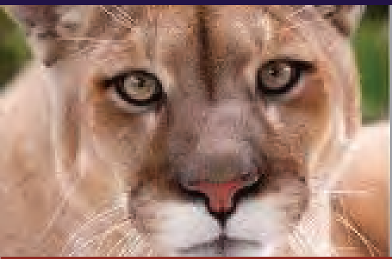

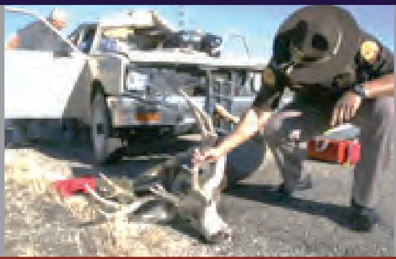

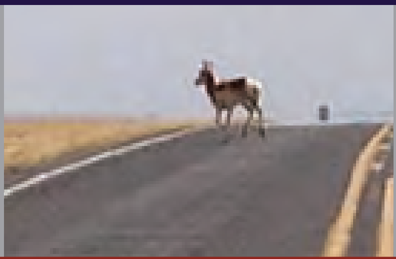

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Wildlife Corridors Action Plan

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List of Acronyms

AADS	animal-activated detection system
AADT	annual average daily traffic
AZDOT	Arizona Department of Transportation
AZGFD	Arizona Game and Fish Department
BACI	Before After Control Impact
BLM	Bureau of Land Management
BNSF	Burlington Northern Santa Fe Railroad
CBC	concrete box culvert
CDOT	Colorado Department of Transportation
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CME	construction maintenance easement
CMP	corrugated metal pipe
CPW	Colorado Parks and Wildlife
DBS&A	Daniel B. Stephens & Associates, Inc.
CSU	Colorado State University
DOD	Department of Defense
DOT	department of transportation
FDR	false discovery rate
FHWA	Federal Highway Administration
GIS	geographic information system
GPS	global positioning system
ha	hectare
HJM	House Joint Memorial
HS	habitat suitability
HSIP	Highway Safety Improvement Program
I-	Interstate Highway
KDE	kernel density estimation
LCC	Landscape Conservation Cooperative
m	meter(s)
MP	milepost
msl	above mean sea level

NDOT	Nevada Department of Transportation
NDOW	Nevada Department of Wildlife
NGO	non-government organization
NM	New Mexico Highway
NMDGF	New Mexico Department of Game and Fish
NMDOT	New Mexico Department of Transportation
NMSU	New Mexico State University
NPS	National Park Service
NWR	National Wildlife Refuge
OHSA	Optimized Hotspot Analysis
OHV	off-highway vehicle
PDO	property damage only
QA/QC	quality assurance/quality control
PIP	public involvement plan
R	resistance
RTA	Regional Transportation Authority
SH	State Highway
SLO	[New Mexico] State Land Office
S.O.	Secretarial Order
SR	State Route
T&E	threatened and endangered
UDOT	Utah Department of Transportation
UDWR	Utah Division of Wildlife Resources
UNICOR	Universal Corridor Network Simulator
UNM	University of New Mexico
US	U.S. Highway
USBR	U.S. Bureau of Reclamation
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
WCAP	Wildlife Corridors Action Plan
WVC	wildlife-vehicle collision
WMA	Wildlife Management Area
WMU	Wildlife Management Unit

List of Collaborators

The Action Plan development team is indebted to the following individuals and institutions for their valuable contributions.

- James W. Cain, Ph.D., USGS Cooperative Wildlife Research Unit Assistant Unit Leader, New Mexico State University (large game animal telemetry data)
- Jonathan L. Dunnum, Ph.D., University of New Mexico (species of concern)
- Jennifer K. Frey, Ph.D., New Mexico State University (species of concern)
- David S. Gutzler, Ph.D., University of New Mexico (climate change projections)
- Hall Sawyer, West Inc. (mule deer movement data)
- Travis W. Perry, Ph.D., Furman University (cougar telemetry data)
- Leland J. Pierce, New Mexico Department of Game and Fish (species of concern)
- Caitlin Ruhl, New Mexico Department of Game and Fish (bighorn sheep telemetry data and movement corridors)
- James N. Stuart, New Mexico Department of Game and Fish (species of concern)
- Myles Traphagen, Wildlands Network (sharing of report and photos in the Peloncillo Mountains)
- J. Francis Triepke, U.S. Forest Service (ecosystem types and climate change)
- Jicarilla Apache Natural Resources Department (large game animal movement information)
- Mescalero Apache Tribe (large game animal-vehicle collision data)
- Pathways: Wildlife Corridors of New Mexico (wildlife movement information)
- Pueblo of Santa Ana Natural Resources Department (large game animal telemetry data)
- Pueblo of Tesuque Department of Environment and Natural Resources (wildlife-vehicle crash data)

Executive Summary

Individual animals and wildlife populations need to move across the landscape to follow seasonal food sources or disperse from their natal area, and human-created barriers pose a threat to those movements. Roads in particular fragment habitat, and may prevent animals from meeting their nutritional and life history requirements. Wildlife-vehicle collisions (WVCs) not only present a well-documented risk to the safety of the traveling public; they can represent a significant cause of mortality in some animal species. In 2019, New Mexico took action to help prioritize and maintain habitat linkages with the signing of the New Mexico Wildlife Corridors Act (the Act) (https://www.nmlegis.gov/sessions/19%20Regular/final/SB0228.pdf). This important piece of legislation mandated the development of a Wildlife Corridors Action Plan (the WCAP, also Action Plan) providing comprehensive guidance to the New Mexico Department of Transportation (NMDOT) and the New Mexico Department of Game and Fish (NMDGF) to (1) identity, prioritize, and maintain important areas for wildlife movement and (2) develop a list of priority projects for building road-crossing structures designed to help animals cross roads and protect the traveling public from collisions with large wild animals. The provisions of the Act do not apply to private property or private property owners unless those owners choose to participate voluntarily.

Introduction

The approach to developing the Action Plan was science-driven and two-pronged, with a focus on identifying (1) the top WVC hotpots in the state, representing the areas of greatest concern in terms of public safety, and (2) the top wildlife corridors intersecting high-traffic volume roads, representing conflict areas that are a mitigation priority for helping individual animals and wildlife populations for moving across the landscape.

The Wildlife Corridors Act identifies by name six large focal species, all mammals, whose movements across the landscape are disrupted by roads and road traffic while at the same time posing a threat to the traveling public. These six large mammals are the mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), pronghorn (*Antilocapra americana*), bighorn sheep (*Ovis canadensis*), black bear (*Ursus americanus*), and cougar (*Puma concolor*) (also known as mountain lion or puma). They represent the main focus of all the analyses and modeling in the Action Plan.

A more complete list of species of concern (Table ES-1) was developed jointly by the Action Plan development team and the NMDGF based on the existing literature and with input from expert wildlife biologists in New Mexico. These species are identified as being adversely affected by habitat fragmentation, exacerbated by human caused barriers and the high potential of wildlife-vehicle collisions.

Table ES-1. Species of concern selected for the New Mexico Wildlife Corridors Action Plan.

Class	Common Name	Scientific Name
Reptilia	Ornate box turtle	*Terrapene ornata*
	Gila monster	*Heloderma suspectum*
	Mexican garter snake	*Thamnophis eques*
	Western massasauga	*Sistrurus tergeminus*
Mammalia	White-sided jackrabbit	*Lepus callotis gaillardi*
	White-tailed jackrabbit	*Lepus townsendii*
	Cougar	*Puma concolor*
	Kit fox	*Vulpes macrotis*
	Swift fox	*Vulpes velox*
	Red fox	*Vulpes vulpes*
	Black bear	*Ursus americanus*
	American badger	*Taxidea taxus*
	White-backed hog-nosed skunk	*Conepatus leuconotus*
	White-nosed coati	*Nasua narica*
	Collared peccary	*Tayassu tajacu*
	Pronghorn	*Antilocapra americana*
	Bighorn sheep	*Ovis canadensis*
	Mule deer	*Odocoileus hemionus*
	White-tailed deer	*Odocoileus virginianus*
	Elk	*Cervus canadensis*

In addition to science, public outreach was an important component of the Action Plan development process. A public involvement plan (PIP) was drafted in late 2019 and early 2020 to identify target audiences, outreach methods, and engagement activities. A list of

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stakeholders was developed and continuously updated, and public meetings were organized around the state, to both present the Action Plan and its goals and seek early public input. The meetings were advertised in advance in letters to all the stakeholders and in postings on agency social media sites. Public comments recorded during the meetings or received afterward were compiled. Input received on possible wildlife-vehicle conflict areas was reviewed and discussed, and was incorporated as needed into the Action Plan. The developing Covid-19 pandemic led to the cancellation of three of the planned public meetings. The five public meetings held to present the Action Plan are listed in Table ES-2.

Table ES-2. Public meetings conducted prior to the pandemic to introduce the Wildlife Corridors Action Plan and solicit input from the public.

Location		Date	Time
Raton	NMDGF Office, 215 York Canyon Road	February 25, 2020	6:30-8:00 p.m.
Albuquerque	NMDGF Office, 7816 Alamo Road NW	February 27, 2020	6:30-8:00 p.m.
Santa Fe	Santa Fe Higher Education Center, 1950 Siringo Road	March 3, 2020	6:30-8:00 p.m.
Farmington	McGee Park, 41 County Road 5568, Multi-Purpose Building (located south of Sun Ray Park & Casino)	March 5, 2020	6:30-8:00 p.m.
Las Cruces	NMDGF Office, 2715 Northside Drive	March 10, 2020	6:30-8:00 p.m.

All Tribes and Pueblos around the state were contacted and data-sharing partnerships were formed with the Jicarilla Apache Nation, Mescalero Apache Tribe, Navajo Nation, Pueblo of Santa Ana, San Felipe Pueblo, and Pueblo of Tesuque. The datasets received through these partnerships informed some key steps in the development of the Action Plan, including the identification of top wildlife corridors intersecting high-volume roads. San Felipe Pueblo, Pueblo of Santa Ana, and Jicarilla Apache Nation staff were also key in helping identify priority road wildlife mitigation areas in the field.

Hotspot Analysis

Methodology

We used the software ArcMap 10.6.1 by ESRI Inc., the NMDOT-administered road GIS layer, and the Optimized Hotspot Analysis tool, which calculates the Getis-Ord Gi* statistic, all in an effort to model New Mexico wildlife-vehicle crash data from 2009-2018. Analyses were conducted using the Universal Transverse Mercator (UTM) projection, Zone 13N, North American Datum 1983 (meters). Area and magnitude calculations were conducted in meters and relayed as equivalent imperial measurement values. Common conversions reported here include 0.5 mile = 804.672 meters (m), 1 mile = 1,609 m, and 2 miles = 3,218 m.

The hotspot analysis was conducted using the following steps:

1. Obtain most recent NMDOT Roads georeferenced files and crash data.
2. Collapse multi-lane roads into a single line feature.
3. Buffer roads by 500 feet.
4. Determine the center line of the road polygons.
5. Develop 0.5-mile aggregated polygons for all NMDOT roads.
6. Apply the Optimized Hot Spot Analysis (OHSA) tool to the road and crash data.
7. Interpret output data at different confidence intervals.
8. Interpret output data at different scales.
9. Generate statewide and NMDOT districts top WVC hotspot maps and tables.

Results

Annual numbers of crashes involving the six focal species of concern are provided in Table ES-3 for the entire period of record (2002 to 2018). The annual average number of wildlife-vehicle crashes during the 18-year time period was lowest for bighorn sheep and highest for deer. Only the last 10 years of data were used in the hotspot analysis.

The WVC hotspot modeling resulted in identification of 60 WVC hotspots across the state, totaling 349 miles of NMDOT roads. The hotspots ranged in size from 1 to 34 miles. The number of wildlife crashes per mile per 10 years ranged from 17.6 for the top hotspot to 1.0 for the 50th to 60th hotspots. The hotspots were selected based on sheer numbers of wildlife-vehicle crashes per mile. Deer (both mule and white-tailed deer) were overwhelmingly the top animals involved within the hotspots, with 2,579 reported crashes (2009-2018); the hotspots were therefore largely located where these two species were reported to be involved in crashes. Elk were the second most often involved wild animal within the hotspots, with 737 reported crashes in the database. There were 118 reported black bear mortalities and 13 cougar mortality data points in the 60 hotspots. There were 9 pronghorn crashes and no known bighorn sheep crashes in the top 60 hotspot locations.

Table ES-3. Number of crashes involving the six focal species of concern, 2002–2019.

Year	Number of Crashes Reported					
	Deer	Elk	Pronghorn	Bighorn Sheep	Black Bear	Cougar
2002	568	181	13	—	29	1
2003	572	169	16	1	9	2
2004	555	186	6	—	17	2
2005	623	149	5	—	10	1
2006	668	139	16	—	20	3
2007	644	154	7	—	24	2
2008	665	140	20	—	33	7
2009	762	167	18	—	36	7
2010	606	183	11	—	30	8
2011	662	207	17	—	72	16
2012	494	145	10	—	65	12
2013	489	132	7	—	72	10
2014	597	164	8	3	49	14
2015	686	156	9	6	35	15
2016	842	245	19	3	19	19
2017	980	235	21	1	79	14
2018	991	289	18	3	51	20
2019	—	—	—	—	—	1
Total	11,404	3,041	221	17	650	154
Annual average	634	169	12	0.9	36	9

The 60 WVC hotspots are mapped in Figure ES-1. The lower-ranked hotspots are represented by orange to green colors. The top WVC hotspots were prioritized, with the top 10 hotspots summarized in Table ES-4 and numbered on the map.

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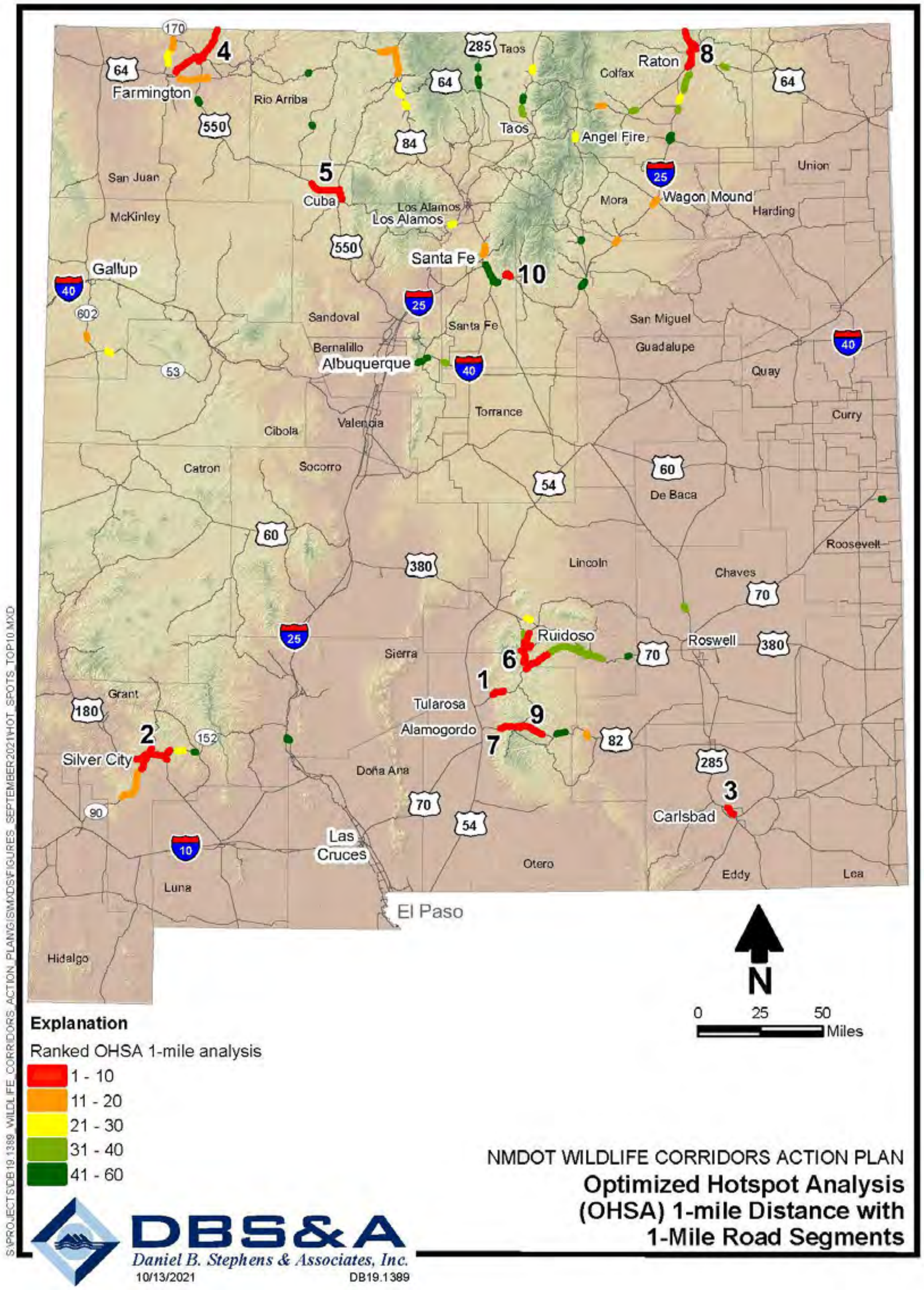

Figure ES-1. Hotspot analysis results. A total of 60 wildlife-vehicle crash hotpots were identified. Only the top 10 hotspots are numbered.

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Table ES-4. Top 10 WVC hotspots in New Mexico based on the number of crashes per mile.

Rank	Name	Length (miles)	Total Wildlife Crashes	Crashes per Mile (10 years)	Number of Crashes for Each Species					
					Deer	Elk	Bear	Mountain Lion	Pronghorn	Bighorn Sheep
1	US 70 Bent – Sacramento Mountains	5.0	88	17.60	18	70	0	0	0	0
2	US 180 NM 90 Silver City	27.6	471	17.05	455	13	2	1	0	0
3	US 285 North Carlsbad – Pecos River	4.00	66	16.50	66	0	0	0	0	0
4	NM 516 and US 550 Farmington to Aztec to CO	33.77	453	13.41	446	2	4	0	1	0
5	US 550 North of Cuba	17	205	12.06	81	12	4	0	0	0
6	US 70 SR 48 Ruidoso - Sacramento Mountains	33	358	10.85	256	97	4	1	0	0
7	US 82 West of Cloudcroft	5.0	54	10.80	13	40	0	1	0	0
8	I-25 North Raton to Colorado Border and South of Raton	26.5	280	10.58	183	42	49	3	3	0
9	US 82 East of Cloudcroft	13.0	134	10.31	46	85	3	0	0	0
10	I-25 Glorieta Pass	4.0	38	9.50	30	2	6	0	0	0

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Habitat Linkage Modeling and Selection of the Top-Priority Wildlife Corridors in New Mexico

The objective of the wildlife habitat linkage modeling was to identify core movement habitat and linkages across New Mexico for the six focal species.

Methodology

Habitat suitability maps for each of the six focal species were developed based on elevation/topography, slope, type of landcover and vegetation, water and riparian areas, human development, roads, and in some models, climate and soil.

From the habitat suitability maps, GIS layers were developed for depicting levels of resistance to movement across the landscape for each of the six focal species. The individual-based species connectivity and corridor identification simulation tool Universal Corridor Network Simulator (UNICOR) was then used to predict map connectivity corridors for each species studied. The resulting output is a map of raster cells that show the expected density of dispersing individuals of the species of interest. Two types of corridors were mapped: (1) kernel density estimation (KDE) on least cost paths and (2) cumulative resistant kernel. Factorial least cost path analysis is commonly used for analyzing connectivity patterns. It quantifies pairwise optimal paths among all individuals on a landscape. To better estimate a general area and not just the paths of hypothetical animals, a KDE was incorporated by buffering all least cost paths with a 1-kilometer Gaussian smoothing kernel. This additional step smooths the information to give a density surface of the most probable movement route connecting populations. Cumulative resistant kernel does not assume a single path between two individuals' source nodes in the simulation. It considers the dispersal ability of a species, and estimates many directions for movement from each point of location—meaning that it calculates all possible paths in each run of the model. There is a dispersal threshold, after which all kernels are added together to produce a density map predicting connectivity strength at each location on the landscape.

Subsequent steps of the modeling involved intersecting the wildlife corridors with roads and incorporating traffic volume, thus progressing toward identifying not just wildlife corridors but main areas of conflict between those corridors and roads. Modeling results were partially validated and calibrated based on wildlife-vehicle crash and telemetry data, supplemented by expert opinion and movement datasets provided by Action Plan partners.

Results

The habitat linkage modeling produced numerous results presented in the Action Plan (e.g., Figure ES-2).

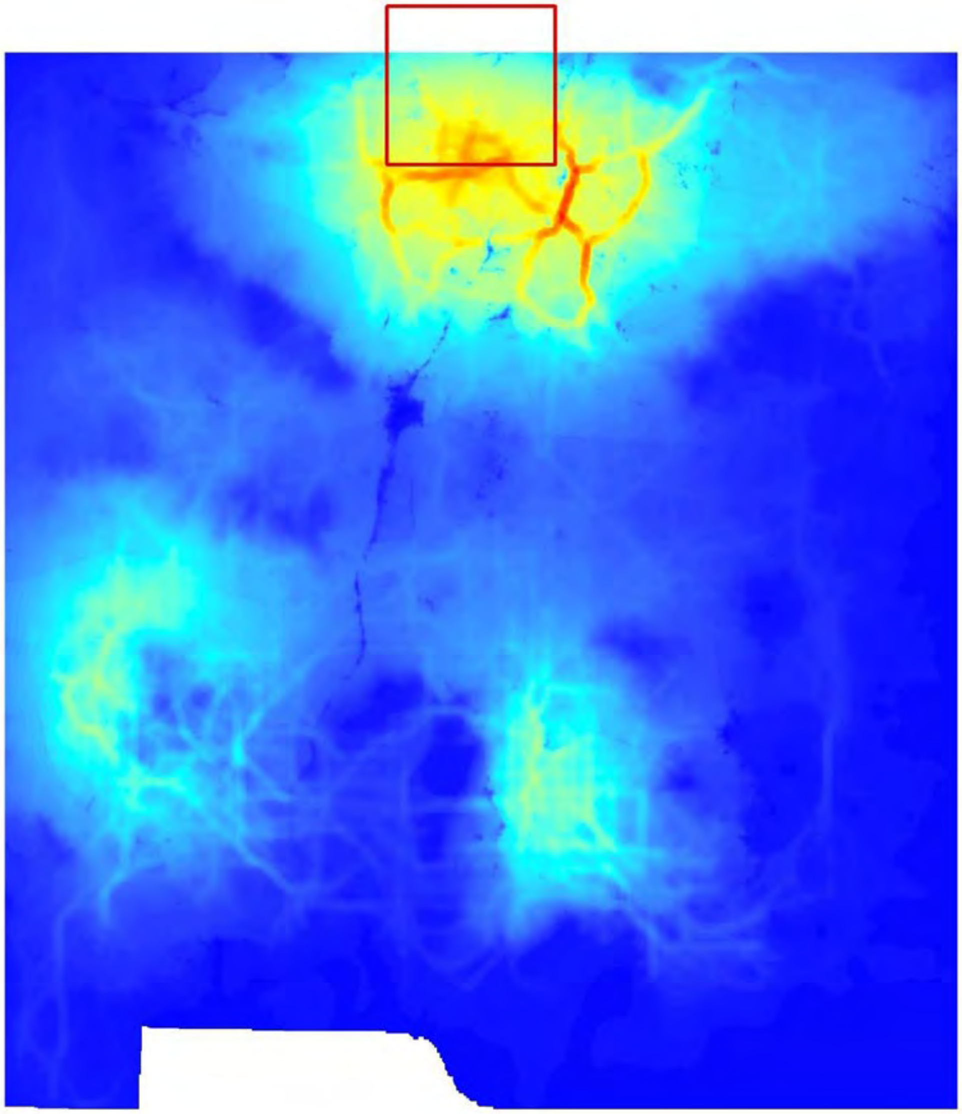

Figure ES-2. Calibrated resistance model for elk based on the weighted average of input models based on their weight in the random forest machine learning analysis. The red box shows the extent of the telemetry movement data used to train the model.

Using the results of the habitat linkage modeling, past modeling efforts (e.g., Menke, 2008) telemetry and other movement data from NMDGF and other entities (Tator, 2016 and 2020; Watts, 2014), expert opinion, and input from Tribes, the public, government agencies, and non-profit organizations, the following 10 high-priority corridors were identified:

- *U.S. Highway 285 (US 285) Rio Grande Del Norte National Monument North of Tres Piedras*. Supported by the habitat linkage modeling and by NMDGF unpublished global positioning system (GPS) radio collar data for elk and pronghorn, and within the Secretarial Order (S.O.) 3362 Action Plan high priority Northcentral Landscape. The Taos Plateau east of U.S. Highway 285 (US 285) represents an important winter range for elk and pronghorn, which move across US 285 to higher elevation calving/ fawning range west of US 285. This priority area is also supported by Presidential Proclamation 8946 declaring the establishment of the Rio Grande del Norte National Monument, which recognizes the importance of the national monument (both sides of US 285) to big game migration and habitat connectivity. Selection of this priority area offers partnership opportunities with the Bureau of Land Management (BLM) Taos Field Office, which manages the national monument, and the Carson National Forest, which manages some of the calving and fawning habitat in the Tusas/South San Juan Mountains.
- *US 64/US 84 South of Tierra Amarilla to Chama to the US 64/84 Junction, then US 284 to the Colorado Border*. Supported by mule deer and elk habitat linkage models, published Jicarilla Apache Tribe elk GPS radio collar data (Sawyer et al., 2011; Tator, 2016 and 2020; Watts, 2014), and NMDGF unpublished GPS radio collar data for mule deer, and also identified within the S.O. 3362 Action Plan high priority Northcentral Landscape. Mule deer occupy winter range near and around Heron and El Vado Reservoirs, and cross US 64/84 south and west of Chama to higher-elevation fawning habitat in the Tusas/south San Juan Mountains. The selection of this priority area offers partnership opportunities with NMDGF, which owns the Humphries, Sargent, and Rio Chama Wildlife Management Areas in this corridor, the Carson National Forest, which manages some of the calving and fawning habitat in the Tusas/south San Juan Mountains, and the Jicarilla Apache Tribe, which owns Tribal land along US 64/84 west and south of Chama.
- *I-25 South, US 64, NM 505, and NM 445 South of Raton to Maxwell (Pronghorn Triangle)*. Supported by habitat linkage modeling results for pronghorn, mule deer, and elk, and the S.O. 3362 Action Plan as part of the I-25 Las Vegas to Colorado priority landscape for pronghorn habitat connectivity. This corridor contains both the 26th ranked and 35th ranked WVC hotspots. More pronghorn have been recorded killed in this corridor than

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any other hotspot or wildlife corridor identified in the Action Plan. Private landowners in the area will be critical partners of any potential actions in this corridor. Partnership opportunities may be limited to private landowners such as Turner Enterprises Vermejo Park Ranch.

- *I-25 Glorieta Pass to Glorieta*. Supported by habitat linkage models for elk, black bear, and cougar. The Santa Fe National Forest, which submitted a letter of support, and the National Park Service's Pecos National Historical Park both represent potential partners. Private landowners in the area will be critical partners of any potential actions in this corridor.
- *I-10 Peloncillo Mountains Steins* . Supported by NMDGF and Arizona Game and Fish Department (AZGFD) desert bighorn (*Ovis canadensis mexicana)* GPS collar data. Interstate Highway 10 (I-10) is a known major barrier to habitat connectivity for desert bighorn sheep populations on both the north and south sides of this major interstate. Desert bighorn sheep roadkill mortalities have occurred (NMDGF unpublished data), and wide-ranging carnivores such as the Mexican gray wolf (*Canis lupus baileyi*) and jaguar (*Panthera onca*) have been documented on the south end of the Peloncillo mountains. Partnering opportunities are possible with the AZGFD, New Mexico State Lands Office, BLM, Wild Sheep Foundation, Malpais Borderlands Group, and Wildlands Network.
- *I-25 US 550 Sandia – Jemez Mountains Bernalillo Corridor*. Substantial public, agency, and Tribal support exists for this corridor. The Pueblo of Santa Ana supplied GPS locational data, maps, and carcass and crash data on mule deer, elk, pronghorn, black bear, and cougar on their lands and adjoining areas. There is non-profit, public citizen, and agency support in particular for the Crest of Montezuma wildlife corridor, which is located in the northeastern portion of this larger corridor. Data from Furman University and Kirtland Airforce Base on cougar movements demonstrate the need for these animals to cross under I-25 between the Sandia and Jemez mountain ranges. Private and Tribal land will be critically important for establishing wildlife crossing structures under and above I-25 and US 550. Both the Pueblo of Santa Ana and San Felipe Pueblo are committed to working with NMDOT to establish wildlife crossing structures on their lands.
- *NM 38 Questa to Red River.* This corridor is based primarily on the needs of Rocky Mountain bighorn sheep to safely cross NM 38 and not be involved in wildlife-vehicle collisions, which are also a danger to motorists. NMDGF identified this area as one of primary importance for Rocky Mountain bighorn sheep conservation. NMDGF bighorn sheep biologists emphasized the importance of keeping bighorn sheep off the road and the side of the road, adding that there had been a case of human fatality in a crash with a herd of bighorn sheep. The crash

was not identified as a wildlife-related crash in the NMDOT database, but NMDGF biologists are very certain of the reality of this event. Partnering possibilities would be with the Questa Mine owners, who own a section north of the highway, and the Carson National Forest.

- *New Mexico Highway 4 (NM 4), Jemez Mountains*. Supported by modeling results for elk, black bear, and cougar and Dr. James Cain's (U.S. Geological Survey [USGS] New Mexico Cooperative Fish and Wildlife Research Unit, New Mexico State University [NMSU]) GPS collar data for elk and mule deer. Partnering opportunities are possible with Jemez Pueblo, Santa Fe National Forest, Valles Caldera National Preserve, and Bandelier National Monument.
- *I-40 and NM 333, Tijeras Canyon*. Supported by the habitat modeling results for black bear and cougar, Dr. Travis Perry (Furman University) cougar GPS collar data, the cougar corridor model (Menke, 2008), NMDOT Research Bureau camera monitoring data for mule deer and cougar, and New Mexico Highlands Wildlands Network Vision (Foreman et al., 2003). Partnering opportunities are possible with the Cibola National Forest, City of Albuquerque and Bernalillo County Open Space programs, Sandia Bear Watch, and other local conservation groups.
- *US 70, San Augustin Pass*. Supported by habitat linkage modeling results for bighorn sheep, unpublished NMDGF bighorn sheep GPS radio collar data, the cougar corridor model (Menke, 2008), and New Mexico Highlands Wildlands Network Vision (Foreman et al., 2003). Partnering is possible with the BLM, which manages the Organ Mountains–Desert Peaks National Monument, the New Mexico State Lands Office, the U.S. Army's White Sands Missile Range, and the U.S. Fish and Wildlife Service's San Andres National Wildlife Refuge.

Further Prioritization of WVC Hotspots and Wildlife Corridors, Field Reconnaissance, and Benefit-Cost Analysis

Further Prioritization of the Top WVC Hotspots and Wildlife Corridors

The top 10 WVC hotspots were selected and prioritized based solely on the number of reported wildlife crashes per mile per year. Additional transportation, ecological, and feasibility factors were used to further rank and filter out hotspots. Only the hotspots ranked first to fifth were selected as five of the recommended projects.

The transportation factors that were quantified included (1) number of severe injury crashes per mile due to WVCs, (2) average annual daily traffic (AADT), and (3) the percentage of all reported crashes that were wildlife related. The total scores each hotspot received for these additional transportation factors ranged from 6.83 to 16.27. The ecological or wildlife factors quantified within the WVC hotspots summed the number of focal species and other species of concern that could potentially occur locally. The scores received by each hotspot ranged from 3 to 9. Two feasibility factors were analyzed for each WVC hotspot: (1) the amount of public land adjacent to the road segment and (2) public support for the hotspot and associated mitigation. Scores received by each hotspot ranged from 0 to 4. The above factors were brought together in a score card matrix for all the hotspots. Total scores ranged from 14.03 to 29.29. These values were factored in the next steps of ranking the hotspots.

The top 5 WVC hotspots that were selected as top-recommended projects are listed below in order of importance.

1. US 550 North of Cuba
2. US 180 and NM 90 Silver City
3. US 70 and NM 48 Ruidoso
4. I-25 Glorieta Pass
5. US 70 Bent Sacramento Mountains

The top 10 wildlife corridors were further examined using GPS locational data on wildlife movement, camera trap photographs, past modeling of potential wildlife corridors, the modeling of WVC hotspots for the Action Plan, expert opinion from NMDGF wildlife biologists, the extent of Tribal, non-profit organization, public, and agency support, and feasibility for constructing wildlife crossing structures in protected areas. Unlike for hotspots, the process of further prioritizing wildlife corridors was not quantitative. Rather, the selection of the top Wildlife Corridors came about through numerous internal meetings of the Action Plan development team. A total of six top-priority corridors were selected to represent various New Mexico ecosystems and to collectively facilitate wildlife movement for all six focal species, especially those not represented in the WVC hotspots. The six Wildlife Corridors selected as top recommended projects are listed below in order of priority.

1. US 64/US 84 Chama from South of Tierra Amarilla to Chama to US 64/84 Junction to Colorado
2. US 285 Rio Grande Del Norte National Monument North of Tres Piedras
3. I-25, US 64, NM 505, and NM 445 South of Raton to Maxwell, the Pronghorn Triangle
4. I-10 Peloncillo Mountains-Steins
5. I-25 and US 550 Sandia-Jemez Mountains-Bernalillo
6. NM 38 Questa to Red River

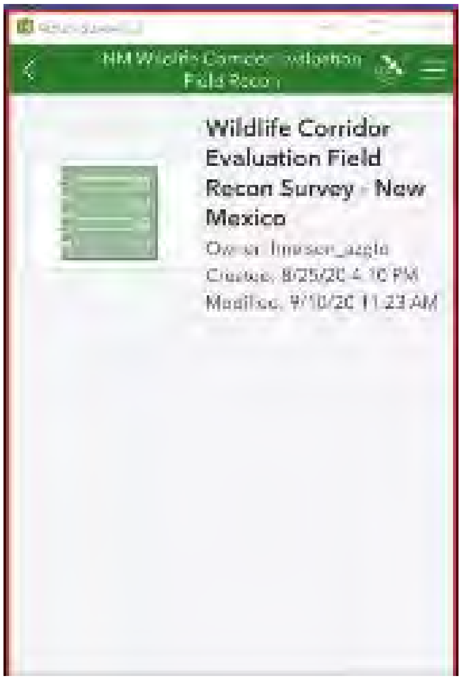
Field Reconnaissance of Top-Priority Hotspots and Wildlife Corridors

The field reconnaissance phase of the Action Plan relied on the following three major steps:

1. Development of field data collection forms using ArcGIS Survey123, allowing for the input of data, photographs, and videos that are automatically compiled into an on-line, interactive map
2. Field reconnaissance of sites for data gathering and the evaluation of potential location-specific mitigation opportunities
3. Recommendations based on all of the information brought together for potential projects within each WVC hotspot and habitat linkage bisected by roads

An ArcGIS Survey 123 App survey form (Figure ES-3) was developed for field verification of potential mitigation opportunities, fence limits, and sources of collisions within each priority area identified.

Field biologists visited all priority areas and used the app to collect data to guide opportunities and site-specific recommendations (e.g., retrofit, upsize culvert). The app survey form served three primary goals: (1) help field crew members locate specific mitigation opportunities on the ground and in the app's map, (2) consistently record all ecological and transportation factors important for mitigation opportunities, fence ends or sources of crashes, and (3) make site-specific recommendations for wildlife mitigation projects.



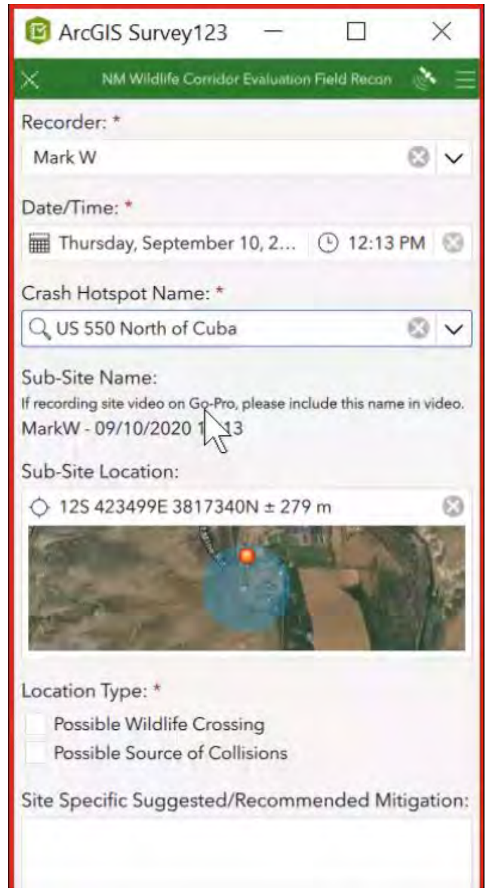


Figure ES-3. Introduction page of the survey form (left) and input page for a mini-site within the Cuba hotspot (right).

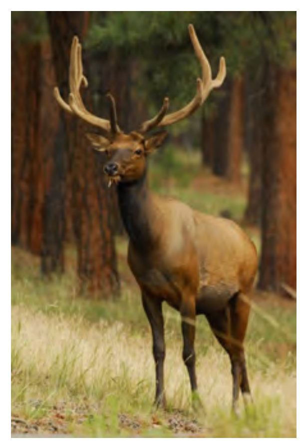
Benefit-Cost Analysis

Benefit-cost ratios were calculated for specific recommendations within each of the 11 recommended, top priority projects. Calculation of these ratios required that the costs of the proposed infrastructure be estimated. Benefits were monetized by calculating the reduction of costs associated with fewer crashes taking place as a direct result of the proposed mitigation over a 75-year period. The cost of infrastructure and its maintenance was placed in the denominator of the equation, and the estimated monetary benefit from the reduced number of animal-vehicle crashes (i.e., crashes with wildlife and domestic animals) over the lifetime of the mitigation was placed in the numerator. Crashes involving domestic animals were factored in, as they are expected to decrease directly as a result of the same mitigation proposed for wildlife.

Cost estimates for recommended structures and infrastructure were based on both current NMDOT construction costs and neighboring state infrastructure costs. The benefits of the proposed mitigation were estimated based on (1) the current cost associated with the annual average number of animal-vehicle crashes of different crash severities and (2) projected reductions in the number of crashes over the lifetime of the mitigation. The costs to society associated with crashes were taken from NMDOT 2019 cost estimates and from Federal Highway Administration (FHWA) cost estimates (Harmon et al., 2018). The annual animal-vehicle crash costs per mile were calculated, and then multiplied by the length (number of miles) of the project. Mitigation projects were projected to last 75 years, with a percentage in the expected reduction in crashes ranging from 30 to 90 percent, depending on the amount of infrastructure proposed. The dollar value associated with the number of deer and elk saved over the 75 years of mitigation, based on Colorado DOT estimates ($2,061 and $2,392, respectively) (Kintsch et al., 2019), was added to the benefit in the benefit-cost equations. Two separate benefit-cost ratios were calculated: one using NMDOT cost estimates and the other using FHWA estimates. If the benefit-cost ratio is greater than or equal to 1, the mitigation is expected to pay for itself. If it is less than 1, the mitigation is not expected to pay for itself over the 75-year period. The benefit-cost ratio values reported in the project descriptions have no bearing on the ranking of the hotspots or corridors.

Project Recommendations

US 550 North of Cuba WVC Hotspot

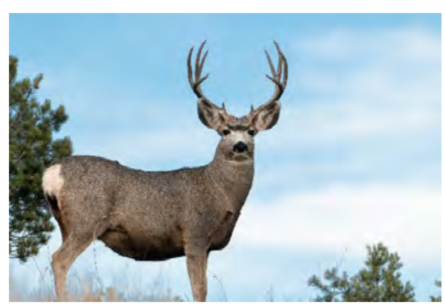


The US 550 North of Cuba WVC hotspot is located within NMDOT District 6 on US 550 from milepost (MP) 64 to MP 80. The hotspot is 17 miles long with 14 miles of recommended project mitigation. From 2009 to 2018, an annual average of 1.21 reported wildlife-vehicle crashes per mile involved the six focal species. Elk represented the majority (58 percent) of those crashes. The hotspot is of prime importance for wildlife-transportation mitigation in New Mexico. Public lands are present, while wildlife agencies, a Tribe, and public citizens are all voicing their support of mitigation options that would help deer, elk, black bear, and other species of animals cross over and beneath US 550 to avoid vehicle collisions, thereby maintaining or enhancing habitat connectivity. Specific project recommendations include four overpasses, four single span bridges, and one arch culvert that would be placed as new structures. If these structures are all placed within the hotspot, then the wildlife exclusion fence would extend 14 miles. Because elk are hesitant to use any culverts or small bridge structures, only span bridges and overpasses would work to keep them moving below and above the highway in large numbers. If all the recommended infrastructure is constructed, the cost is estimated at $45 million. If the NMDOT crash costs are used in a benefit-cost equation, the benefit-cost ratio would be 0.51. If FHWA costs for crashes are used, the ratio equal 1.02. Future wildlife mitigation actions would require working with the U.S. Forest Service (USFS), the Jicarilla Apache Nation, the Bureau of Land Management (BLM), and private landowners.

US 180 NM 90 Silver City WVC Hotspot

The Silver City WVC hotspot is approximately 27 miles long, and essentially includes all roads to and through Silver City. It is located within the boundaries of NMDOT District 1. From 2009 to 2018, an annual average of 1.78 wildlife-vehicle crashes per mile was reported involving the focal species. Mule deer were involved in 97 percent of these crashes. The recommended mitigation measures extend for 11.7 miles. Recommendations predominantly refer to the replacement or retrofitting of the 17 box culverts and corrugated metal pipe culverts the field reconnaissance team examined. There are two recommendations for overpasses along US 180. A total of 7 new wildlife underpass culverts are also recommended, while 11 existing culverts and bridges are recommended to be retrofitted with wildlife exclusion fence and other measures to encourage wildlife use. Wildlife exclusion fencing should be placed along 12.5 miles of roads within this hotspot. The total cost of mitigation was estimated at $39.4 million. If the NMDOT crash costs are used in a benefit-cost equation, the benefit-cost ratio is 0.61. If FHWA costs for crashes are used, then the ratio equals 1.07. Future wildlife mitigation actions would require working with the USFS, the New Mexico State Lands Office (SLO), the U.S. Department of Defense (DOD), and private landowners.

US 70 and NM 48 Ruidoso WVC Hotspot



The Ruidoso WVC hotspot is located within the boundaries of NMDOT District 2, centered around the Ruidoso area in the White Mountains of south-central New Mexico. The hotspot is 34 miles long and includes multiple roads. From 2009 to 2018 there were on average 1.08 wildlife-vehicle crashes reported per mile each year with the focal species. Mule deer were involved in 72 percent of these crashes. The recommended mitigation measures extend for 9 miles. There are many residences and small towns in this hotspot, so

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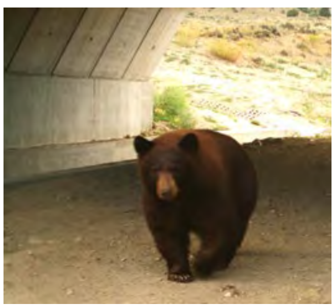
opportunities are more limited for mitigation solutions compared to other priority areas with public lands found on both sides of the highways. One overpass and eight wildlife underpass bridges are recommended for new construction, with retrofitting of three existing bridges and culverts and the installation of wildlife exclusion fencing. One wildlife crossing bridge recommended for placement would be on the Mescalero Apache Nation lands. There are about 8.7 miles of recommended wildlife exclusion fence. The total approximate cost of mitigation is $30.7 million. If the NMDOT crash costs are used in a benefit-cost equation, the ratio is 0.35. If FHWA costs for crashes are used, the ratio is 0.59. Recommended wildlife mitigation actions would necessitate working with USFS, the Mescalero Apache Nation, and multiple private landowners.

I-25 Glorieta Pass WVC Hotspot



This WVC hotspot is located within NMDOT District 5 along I-25 at Glorieta Pass, in the southern Santa Fe Mountain subrange of the Sangre de Cristo Mountains. It also corresponds to one of the top 10 wildlife corridors selected in earlier steps of the Action Plan development. The hotspot totals 3 miles in length, but 5 miles of mitigation are recommended over two phased projects. From 2009 to 2018 there were on average 1.43 wildlife-vehicle crashes reported per mile per year involving the focal species. Mule deer were involved in 77 percent of these crashes, while black bear were involved in 8 percent. More black bears were recorded as being involved in WVCs in this hotspot than in any other WVC hotspot (though one wildlife corridor is associated with a higher number of black-bear-vehicle crashes). Specific recommended mitigation actions are divided into two separate phases. During the first phase, 3 miles of wildlife exclusion fence would be placed in the hotspot from MP 297 to MP 300. In the second phase, additional fencing would be added at either end of the 3-mile hotspot segment, together with mitigation. In total, one overpass, three arch culverts, and one bridge are recommended for construction across both phases. The total cost is expected to be approximately $21 million. If the NMDOT crash costs are used in a benefit-cost equation, the ratio is 0.14. If FHWA costs for crashes are used, the ratio is 0.21. Recommended wildlife mitigation actions would require working with the USFS and private landowners.

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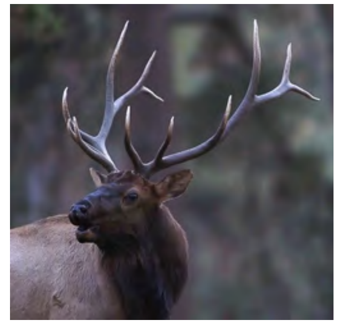
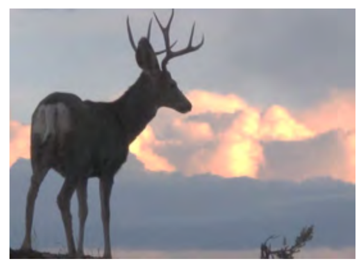
US 70 Bent Sacramento Mountains WVC Hotspot



This is the number one WVC hotspot in New Mexico based on the number of crashes per mile involving the focal species (1.8 per mile annually). Elk is the species most involved in these crashes (80 percent). The hotspot is located in NMDOT District 2 and extends for 5 miles along US 70 from MP 237 in the west to MP 242 in the east. Specific recommendations include a potential warning system for motorists and, listed in order of priority, one overpass, five bridges to replace existing culverts, two arch culverts, and fences to existing structures that extend for 6 miles within and beyond the hotspot. The recommended infrastructure was estimated to cost approximately $28 million. The benefit-cost analysis found an NMDOT ratio of 0.46 and a FHWA ratio of 1.02. Recommended wildlife mitigation actions would require working with BLM, the Mescalero Apache Nation, and private landowners.

US 64/US 84 Chama from South of Tierra Amarilla to Chama to US 64/84 Junction and US 84 to Colorado Wildlife Corridor



The Chama wildlife corridor in northern New Mexico is bisected by US 84 and US 64. The project area extends from just south of Tierra Amarilla in the south, north to Chama, west to the junction of US 64 and US 84, and north to the Colorado border on US 84, for a total of 38 miles. It is located within the boundaries of NMDOT District 5. From 2009 to 2018, there was an average of 0.60 wildlife crashes per mile per year reported involving the focal species. Mule deer were involved in 63 percent of the crashes, with elk representing another 30 percent. Specific project recommendations consider the GPS movement data for elk and mule deer, and WVC hotspots within the corridor. These data helped to prioritize project recommendations for overpasses and bridges. Elk were of primary concern; therefore, structures recommended include those that elk are known to use (i.e., bridges and overpasses), with their placement in areas with the greatest concentrations of known elk movements and crashes. A total of 7 overpasses are recommended, along with 10 new wildlife underpass span bridges, and 1 new box culvert underpass. Recommended fencing totals 34.8 miles in length. The total estimated cost for all mitigation is $50.6 million. The NMDOT benefit-cost ratio is 0.96, and the FHWA ratio is 2.26. Recommended wildlife mitigation actions would necessitate working with USFS, the Jicarilla Apache Nation, NMDGF, and private landowners.

US 285 Rio Grande Del Norte National Monument North of Tres Piedras Wildlife Corridor

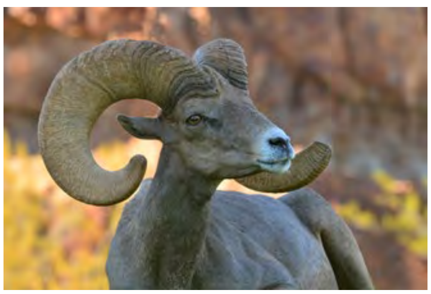
The US 285 Del Norte Wildlife Corridor is approximately 25 miles long, located within and outside of the Rio Grande Del Norte National Monument in northern New Mexico. This north-south stretch of US 285 bisects a major winter range and migration corridor for mule deer, elk, and pronghorn. It is located within NMDOT District 5. There were 0.32 wildlife crashes per mile per year on average involving the focal species. The majority of crashes (69 percent) were with elk. The Action Plan development team used preliminary GPS collar movement data for pronghorn and elk, habitat linkage modeling results, WVC crash data, and field reconnaissance results to recommend wildlife mitigation in three phases. Phase I was given highest priority based on its position just south of San Antonio Mountain from MP 392.1 to MP 396.6, where GPS collar data show the highest concentration of movement. The construction of two overpasses and one bridge is recommended for Phase I. Phase II, from MP 401 to MP 405, involves the recommended construction of two overpasses and two bridges. Also required would be the installation of multiple animal detection systems between the Phase I and II projects. Phase III recommendations consist of one bridge, one arch culvert, and the retrofitting of two concrete box culverts. The total length of required fence would be approximately 11.8 miles. The estimated cost of the mitigation totals $28.6 million. The NMDOT benefit-cost ratio is 1.00, and the FHWA ratio is 2.61. Recommended wildlife mitigation actions would require working with the BLM, which manages the Rio Grande del Norte National Monument, as well as several private landowners.

I-25, US 64, NM 505, and NM 445 South of Raton to Maxwell, the Pronghorn Triangle Wildlife Corridor

The approximately 69-mile South Raton to Maxwell – Pronghorn Triangle wildlife corridor primarily focuses on pronghorn needs, but mule deer, elk, and black bear mortality from WVCs have also been recorded in this area. The Sangre de Cristo Mountains and the Carson National Forest are to the northwest of this “triangle” formed by I-25, US 64, NM 505, and NM 445, and the project area is primarily short grass prairie within the High Plains and Tablelands ecoregion. The wildlife corridor is within NMDOT District 4. From 2009 to 2018, an average of 0.29 crashes per mile per year occurred involving the focal species. The majority of these crashes occurred from collisions with deer (35 percent) and elk (34 percent), but more pronghorn-vehicle crashes

(22; 10 percent), and more black bear-vehicle crashes (16; 7 percent) have been recorded here than in any of the other wildlife corridors or WVC hotspots. Our recommended approach for this corridor is the implementation of multiple, smaller, separate projects. In total, we recommend 2 overpasses, 2 span bridges, 2 sets of arch culverts, and 19 miles of wildlife exclusion fence that would tie into both the new structures and the 10 existing culverts and bridges. The total estimated cost is $30.6 million. The benefit-cost ratio for the NMDOT crash values is 0.64, while the FHWA ratio is 1.39. Recommended wildlife mitigation actions would require working with several large ranches, as the area is almost entirely privately owned.

I-10 Peloncillo Mountains – Steins Wildlife Corridor

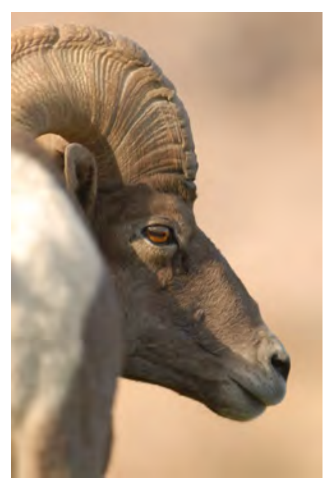


The Peloncillo Mountains corridor is located within the boundaries of NMDOT District 1. It is 5 miles wide where it is bisected by I-10, which runs east west in the “bootheel” area of New Mexico. The Peloncillo Mountains are important for wildlife movement north and south into and out of southwestern New Mexico. Desert bighorn sheep are especially vulnerable to habitat fragmentation caused by the highway; NMDGF and AZGFD have both documented desert bighorn sheep movements along opposite sides of the highway, but not a single collared animal is known to have crossed I-10. There is 3.3 miles of recommended mitigation within the corridor. The high traffic volume on I-10 precludes many wild animals from attempting to cross the highway, which is why the average of crashes involving focal species is only 0.06 crashes per mile per year. The emphasis is on bighorn sheep in this corridor, and entire herds including all gender and age classes will only use overpass structure(s) to cross the interstate (see Gagnon et al., 2021; Kintsch et al., 2021). The specific recommendations are to install one or two overpass structures for desert bighorn sheep, and three bridge underpasses and three culvert underpasses to accommodate other mammals such as mule and white-tailed deer, black bear, javelina, coyote, bobcat, Mexican gray wolves, and jaguar. A total of 3.3 miles of wildlife exclusion fence is recommended. The cost of this infrastructure is approximated to be $46.2 million. The NMDOT benefit-cost ratio is 0.011, and the FHWA ratio is 0.025. The BLM and the SLO own the lands where the proposed infrastructure would be placed, and would need to be consulted in early project planning stages.

I-25 and US 550 Sandia-Jemez Mountains – Bernalillo Wildlife Corridor

The Sandia-Jemez Mountains corridor is located within the boundaries of NMDOT Districts 3 and 6, between the Sandia Mountains on the south side of I-25 and the Jemez Mountains north-northwest of I-25. Within this corridor, wildlife captured and GPS-collared on the Pueblo of Santa Ana west of I-25 also moved south and north of US 550 on the south side of the Pueblo. These movements documented by the Pueblo of Santa Ana show that the corridor extends on the north and south sides of US 550 west of the I-25 corridor. The corridor is bisected by a total of 36 miles of these two highways combined. The high traffic volumes on I-25 and US 550 preclude the possibility of much wildlife movement across these two roads, which is why the average number of crashes per mile per year involving focal species is just 0.05. A total of 10 deer, 6 elk, 3 black bears, and 1 cougar were involved in the reported crashes. The Pueblo of Santa Ana has collected additional data on wildlife carcasses collected along I-25 and US 550 on Tribal land. The stretch of US 550 with the highest numbers of crashes and carcasses extends from MP 7 to MP 12. There are existing bridges that span wide washes (arroyos) where seasonal waters flow. Specific recommendations for US 550 include four overpasses, two underpass culverts, and 7 miles of fence to tie into existing and future structures. Along I-25, specific recommendations consist of one overpass, one bridge underpass, and 19 miles of wildlife exclusion fence. The total cost of the project was estimated at $49.3 million. The benefit-cost ratio with NMDOT crash values is 0.14, and the FHWA ratio is 0.31. The project will need to be implemented in conjunction with the Pueblo of Santa Ana, San Felipe Pueblo, Kewa (Santo Domingo) Pueblo, and private landowners.

NM 38 Questa to Red River Wildlife Corridor



The approximately 9-mile NM 38 Questa to Red River Wildlife corridor is based primarily on the needs of bighorn sheep to safely cross the road headed north and south, although mule deer and elk-vehicle collisions have also been recorded in this area. The corridor is located within the boundaries of NMDOT District 5, in the Taos Mountains subrange of the Sangre de Cristo Mountains in northern New Mexico. From 2009 to 2018, an average of 0.21 crashes per mile per year was documented involving focal species. Most recorded crashes involved deer (8 crashes) and bighorn sheep (8 crashes). Bighorn sheep are the emphasis within this corridor, and entire herds including all gender and age classes will only use overpass structure(s) for crossing. For that reason, overpass structures are the only option (e.g., Gagnon et al., 2021; Kintsch et al., 2021). The placement of a wildlife exclusion fence is only recommended if multiple wildlife crossing structures are installed. With daily traffic levels well below 1,700 vehicles on NM 38, there is still an opportunity for many types of wildlife species to cross this road when the traffic is not present. Specific project recommendations consist of three overpasses, one wildlife underpass bridge, and 7.6 miles of wildlife exclusion fence that would also direct animals to two existing culverts. An animal-activated detection driver warning system is also recommended for each end of the exclusion fence. The total estimated cost for the project is $17.2 million. The NMDOT benefit-cost ratio is 0.07, and the FHWA benefit-cost ratio is 0.12. Mitigation planning would involve working with the USFS (Carson National Forest) and the Questa Mine.

New Mexico Department of Transportation Districts' Hotspots and Corridors

Every NMDOT district harbors at least one of the top WVC hotspots and wildlife corridor projects, with four of these top projects located in District 5 in north-central New Mexico (Table ES-5).

NMDOT District	WVC Hotspots and Wildlife Corridors
1	US 180 NM 90 Silver City WVC hotspot
	I-10 Peloncillo Mountains-Steins corridor
2	US 70 NM 48 Ruidoso WVC hotspot
	US 70 Bent Sacramento Mountains WVC hotspot
3	Sandia-Jemez Mountains corridor
4	Pronghorn Triangle Wildlife corridor
5	I-25 Glorieta Pass WVC hotspot
	Chama Wildlife corridor
	Rio Grande Del Norte Wildlife corridor
	Questa Wildlife corridor
6	Sandia-Jemez Mountains corridor
	US 550 North of Cuba WVC hotspot

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Monitoring Recommendations

Before- and after-mitigation monitoring is important for the dual purpose of (1) understanding what project components may be successful or unsuccessful and (2) then making any needed corrections for improvement. Monitoring is especially important in a context of accelerating climate change impacts affecting ecosystems and species and potentially affecting future wildlife movements at the landscape level. The Action Plan includes an overview of climate change projections developed in partnership with Dr. David Gutzler (University of New Mexico [UNM]) and Dr. Jack Triepke (U.S. Forest Service), as well as a guide to tools and methodologies to conduct appropriate monitoring. Climate change projections for New Mexico include higher annual temperatures, increased aridity, reduced snow cover, and lower spring flows. Associated projections include the expansion of deserts northward and the loss of montane woodland and forest (Cartron et al., in press).

For future road mitigation projects, the Action Plan recommends that NMDOT develop project-specific plans to conduct pre- and post-mitigation monitoring, as well as collaborations with experienced biologists throughout the process.

The following measures should be implemented pre-mitigation:

- Determine a consistent approach for wildlife-vehicle crash and carcass data collection prior to project implementation based on the type of proposed project and the species of interest, and use the same approach before and after completion. For example, standard crash data may suffice for large animals like elk, but more thorough roadkill surveys may be required for smaller animals or more thorough evaluations.
    - ◇ Where possible, collect data within the planned treatment area at a minimum, but preferably beyond the extent of the treatment area to identify end-runs and controls where appropriate.
    - ◇ A period of at least 2 years of pre-mitigation WVC data collection is recommended to account for variation in seasonality and changes in precipitation that can affect WVC rates.
- Where possible, collect GPS movement data to obtain baseline levels of highway permeability and determine the distribution of crossing locations. This is particularly important for species that show high road avoidance and are associated with low WVC incidence.

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- Consult with experienced biologists on both monitoring and construction plans to make sure both are implemented properly.

The following recommendations should then be implemented during mitigation construction:

- Regularly consult with experienced biologists to ensure mitigation components, such as wildlife crossings, fences, escape ramps, and detection systems, are installed correctly. Also, coordinate with experienced biologists or monitoring teams to ensure that any integrated monitoring equipment, such as built-in camera boxes and video surveillance systems, are properly incorporated.

Recommendations for the post-construction phase consist of the following:

- Conduct long-term, post-mitigation monitoring for 3 to 4 years (5 years for elk and pronghorn) to allow for wildlife to adapt to the new mitigation structures, account for seasonal variation, and identify adaptive management opportunities to improve the project.
- Collect wildlife-vehicle crash and carcass data using the same methods and consistency as pre-mitigation—at a minimum at the mitigation site, but if possible in adjacent sections and control sections (if monitored during pre-construction).
- Where appropriate, collect camera or video data on use, or lack thereof, of mitigation features. Collect approach and crossing information to determine success and failure rates; also include camera monitoring outside of the road right-of-way to identify animals occurring locally but not approaching the road crossing structures.
- Where possible, collect additional GPS movement data to assess levels of post-mitigation highway permeability and distribution of crossing locations. If GPS data are collected pre-mitigation, then permeability can be compared to determine changes, if any, in highway permeability.

Conclusion

As a result of climate change-driven impacts on ecosystems, animals will need to move across the landscape in order to follow their climatic niche (Cartron et al., in press). Many of those movements will be toward higher elevations and higher latitudes, or to more moist and cooler areas. Habitat connectivity will be key to lessen climate change-driven impacts on species. To that end, we hope that the Action Plan, which identifies the highest-priority road mitigation projects for decreasing wildlife-vehicle crashes and facilitating wildlife movements in New Mexico, will prove an important tool going forward. It should be viewed as a living document that serves as the basis for establishing partnerships with government agencies, Tribes, non-government organizations, and the public for implementation of road mitigation projects across the state, before-and-after mitigation monitoring, and the collection of more wildlife movement data.

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Chapter 1. Introduction

Individual animals and wildlife populations need to move across the landscape to follow seasonal food sources or disperse from their natal area, and human-created barriers pose a threat to those movements. Roads in particular fragment habitat, and they may prevent animals from meeting their nutritional and life history requirements. Wildlife-vehicle collisions (WVCs) not only present a well-documented risk to the safety of the traveling public; they can represent a significant cause of mortality in some animal species. Planning and implementing effective mitigation measures require that the more heavily populated and traveled wildlife movement corridors be identified, along with the exact locations where they are bisected by roads. If New Mexico can ensure that movements among current (and potential future) habitats remain possible for whole suites of species, wildlife populations will stand a better chance of persisting and thriving. In 2019, New Mexico took action to help prioritize and protect habitat linkages with the signing of the New Mexico Wildlife Corridors Act (the Act) (https://www.nmlegis.gov/sessions/19%20Regular/final/SB0228.pdf). This important piece of legislation mandated the development of a Wildlife Corridors Action Plan (the WCAP, also Action Plan) providing comprehensive guidance to the New Mexico Department of Transportation (NMDOT) and the New Mexico Department of Game and Fish (NMDGF) to (1) identity, prioritize, and maintain important areas for wildlife movement across roads and (2) develop a list of priority projects for building road-crossing structures designed to help animals cross roads and protect the traveling public from collisions with large wild animals.

1.1 History of WVC Mitigation Projects and Habitat Connectivity Planning in New Mexico

As of the date of this draft plan, 10 major WVC mitigation projects have been completed in New Mexico, with another one currently under construction (Figure 1-1 and Appendix A).

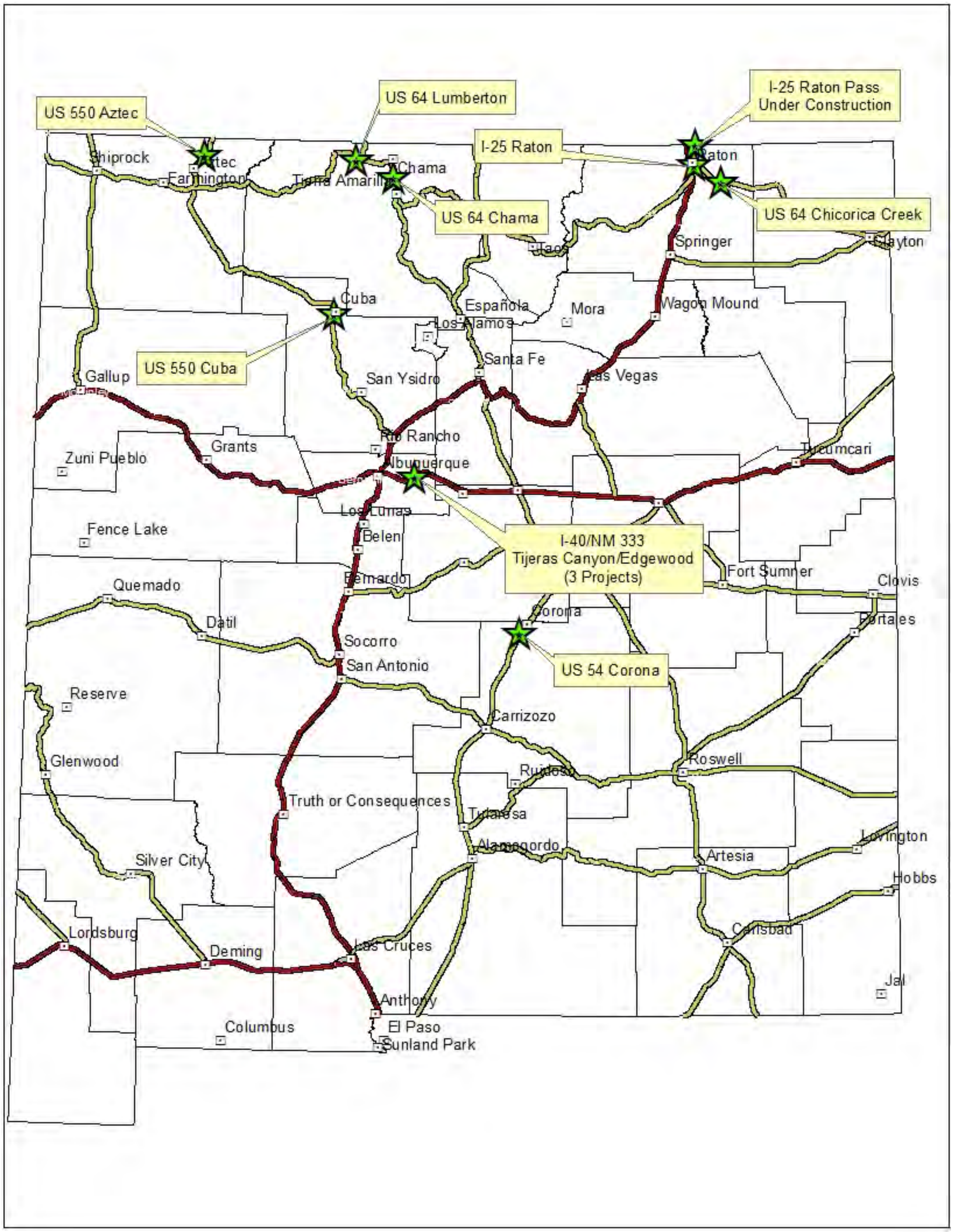

Figure 1-1. Major wildlife-vehicle collision mitigation projects implemented in New Mexico since 1998. Most recently, NMDOT completed a project on US 550 south of Cuba and started construction of a new project on I-25 at Raton Pass, which will feature the state's first arch culvert wildlife underpass.

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Planning and implementation of New Mexico's first WVC mitigation project began in 1998 when a Farmington legislator directed NMDOT and NMDGF to reduce the high rate of deer-vehicle collisions on New Mexico Highway 44 (NM 44) between Aztec and the Colorado border. At the time, NMDOT was widening NM 44 into what became U.S. Highway 550 (US 550), the major arterial highway that connects Albuquerque and Santa Fe to northwestern New Mexico and the Farmington/San Juan Basin area. NMDOT consulted with Dale Reed, a retired biologist formerly with the Colorado Division of Wildlife, who had conducted research on deer-vehicle collision mitigations and the optimal culvert size for allowing mule deer (*Odocoileus hemionus*) to pass under a road. Based on locality recommendations by NMDGF, three small corrugated metal pipe culverts were retrofitted to large concrete box culverts (CBCs). Approximately 4 miles of 8-foot-tall woven wire game fence was installed to direct mule deer below the highway through the CBCs.

No other WVC mitigations projects were planned or implemented until 2003, when Governor Richardson signed House Joint Memorial 3 (HJM3). HJM3 directs NMDGF and NMDOT to work together to reduce WVCs and improve habitat connectivity across highways. As a result of HJM3, the New Mexico Carnivore Working Group, an organization of federal and state wildlife biologists, convened the Critical Mass Workshop in June 2003. This workshop brought together WVC mitigation project experts from western states, state and federal agency biologists, NMDOT engineers and maintenance personnel, private consultants, conservationists, and concerned citizens. The workshop was the state's first collaborative landscape-level planning effort to identify and prioritize WVC hotspots and important habitat connectivity corridors bisected by highways based on accident report data and expert opinion. During the workshop, NMDOT advised attendees of a pending Interstate 40 (I-40) highway improvement project in Tijeras Canyon, which had been identified during the workshop as a high-priority deer-vehicle collision hotspot and wildlife habitat linkage.

A direct outcome of the Critical Mass Workshop was the formation of the Tijeras Canyon Safe Passage Coalition, which formed to advocate for safe passage for wildlife in Tijeras Canyon. As a result of the coalition's advocacy, NMDOT implemented the first feasibility study ever conducted in the state to assess the need for wildlife crossings in Tijeras Canyon. The coalition was ultimately successful in partnering with NMDOT and NMDGF to implement the Tijeras Canyon Safe Passage Project, which features the state's first wildlife crosswalk over NM 333 (Old Route 66) that parallels I-40 through the canyon (Figure 1-2). The adjacent Hawkwatch Property was purchased as City of Albuquerque Open Space and is now managed as a wildlife corridor. This property funnels wildlife down to the crosswalk at a break in the approximately

5 miles of exclusion fencing that is intended to keep wildlife off both highways. Once across NM 333, mule deer and other wildlife can access Tijeras Arroyo for daily water needs, or continue down the arroyo approximately 0.5 mile and move under a large I-40 bridge to access habitat on the south side of I-40, which effectively reconnects the Sandia Mountains to the Manzano Mountains (Watson and Menke, 2010). Mule deer have been documented by game cameras crossing NM 333 at the crosswalk and moving below I-40 at the eastern bridge (Loberger et al., 2021). The Tijeras Canyon Safe Passage Coalition is currently the only citizen advocacy group formed in New Mexico to advocate for a WVC mitigation/habitat connectivity project (Watson and Menke, 2010).

Figure 1-2. Tijeras Canyon Safe Passage Project wildlife crosswalk across NM 333 from the Hawkwatch Property, looking west toward Albuquerque. Tijeras Arroyo in center and I-40 at top (photo credit: Mark Watson).

In 2013, the New Mexico State Legislature passed a second memorial (House Memorial 1, Senate Memorial 11) directing NMDOT and NMDGF to jointly host a workshop to identify priority road segments for future WVC mitigation measures. During the subsequent workshop, a total of 49 participants helped identify 32 priority segments across New Mexico, all of which merited further investigation. Large animal-vehicle collision accident report data were analyzed and field visits were conducted by the NMDOT Environmental Bureau and NMDGF personnel in each NMDOT district to evaluate the feasibility of new mitigation projects at these locations. A stipulation was that NMDOT districts had to support the proposed mitigation projects for planning to proceed. The field review identified three road segments that could most feasibly be mitigated by NMDOT: US 70 east of Alamogordo, I-25 at Raton, and US 550 south of Cuba. NMDOT was instructed by the memorial to submit Highway Safety Improvement Program (HSIP) funding applications for priority potential mitigation projects. NMDOT received HSIP funds to implement two projects: US 550 south of Cuba and I-25 through Raton. Work along I-25 at Raton was completed in November 2017. The US 550 south of Cuba project was completed in August 2019. The US 550 project south of Cuba includes 4 miles of 8-foot woven wire exclusion fencing that funnels wildlife below the highway at two large bridges over the Rio Puerco (Figure 1-3). Two animal detection systems were installed at each end of the fence to warn motorists of impending wildlife end run events around the end of the fence.

Figure 1-3. Bridge over Rio Puerco, US 550 south of Cuba (photo credit: Mark Watson).

The important WVC mitigation projects implemented early on in Tijeras Canyon, Raton, and Cuba would not have been possible without the advocacy of Wild Friends, a student (grades 4 through 12) wildlife conservation education and civics program whose participants drafted the memorial language, worked directly with legislator sponsors, lobbied, and ushered the memorials through the complex legislative committee and floor vote process of the New Mexico Legislature (Watson and Menke, 2010).

Figure 1-4. A small fencing project implemented in 2004 to mitigate a relatively high deer-vehicle collision hotspot along US 64 in northeastern New Mexico between Raton and Clayton. Chicorica Creek contains riparian vegetation and perennial water in shortgrass prairie habitat. A 0.1-mile game fence was constructed on each end of a bridge that was enlarged during the US 64 highway improvement project (photo credit: Mark Watson).

More recently, the Upper Rio Grande Valley was the focus of a multi-level collaborative model developed for agency and public participation to coordinate wildlife habitat connectivity statewide and across state lines . In 2016, the University of New Mexico (UNM) New Mexico Natural Heritage Program and Colorado State University's (CSU) Colorado Natural Heritage Program hosted the 2016 Wildlife Doorways Workshop (https://connectedcorridors.com/resource/wildlife-doorways-report-march-2016/), which brought together a diverse group of stakeholders to discuss wildlife movement patterns and management practices in the Upper Rio Grande. The National Wildlife Federation, with partner organizations, led the 2017 and 2019 Upper Rio Grande Wildlife Corridor and Connectivity Summits (https://connectedcorridors.com/event/forest-summit-2019/) and the Rio Grande Wildlife Connectivity and Corridor Collaborative Working Group. The goals of the workshops and working group were to collaborate and share data, ideas, and policies on landscape connectivity in New Mexico and Colorado.

In 2019, New Mexico was the first state to pass a Wildlife Corridors Act. The Act instructs NMDOT and NMDGF to develop a comprehensive Action Plan to identify and prioritize important areas for wildlife movement and key road barriers to those movements. The Act instructs that solutions to wildlife-vehicle conflict be considered from not only the public safety viewpoint, but also to benefit wildlife movements. Wildlife-vehicle conflict includes all known and unknown collisions and the other impacts of roads and traffic on wildlife. The provisions of the Act do not apply to private property or private property owners unless those owners voluntarily choose to participate.

1.2 Wildlife Habitat Connectivity Efforts in Other Western States

Overall, there have been thousands of wildlife crossing structures built across the U.S., from small amphibian tunnels to wildlife overpasses that accommodate thousands of ungulate movements over highways. Western states in particular have been installing wildlife crossing structures since 1975, when Colorado placed an underpass, and Utah an overpass, on newly built interstates. Today, hundreds of wildlife crossing structures have been built in the western U.S. These efforts include underpasses and overpasses designed for all types of species, together with new technologies to detect wildlife and warn drivers, innovative designs to deter wildlife from entering the road at ingress and egress points, and escape mechanisms for animals trapped in the fenced roadway. New partnerships have been developed with transportation agencies and other agencies, non-profit organizations, and the public to make all these types of projects possible. This section provides a broad overview of wildlife-vehicle conflict mitigation efforts with select examples from nearby states. For overviews on what various U.S. states have implemented in recent years, and how the practice and science are changing, we also refer the reader to Cramer et al. (2021) and Ament et al. (2021).

1.2.1 Nevada

Nevada may have had wildlife crossing structures built prior to 2010, but it was not until that year that an increased focus on WVCs led the Nevada Department of Transportation (NDOT) to begin implementing more modern road mitigation projects for wildlife. In the years leading up to 2020, NDOT launched an ambitious wildlife crossing structure program, with at least 6 wildlife overpasses and 17 underpasses built by 2020 (Cramer and McGinty, 2018). One of the earliest projects, which was located along US 93, included 2 overpasses. Subsequent monitoring documented more than 35,000 successful mule deer crossings at the newly built wildlife crossing structures (Simpson et al., 2016). NDOT looked to prioritize the next steps of the program by funding a study to look at the top wildlife-vehicle conflict areas in the state (Figure 1-5). The results of this study continue to help guide the NDOT and partner agency efforts in locating where structures are needed for mule deer, pronghorn (*Antilocapra americana*), elk (*Cervus canadensis*), bighorn sheep (*Ovis canadensis*), horses, and cattle (Cramer and McGinty, 2018).

Nevada partnered with Arizona in a unique example of interstate collaboration during the design and construction of Boulder City Bypass Phase II, a section of the new I-11 in southeastern Nevada. As planning was underway for this new stretch of road through previously undisturbed habitat, Nevada reached out to Arizona for information on the best options for mitigation of desert bighorn sheep collision and habitat fragmentation. The Arizona Game and Fish Department (AZGFD) had recently completed a long-term evaluation of US 93 directly across the Colorado River and gained insights on successful mitigation measures. NDOT and Nevada Department of Wildlife (NDOW) ultimately brought AZGFD on board to help oversee the design, implementation, and monitoring of the mitigation. Construction was completed in 2018, including one overpass (Figure 1-6) and several large underpasses. To date, AZGFD has documented more than 10,000 successful desert bighorn sheep crossings at the new wildlife crossing structures, zero collisions with sheep, and global positioning system (GPS) collared sheep roaming freely across the original range now bisected by the highway. Monitoring will continue through 2024.

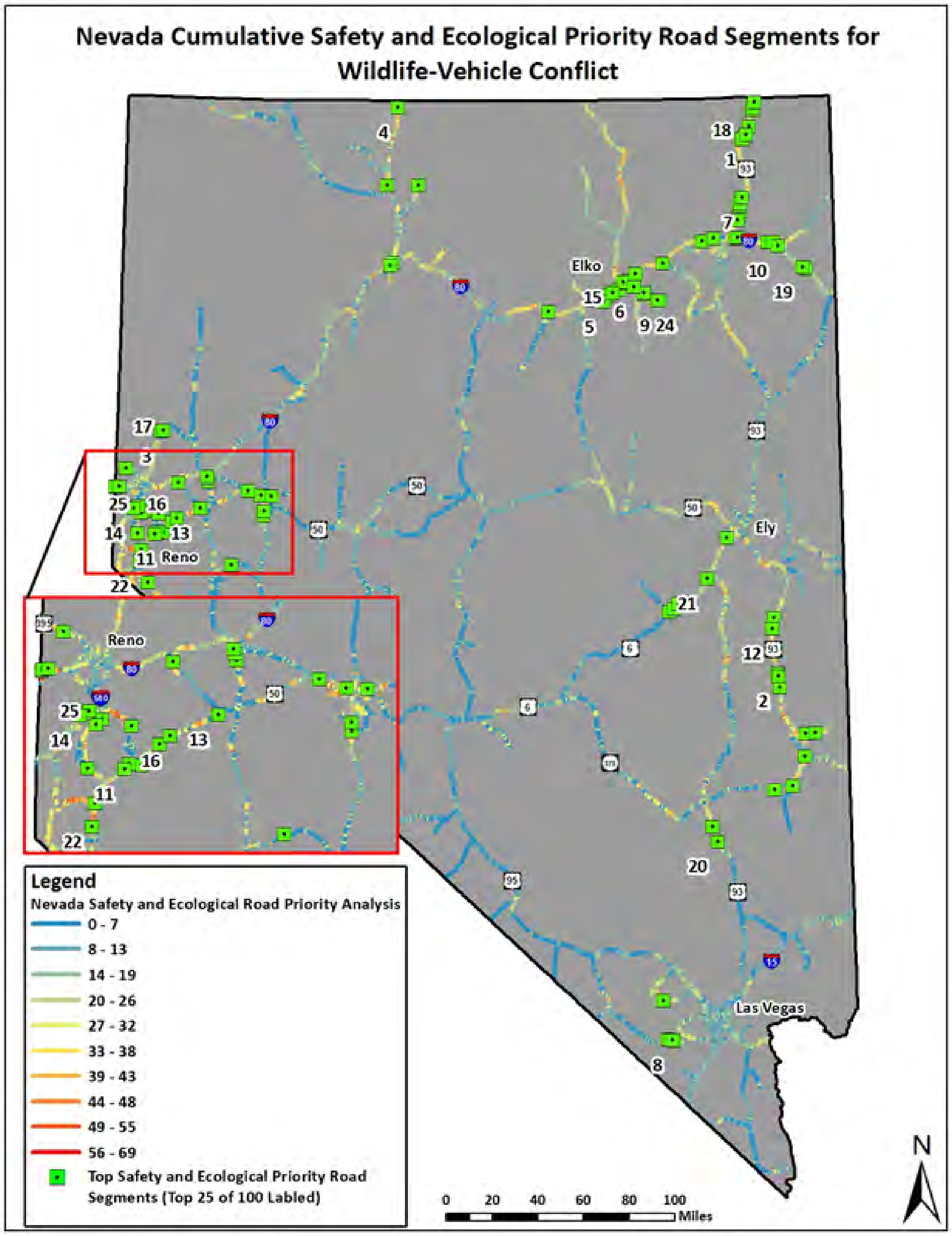

Figure 1-5. **Top 25 Nevada animal-vehicle conflict hotspot priority locations numbered, and top 100 locations represented, based on ecological and safety data, 2007-2016. Reproduced with permission from Cramer and McGinty (2018).**

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Figure 1-6. Desert bighorn sheep overpass built during Phase II of the I-11 Boulder City Bypass mitigation project in southeastern Nevada (photo credit: Jeff Gagnon).

1.2.2 Utah

Utah has created more than 50 dedicated wildlife crossing structures since 1975. The majority are for ungulates. Cramer (2012 and 2014) studied dozens of these structures, in addition to existing culverts and bridges, and found that the length of structures, as the animals traverse beneath the road, is the most important dimension. The Utah Department of Transportation (UDOT) built wildlife crossing structures for desert tortoises in the southwestern portion of the state, and the animals have been documented using them. Utah began a new chapter of partnerships with the installation of the US 89 Kanab-Paunsaugunt wildlife crossing structures and associated fence (Cramer and Hamlin, 2019). Specifically, the U.S. Bureau of Land Management (BLM), Kane County, non-profit hunting groups, the Utah Division of Wildlife Resources (UDWR), the AZGFD, and others contributed millions of dollars to the project to create three new crossing structures, in addition to 11 miles of fence to these and four existing structures to help protect the migrations of the Paunsaugunt mule deer herd and other wildlife movements. In a collaborative, long-term monitoring effort that involved both Arizona and

Utah researchers, nearly 80,000 successful mule deer crossings were documented (Figure 1-7) (Cramer and Hamlin, 2019).

Figure 1-7. Mule deer migrating through a dedicated wildlife crossing structure along the US 89 Kanab-Paunsaugunt Wildlife Mitigation Project (photo credit: Patricia Cramer, UDOT, Utah Division of Wildlife Resources, and AZGFD).

In 2019, UDOT identified WVC hotspot areas across Utah (Cramer et al., 2019). UDOT and many partners are using this information along with wildlife movement data to plan for the next phases of wildlife mitigation efforts across the state.

1.2.3 Colorado

Colorado was slowly implementing wildlife mitigation over the decades, but with the success of State Highway 9 (SH 9) wildlife crossing structures (Kintsch et al., 2021), the state is now moving forward at a rapid pace toward planning and building wildlife crossing structures across Colorado. The SH 9 wildlife mitigation project included 11 miles of fence, five underpasses, and two overpasses for mule deer, elk, pronghorn, bighorn sheep, black bear (*Ursus americanus*), cougar (*Puma concolor*), and many other species present in the Blue River Valley. Project monitoring and data analyses found that the mitigation measures reduced accidents involving wildlife by over 90 percent, and mule deer were documented as having used the overpasses and underpasses more than 112,000 times in the first five years following construction (Figure 1-8) (Kintsch et al., 2021).

Figure 1-8. Mule deer moving over one of the SH 9 wildlife overpasses in Colorado (photo credit: Josh Richert, Blue Valley Ranch).

Just across the New Mexico border, US 160 has been fitted first with a wildlife crossing structure near Durango (Cramer and Hamlin, 2021), and more recently with both an overpass and an underpass on the Southern Ute Tribal lands in 2021. In 2018, the Colorado Department of Transportation (CDOT) and Colorado Parks and Wildlife (CPW), along with other partners, formed the Wildlife and Transportation Alliance. This working group meets quarterly. It plans for new wildlife crossing structures, conducts fundraising, writes grants, and shares success stories and lessons learned.

1.2.4 Arizona

Arizona has been a leader in the nation for using science to guide the conceptual creation, placement, building, and adaptive management of wildlife mitigation, and overall in identifying wildlife corridors and areas of potential wildlife-vehicle conflict.

Starting in the early 2000s, Arizona recognized the value of wild animal GPS movement data as a tool in wildlife-vehicle conflict planning and monitoring efforts. Arizona State Route 260 (SR 260) was one of the first large-scale wildlife crossing projects in the southwestern U.S., with a phased construction that started in 2000. The upgrade of SR 260 to four lanes included 17 underpass structures suitable for the safe passage of elk and other wildlife. GPS collars on elk and camera monitoring provided insight on underpass design changes that increased elk use. These tools were incorporated into the later construction phases, and identified an increase in elk-vehicle collisions in an area where minimal exclusionary fencing was needed to guide animals to the underpasses. This adaptive management approach resulted in elk using the structures over 10,000 times to safely cross SR 260 (Gagnon et al., 2011; Dodd et al., 2012).

The success of the SR 260 project was a catalyst for a long-planned project along US 93 in northwestern Arizona, which bisects one of the largest remaining populations of desert bighorn sheep in the Southwest. Bighorn GPS movement data were used to identify the best locations for wildlife crossing structures. Three overpasses were built for the sheep, and the animals were documented using the overpasses nearly 6,000 times. Camera monitoring helped identify the need for an adaptive management approach for modifications to fences, escape ramps, and cattle guards. As of the date of this report, these actions have helped WVCs decrease by 100 percent over the past 7 years (Gagnon et al., 2017). Both SR 260 and US 93 won the Federal Highway Administration (FHWA) Exemplary Ecosystem Initiative Award for the innovations they brought at the time. Additional planning projects that used GPS movement data across Arizona are complete and awaiting funding for construction.

Funding for wildlife crossing structures and other habitat connectivity related projects is often difficult to obtain, and forming partnerships can help with new and creative funding solutions. Pima County found a unique way to fund these efforts through the Regional Transportation Authority (RTA), which is funded through a 2006 voter-approved excise tax that created $45 million for wildlife linkages. One of the linkage projects funded through the RTA included an underpass and the first overpass in the Sonoran Desert (Figure 1-9). AZGFD documented a diverse array of 28 species that used the overpass and underpass on more than 15,000 occasions.

Arizona also used science to help develop their first animal-activated detection system (AADS), which was completed in 2007. It used thermal target acquisition software to identify large wildlife and activate a series of signs to alert motorist that animals were in the "elk crosswalk," which is still functioning to date (Gagnon et al., 2019).

Arizona has also been forward thinking with the creation of planning documents including the award-winning Wildlife Linkages Assessment in 2007 (Nordhaugen et al., 2006). This plan identified coarse priority areas for wildlife connectivity. Additional efforts included county- and linkage-level least-cost modeling for further refinements of the original assessment. In 2018, AZGFD identified ungulate migration corridors through Migration Mapper (Kaufman et al., 2020), and ADOT recently sponsored a wildlife-vehicle collision and conflict analysis for the state (Williams et al., 2021).

Figure 1-9. First wildlife overpass in the Sonoran Desert along State Route 77 in southern Arizona (photo credit: AZGFD).

1.3 The New Mexico Wildlife Corridors Action Plan

1.3.1 Definitions

In wildlife conservation, the concept of connectivity is often used to describe the spatial arrangement and quality of habitat patches, and how these affect the movement of individual animals and populations across the landscape (Merriam, 1984 and 1991; Taylor et al.,1993; Forman, 1995; Bennett, 2003). At the landscape scale, multiple terms have been used to measure connectivity, among them “wildlife corridors” and “habitat” or “ecological linkages.” The New Mexico Wildlife Corridors Act defined wildlife corridors as “those areas routinely used by wildlife to travel through their habitat and includes corridors used by migrating wildlife.”

In the Wildlife Corridors Action Plan, we use the terms “corridors” and “linkages” somewhat interchangeably. In this Plan, linkages are defined as broad landscape areas where wildlife species are most likely to live and move. The research behind this Plan first identified wildlife linkages, and then narrowed down those linkages in areas where the models, data, and remaining habitat helped predict movement corridors for different wildlife species. These corridors are where wildlife is predicted to move across less hospitable landscapes. The locations where wildlife corridors are bisected by roads are the focus of much of this Plan.

It is also important to define the differences in terms that reflect the effects of roads and traffic on wildlife. The concept of WVCs is an overall concept of reported and unreported collisions with all types of wildlife, from the smallest to the largest animals. When those collisions are reported in the NMDOT database, they are considered reported accidents, or wildlife-vehicle crashes. The overall effect of roads and traffic on wildlife movements, their habitats, and their persistence—from invertebrates to the largest mammals—is considered wildlife-vehicle conflict. Only the term wildlife-vehicle collision will be abbreviated with WVC. The other terms will be spelled out.

The focal species of concern are the large mammals identified in the Wildlife Corridors Act, namely the cougar, black bear, pronghorn, bighorn sheep, mule deer, and elk.

Species of concern (see Chapter 2) are those that (1) pose a particular risk to the traveling public in New Mexico, (2) experience mortality from collisions with road traffic to the degree that it depresses or potentially depresses population levels or population densities in the state, and/or (3) avoid roads to the extent that roads represent important habitat connectivity barriers.

The WVC crash and carcass data were modeled to identify WVC hotspots. These hotspots correspond to road segments associated with significantly higher concentrations of wildlife-vehicle crashes per mile per year than would be expected by chance alone. They were the basis of identification for half of the ideal locations for targeted mitigation measures.

The other half of the ideal locations for mitigation measures were based on wildlife corridors across New Mexico roads. These wildlife corridors were identified through wildlife movement computer modeling, GPS collar locations recorded for the six large mammal species (focal species of concern), NMDGF wildlife biologist expert opinion, NMDGF Secretarial Order (S.O.) 3362 Action Plan priority landscapes, and additional input from the public, non-profit organizations, academic researchers, and Tribal agencies.

The Action Plan includes many recommendations for improving wildlife connectivity across New Mexico roads with a variety of actions. These actions overall are considered wildlife mitigation measures. They include building passage structures for wildlife, highway exclusion fences, escape ramps for animals to exit fenced road areas, cattle guards and other in-road deterrents to keep wildlife from entering the road, driver warning systems that detect the animals and alert drivers to the danger of wildlife on the road, wildlife crosswalks, and variable message boards that alert drivers to potential dangers of wildlife on the road. Other commonly used terms are retrofit, span bridge, box culvert, arch culvert, underpass, and wildlife dedicated overpass. A retrofit indicates an action that improves existing infrastructure without replacing it. This could include placement of wildlife exclusion fence to a bridge or culvert to guide wildlife to it, or placement of a path in existing rocks and boulders under a bridge to allow wildlife and humans to move beneath it. A span bridge is a bridge that is simply a span between supports. Few bridges have complete spans; instead, most have piers for support within the span. A box culvert is a type of culvert that is square and made of concrete. An arch culvert is typically made of prefabricated concrete arches that are placed next to one another and form an arch top with more vertical sides. The term underpass refers to all structures placed specifically for wildlife beneath a road. A wildlife-dedicated overpass is a structure above a highway where wildlife moves above the road. Additional terms are found in the glossary and list of abbreviations.

1.3.2 General Approach

Work on the Action Plan project began in October 2019. Daniel B. Stephens & Associates, Inc. (DBS&A) led the project involving cooperation among road ecology experts, with Dr. Jean-Luc Cartron of DBS&A as the project manager and Dr. Patricia Cramer, independent scholar, as the principal investigator. The approach to developing the Action Plan was science-driven and two-pronged, with a focus on identifying (1) the top WVC hotpots in the state, representing the areas of greatest concern in terms of public safety, and (2) the top wildlife linkages and corridors that are believed to be essential to individual animals and wildlife populations for moving across the landscape.

The Action Plan development process entailed the following seven tasks. The chapters of this Plan in which the tasks are discussed are provided in parentheses:

1. Data gathering (Chapters 4 and 5)
2. Data analyses (Chapters 4 and 5)
3. Field reconnaissance of priority areas (Chapter 6)
4. Benefit-cost analysis (Chapter 6)
5. Preparation of the Action Plan
6. Public involvement (Chapter 3)
7. Wildlife corridors project list (Chapter 6)

Chapter 2 introduces the species of concern. Chapter 7 presents details concerning future wildlife mitigation monitoring, and the future outlook for New Mexico with respect to wildlife and ecosystems. There are also appendices that support the work and recommendations presented in the chapters.

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Chapter 2. Species of Concern

The New Mexico Wildlife Corridors Act identifies by name six large mammals whose movements across the landscape are disrupted by roads and road traffic while at the same time posing a threat to the traveling public. These six large mammals are the mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), pronghorn (*Antilocapra americana*), bighorn sheep (*Ovis canadensis*), black bear (*Ursus americanus*), and cougar (*Puma concolor*) (also known as mountain lion or puma). They represent the main focus of all the analyses and modeling in the Action Plan.

A more complete list of species of concern (Table 2-1) was developed jointly by the Action Plan development team and the NMDGF based on the existing literature and with input from the following expert wildlife biologists in New Mexico: Dr. Jonathan L. Dunnum (UNM), Dr. Jennifer K. Frey (NMSU), James N. Stuart (NMDGF), and Leland J. Pierce, state herpetologist for the NMDGF. Species of concern include those that (1) pose a particular risk to the traveling public in New Mexico, (2) experience mortality from collisions with road traffic to the degree that it depresses or potentially depresses population levels or population densities in the state, and/or (3) avoid roads to the extent that roads represent important habitat connectivity barriers. Other factors considered for identifying species of concern included a highly limited distribution or low population numbers in New Mexico, coupled with documented or suspected mortality from road traffic collisions and potential habitat fragmentation exacerbated by roads. Our list of species of concern is provisional and subject to change as more information is gathered in the future on the population status and road ecology of these and other species.

All species of concern are native to New Mexico. They include the six large mammals identified above, in addition to another large mammal, the white-tailed deer (*Odocoileus virginianus*). This last species is lumped with the more common mule deer in all existing wildlife-vehicle collision datasets available for New Mexico, but likely contributes significantly on its own to the total number of crashes caused by wildlife. Additional examples of species of concern include (1) the American badger (*Taxidea taxus*), whose populations can incur high mortality due to vehicle collisions (Sunga et al., 2017), (2) the swift fox (*Vulpes velox*), which tends to be associated with roads throughout its distribution at the same time that collisions with traffic represent a leading cause of mortality (Hines and Case, 1991; Sovada et al., 1998; Pruss, 1999; Olson, 2000; Harrison, 2003; Kamler et al., 2003; Russell, 2006; Butler et al., 2019), and (3) the ornate box turtle

(*Terrapene ornata*), which is known to incur mortality on U.S. Highway 385 (US 385) east of Roswell and NM 412 between Springer and Clayton (NMDGF, unpublished data).

Table 2-1. Species of concern selected for the New Mexico Wildlife Corridors Action Plan.

Class	Common Name	Scientific Name
Reptilia	Ornate box turtle	*Terrapene ornata*
	Gila monster	*Heloderma suspectum*
	Mexican garter snake	*Thamnophis eques*
	Western massasauga	*Sistrurus tergeminus*
Mammalia	White-sided jackrabbit	*Lepus callotis gaillardi*
	White-tailed jackrabbit	*Lepus townsendii*
	Cougar	*Puma concolor*
	Kit fox	*Vulpes macrotis*
	Swift fox	*Vulpes velox*
	Red fox	*Vulpes vulpes*
	Black bear	*Ursus americanus*
	American badger	*Taxidea taxus*
	White-backed hog-nosed skunk	*Conepatus leuconotus*
	White-nosed coati	*Nasua narica*
	Collared peccary	*Tayassu tajacu*
	Pronghorn	*Antilocapra americana*
	Bighorn sheep	*Ovis canadensis*
	Mule deer	*Odocoileus hemionus*
	White-tailed deer	*Odocoileus virginianus*
	Elk	*Cervus canadensis*

The jaguar (*Panthera onca*) and the Mexican gray wolf (*Canis lupus baileyi*) are not included in the list of species of concern. The jaguar is extremely rare in New Mexico, with the last verified record dating back to 2006 and no breeding population ever documented in the state (Stuart and Hayes, in press). Mexican gray wolves have been reintroduced in southwestern New Mexico, and *Canis lupus* is recognized as a keystone species disproportionately influencing local ecosystems and regulating food webs (Oakleaf et al., in press). The decision to exclude the

Mexican gray wolf from our list of species of concern reflects the controversial nature of the wolf reintroduction in the southwestern U.S. and the need to garner as much public support as possible for the Action Plan and current and future road mitigation projects.

The following overview of species of concern includes information on distribution, habitat associations, impacts of roads and road traffic, and legal status/conservation. Population number estimates are only available for a handful of species, and they are provided here. Range boundary maps were prepared for all species, some of them adapted or updated from published works (e.g., Degenhardt et al., 1996), the forthcoming *Wild Carnivores of New Mexico* (UNM Press), and NMDGF shapefiles documenting the movements of GPS-collared animals.

2.1 Overview of Species of Concern

2.1.1 Ornate Box Turtle (*Terrapene ornata*)

2.1.1.1 Distribution and Abundance in New Mexico

In New Mexico, the ornate box turtle (both subspecies *T. o. ornata* and *T. o. luteola*) is absent in the northwestern portion of the state, but is otherwise widespread at elevations below 6,890 feet (2,100 meters [m]) above mean sea level (msl) in eastern and southern New Mexico, and north in the Rio Grande Valley to at least Valencia County (Degenhardt et al., 1996; Painter et al., 2017) (Figure 2-1). In New Mexico, the distribution and intergradation of the two subspecies are unclear and require further study (Degenhardt et al., 2006). Range limits of the two subspecies may have been compromised by translocation of individuals (Painter et al., 2017). Records from outside the main species distribution in New Mexico are due to introductions, but might nonetheless represent breeding populations (Stuart, 2000). The ornate box turtle is considered apparently stable in New Mexico (Painter et al., 2017). In 2006, *Terrapene ornata ornata* was listed under the Natural Heritage New Mexico State Rank "S5 Demonstrably Secure: in New Mexico" (NMDGF, 2006), an indication that the subspecies is not rare.

2.1.1.2 Habitat Associations

The ornate box turtle is not dependent on free water, and therefore can occupy a wide range of habitats. It is most abundant in grasslands with soils suitable for burrowing. Ornate box turtles normally do not occupy dense woodlands, steep, rocky mountain slopes, or elevations above 6,890 feet (2,100 m) msl (Degenhardt et al., 1996).

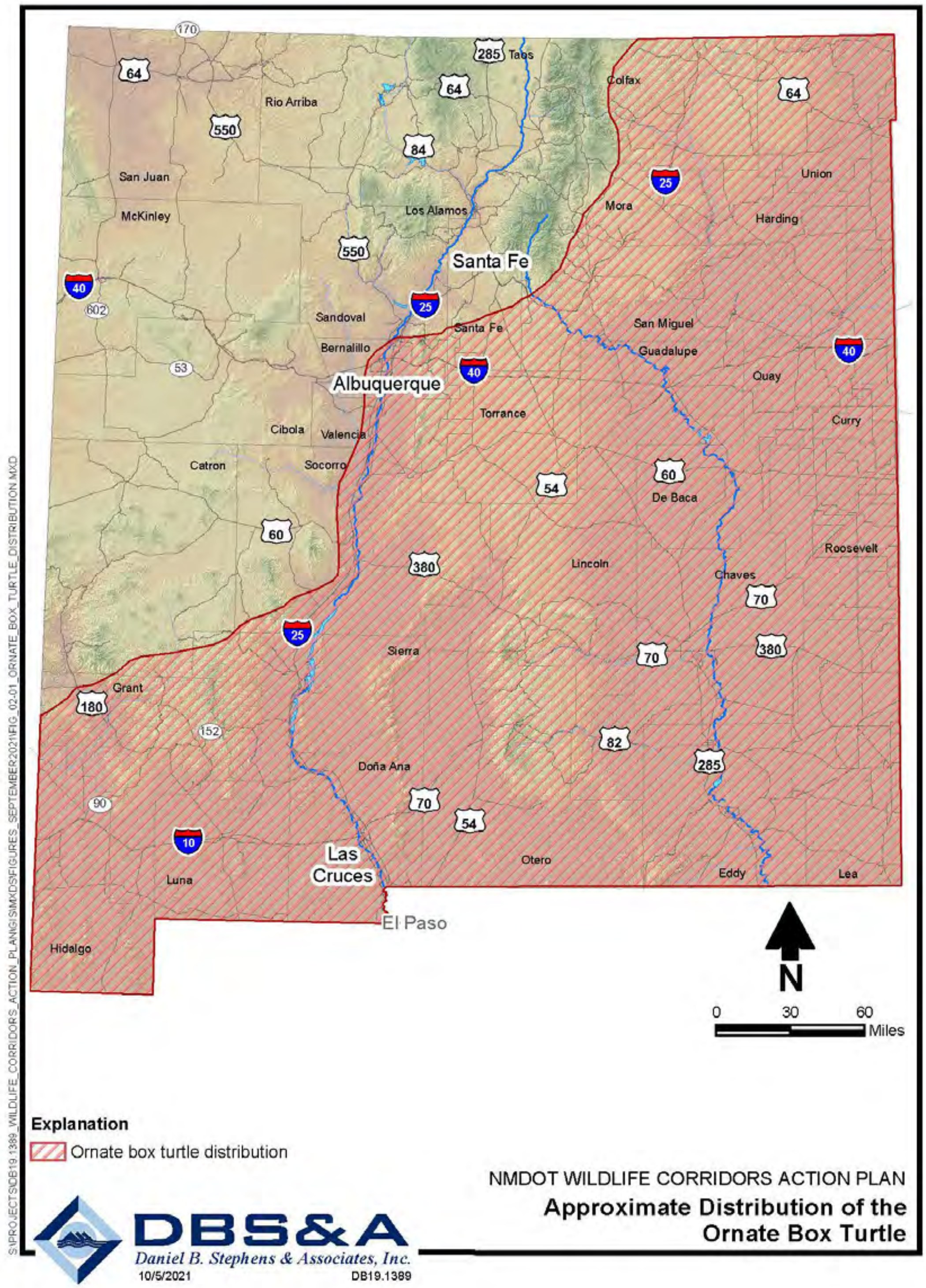

Figure 2-1. Approximate distribution of the ornate box turtle in New Mexico.

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2.1.1.3 *Impacts of Roads and Road Traffic*

Roads and associated traffic create barriers to turtle species movement, and can cause high mortality levels that can ultimately result in local or regional extinction (Shepard et al., 2008). Ornate box turtles are susceptible to high road mortality on some New Mexico highways (NMDGF unpublished data in Painter et al., 2017), including US 385 east of Roswell (C.W. Painter, personal communication) and NM 412 between Springer and Clayton (J.N. Stuart, personal communication). Road mortality is well documented for eastern box turtles (McClure, 1951 and Dodd et al., 1989 in Andrews et al., 2006). Road mortality is known to occur in other turtle species, and may even cause population-level impacts, as in the case of the common snapping turtle (*Chelydra serpentina*) in Ontario, Canada (Piczak et al., 2019).

2.1.1.4 *Legal Status/Species Designations and Relevant Conservation Initiatives*

Although not state or federally listed under the New Mexico Wildlife Conservation Act or the Endangered Species Act, the ornate box turtle is listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) due to harvesting of wild turtles for the pet trade.

2.1.2 Gila Monster (*Heloderma suspectum*)

2.1.2.1 *Distribution and Abundance in New Mexico*

Distribution of the Gila monster in New Mexico is limited to the southwestern part of the state west of the Continental Divide, with questionable records (possibly introduced, historical, or relict populations) from farther east (Painter et al., 2017) (Figure 2-2). Gila monsters are known from Hidalgo, Grant, Luna, and possibly Doña Ana Counties at elevations of 3,800 to 6,400 feet (1,180 to 1,950 m) msl (Degenhardt et al., 1996). Gila monsters are known to be common in New Mexico only at Redrock Wildlife Area in Grant County (Beck, 1994 and 2005) and at Granite Gap in Hidalgo County (NMDGF, 2020).

2.1.2.2 *Habitat Associations*

In New Mexico, Gila monsters occur in desert scrub and, less often, woodland and grassland habitats. Gila monsters are most commonly associated with rocky habitats of desert foothills and canyons. Gila monsters often inhabit rock crevices and burrows excavated by other animals such as packrats. Dominant vegetation often includes creosote bush (*Larrea tridentata*), mesquite (*Prosopis spp.*), acacia (*Acacia greggii*), ocotillo (*Fouquieria splendens*), and snakeweed (*Gutierrezia sarothrae*) (Degenhardt et al., 1996).

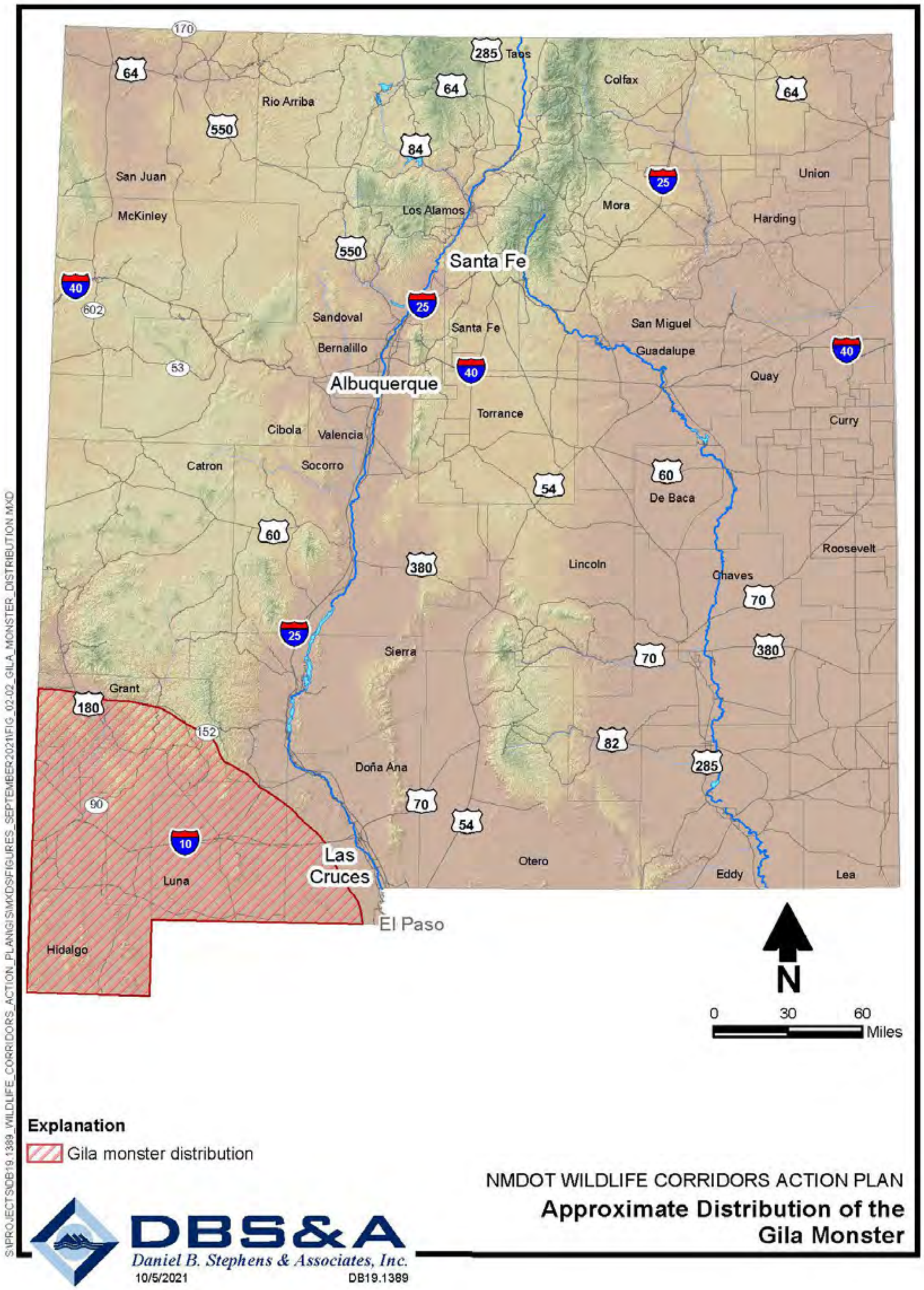

Figure 2-2. Approximate distribution of the Gila monster in New Mexico.

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2.1.2.3 *Impacts of Roads and Road Traffic*

Gila monster populations range-wide have been impacted by road mortality (Nowak, 2005 and Andrews et al., 2008 in NMDGF, 2017a). Highways through Granite Gap and Antelope Pass in the central Peloncillo Mountains are known sites of numerous roadkill records (NMDGF, 2017a). Roadway mortality, likely as a result of increased borderland security traffic, has been observed in southwest New Mexico (NMDGF, 2020). A January 19, 2021 search of iNaturalist for Gila monster photographic observations documented 29 records, 3 of which were roadkills, and 4 additional photographic records of live Gila monsters that were taken on a road surface, making the animals susceptible to mortality from vehicle strikes.

2.1.2.4 *Legal Status/Species Designations and Relevant Conservation Initiatives*

The Gila monster is listed as endangered under the New Mexico Wildlife Conservation Act with a state recovery plan (NMDGF, 2017a), and is also listed by CITES in Appendix II. The Gila monster is also a species of greatest conservation need (NMDGF, 2016).

2.1.3 Mexican Garter Snake (*Thamnophis eques*)

2.1.3.1 *Distribution and Abundance in New Mexico*

Known distribution of the Mexican garter snake in New Mexico is limited to the southwestern part of the state, mainly along Mule Creek (San Francisco River drainage) and a few recently documented locations on the Gila River where it is rarely encountered (Painter et al., 2017) (Figure 2-3). In New Mexico, the Mexico garter snake occurs at elevations ranging from 3,700 to 5,400 feet (1,125 to 1,650 m) msl (Degenhardt et al., 1996). Mexican garter snake records in New Mexico are rare, limited to about 10 confirmed records (L. Pierce, personal communication; NMDGF, unpublished data).

2.1.3.2 *Habitat Associations*

With the exception of two specimens, all Mexican garter snakes in New Mexico have been collected or encountered around a small series of shallow stock tanks with abundant shoreline vegetation, often including a lush growth of cattails. In Arizona, this species was found most abundant in densely vegetated habitat surrounding cienegas, cienega-streams, and stock tanks (Degenhardt et al., 1996). Regardless of the terrestrial habitats surrounding an area of occurrence, the Mexican garter snake is primarily an aquatic species. Aquatic habitats occupied by the species in New Mexico are generally characterized by shallow, slow-moving, and at least partially vegetated bodies of water, such as around springs, within the elevational gradient in which they are known to occur (NMDGF, 1988).

Figure 2-3. Approximate distribution of the Mexican garter snake in New Mexico.

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2.1.3.3 *Impacts of Roads and Road Traffic*

Many desert-dwelling reptiles, including snake species, are subject to high levels of mortality due to vehicle collisions (Rosen and Lowe, 1994; Gerow et al., 2010; Painter et al., 2017). The Mexican garter snake is a desert-dwelling species known to be susceptible to mortality from vehicles within its known narrow distribution in New Mexico on NM 293 (L. Pierce, personal communication; NMDGF, unpublished data). The potential to address Mexican garter snake mortality from vehicles while maintaining habitat connectivity exists based on research on the Eastern garter snake (Markle et al., 2017; Dillon et al., 2020).

2.1.3.4 *Legal Status/Species Designations and Relevant Conservation Initiatives*

The Mexican garter snake is federally listed as threatened under the Endangered Species Act and state listed as endangered under the Wildlife Conservation Act (NMDGF, 2020), and is a species of greatest conservation need (NMDGF, 2016).

2.1.4 Western Massasauga (*Sistrurus tergeminus*)

2.1.4.1 *Distribution and Abundance in New Mexico*

In New Mexico, western massasauga is found primarily in the central and eastern counties, most often in the shortgrass prairies in the central Rio Grande Valley and in the shinnery oak regions of Chaves and Lea Counties, where they were considered fairly common by Degenhardt et al. (1996) (Figure 2-4). It occurs at elevations ranging from approximately 3,000 to 7,000 feet (925 to 2,100 m) msl (Degenhardt et al., 1996).

2.1.4.2 *Habitat Associations*

In New Mexico, the western massasauga is an inhabitant of the desert grasslands or shortgrass prairies with sandy soil. It generally avoids rocky habitat. It is common in low-growing, shrubby shinnery oak habitat in southeastern New Mexico, where it is associated with pure stands of shinnery oak (Degenhardt et al., 1996).

2.1.4.3 *Impacts of Roads and Road Traffic*

The western massasauga has been documented to be susceptible to roadkill from vehicles in Missouri (Siegal, 1986; Siegal and Pilgrim, 2002), Arizona (AZGFD, 1988), and New Mexico (NMDGF unpublished data). The closely related eastern massasauga (*S. catenatus*) has also been documented as being susceptible to roadkill from vehicles in Ontario, Canada (Colley et al., 2017; Shepard et al., 2008).

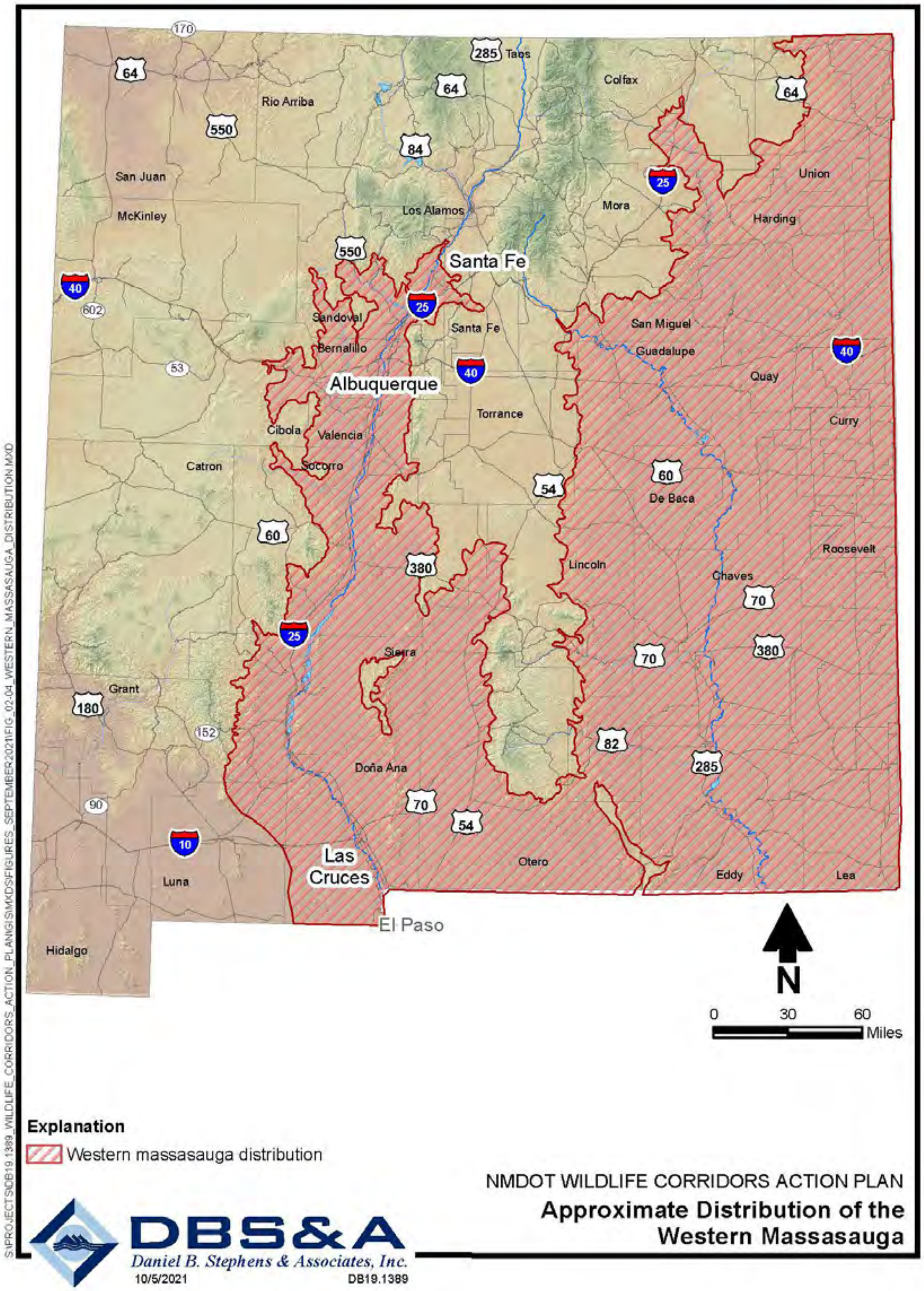

Figure 2-4. Approximate distribution of the western massasauga in New Mexico.

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2.1.4.4 *Legal Status/Species Designations and Relevant Conservation Initiatives*

The subspecies *S. t. edwardsii* is presently being reviewed by the U.S. Fish and Wildlife Service for possible listing under the federal Endangered Species Act (Painter et al., 2017). The western massasauga is a species of greatest conservation need (NMDGF, 2016).

2.1.5 White-Sided Jackrabbit (*Lepus callotis gaillardi*)

2.1.5.1 *Distribution and Abundance in New Mexico*

In New Mexico, the white-sided jackrabbit is only known from Hidalgo County's Animas and Playas Valleys in the extreme southwestern part of the state (Bednarz and Cook, 1984) (Figure 2-5). White-sided jackrabbits are more abundant in high-elevation plains grasslands than other Lepus species such as the black-tailed jackrabbit (*L. californicus*), a species that is more abundant in semi-desert grasslands (Desmond, 2003). The white-sided jackrabbit population in New Mexico appears to be in decline, due in large part to habitat deterioration caused primarily by overgrazing resulting in shrub encroachment into grasslands (Bednarz and Cook, 1984).

2.1.5.2 *Habitat Associations*

The white-sided jackrabbit is found within grasslands with minimal shrub cover. The species prefers level topography and avoids hilly terrain (Bednarz and Cook, 1984). The desert grassland communities of the Animas and Playas Valleys that provide suitable habitat have a good growth of grass species such as blue grama (*Bouteloua gracilis*), black grama (*B. eriopoda*), ring muhly (*Muhlenbergia torreyi*), buffalo grass (*Buchloe dactyloides*), wolftail (*Lycurus phleoides*), and bottlebrush squirreltail (*Sitanion hystrix*) intermixed with small forbs and shrubs including goldenweed (*Haplopappus spp.*), globemallow (*Sphaeralcea spp.*), flatsedge (*Cyperus spp.*), night shade (*Solanum jamesii*), snakeweed (*Gutierrezia sarothrae*), soaptree yucca (*Yucca elata*), and honey mesquite (*Prosopis glandulosa*). Elevation in the Animas and Playas Valleys ranges from 5,000 to 5,315 feet (1,525 to 1,620 m) msl, with a climate characterized by warm summers and mild winters.

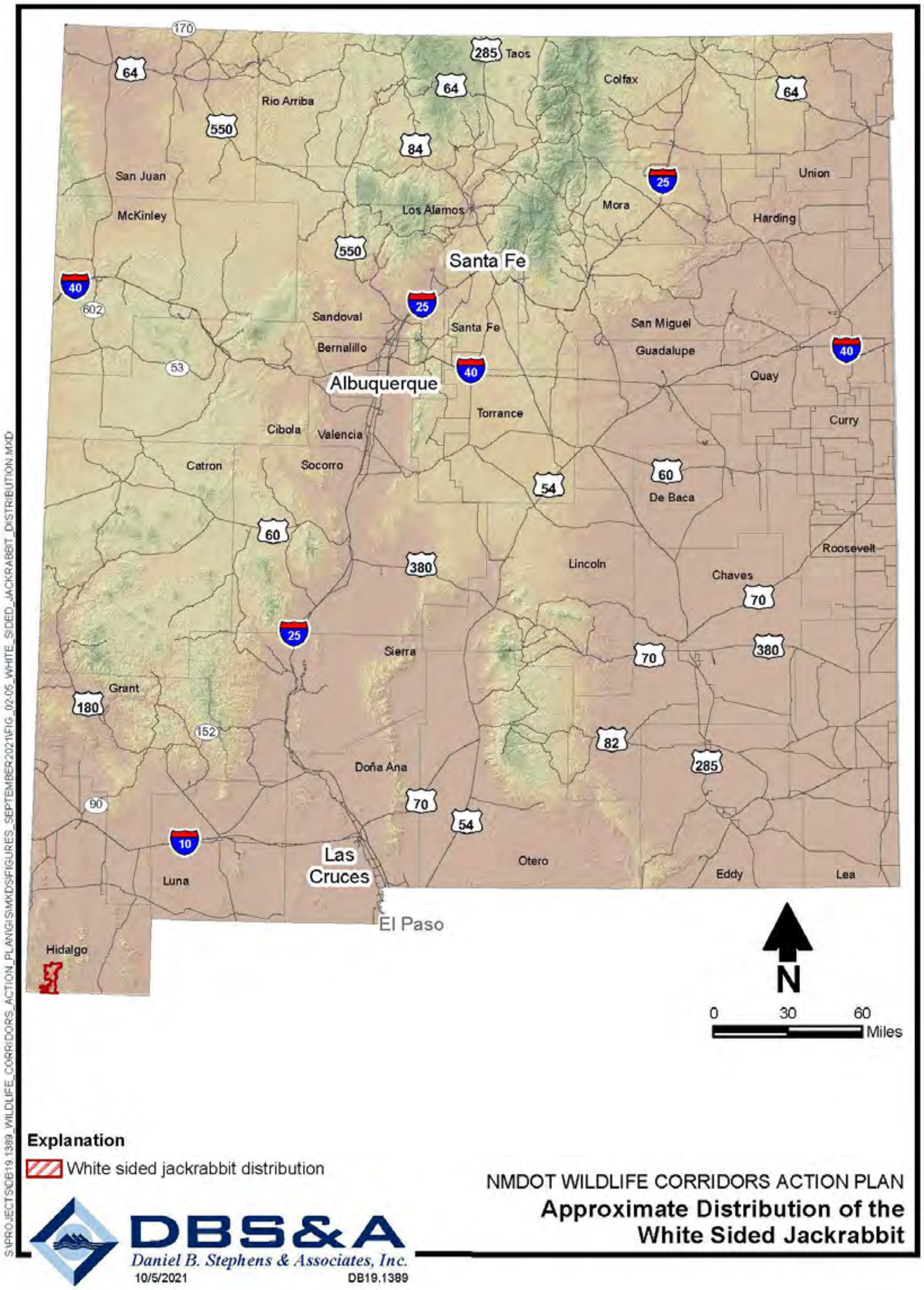

Figure 2-5. Approximate distribution of the white-sided jackrabbit in New Mexico.

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2.1.5.3 *Impacts of Roads and Road Traffic*

White-sided jackrabbit mortality from collisions with vehicles has been documented in New Mexico (USFWS, 2010; Traphagen, 2011). Although vehicle impacts have been considered a minor threat in the past, the pronounced increase in human activity and traffic along the U.S.-Mexico border in recent years may be adversely affecting white-sided jackrabbits in New Mexico (NMDGF, 2020). The increase in U.S. Border Patrol activity may have significantly increased the magnitude of this impact on white-sided jackrabbit populations in New Mexico (Brown, 2017). Traphagen (2011) sampled nighttime vehicle traffic along Hidalgo County Road 1 (formerly known as NM 338), and documented 18 times more U.S. Border Patrol vehicles than personal vehicles. Significant reductions of white-sided jackrabbits have been documented along this stretch of roadway, yet no degradation of grassland quality or significant shrub invasion is evident (Traphagen, 2011).

2.1.5.4 *Legal Status/Species Designations and Relevant Conservation Initiatives*

The white-sided jackrabbit is state listed as threatened and is a species of greatest conservation need (NMDGF, 2016). Citing drastic population declines in the Animas Valley and the extirpation of the species in the Playas Valley, WildEarth Guardians (2008) petitioned the U.S. Fish and Wildlife Service for listing of the white-sided jackrabbit as threatened or endangered under the Endangered Species Act. That petition, which also mentioned the threat of climate change, was ultimately denied.

2.1.6 White-Tailed Jackrabbit (*Lepus townsendii*)

2.1.6.1 *Distribution and Abundance in New Mexico*

The white-tailed jackrabbit has been documented in north-central New Mexico, both in the San Luis Valley in Taos County and the San Juan Mountains in Rio Arriba County (Frey, 2004) (Figure 2-6).

2.1.6.2 *Habitat Associations*

Within their distribution in New Mexico, white-tailed jackrabbits occur in montane grasslands (Frey, 2004).

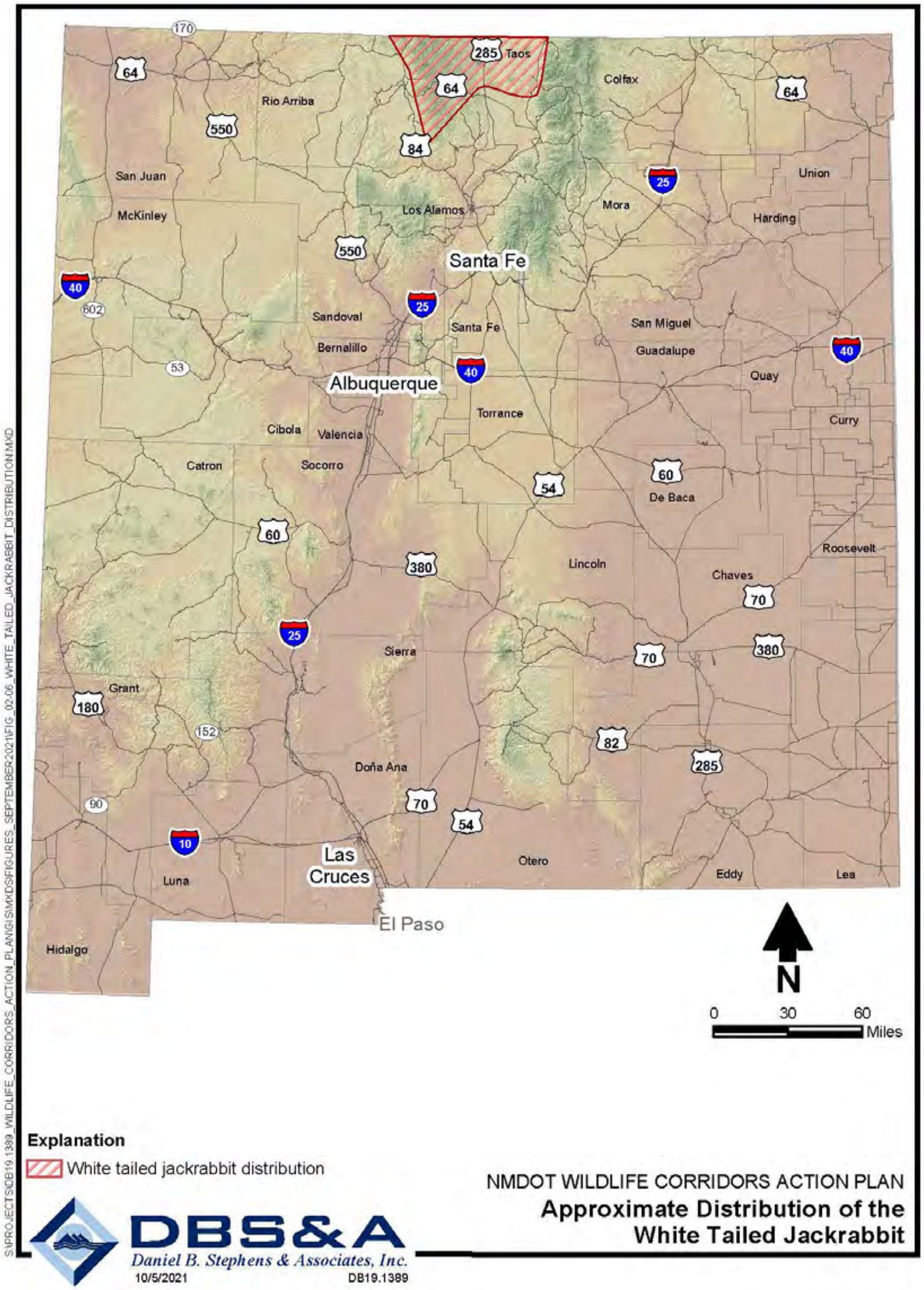

Figure 2-6. Approximate distribution of the white-tailed jackrabbit in New Mexico.

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2.1.6.3 *Impacts of Roads and Road Traffic*

White-tailed jackrabbit population levels have declined significantly since 1950, continuing a trend that began in some regions of the species range in the late 1800s (Brown et al., 2020). The main reasons for the decline and extirpation of white-tailed jackrabbit populations likely include conversion of grasslands to annual crop production in the Great Plains, climate change, past depredation measures, and increased populations of predators such as coyotes (*Canis latrans*). Mortality from road traffic might have contributed in some areas, based on large numbers of roadkilled white-tailed jackrabbits reported in Idaho (Williams and Nelson, 1939) and South Dakota (Over and Churchill, 1941). This hypothesis is supported by the high number of closely related black-tailed jackrabbits documented killed on roads in southern California (Caro et al., 2000; Caro, 2013).

2.1.6.4 *Legal Status/Species Designations and Relevant Conservation Initiatives*

The white-tailed jackrabbit has no special federal or state designation, and no conservation initiatives have been launched in the state specifically for the species.

2.1.7 Cougar (*Puma concolor*)

2.1.7.1 *Distribution and Abundance in New Mexico*

In New Mexico, cougars occur mainly in association with foothills and mountains in the north-central, south-central, and western portions of the state (Logan and Sweanor, in press) (Figure 2-7). The NMDGF estimates New Mexico's population of cougars to number 3,512 independent individuals (i.e., adults and subadults) (NMDGF, unpublished data).

2.1.7.2 *Habitat Associations*

Cougars are primarily associated with an abundance of suitable prey, together with vertical cover and rugged terrain (Logan and Sweanor, in press). New Mexico's low-elevation deserts and the eastern plains shortgrass prairie are avoided.

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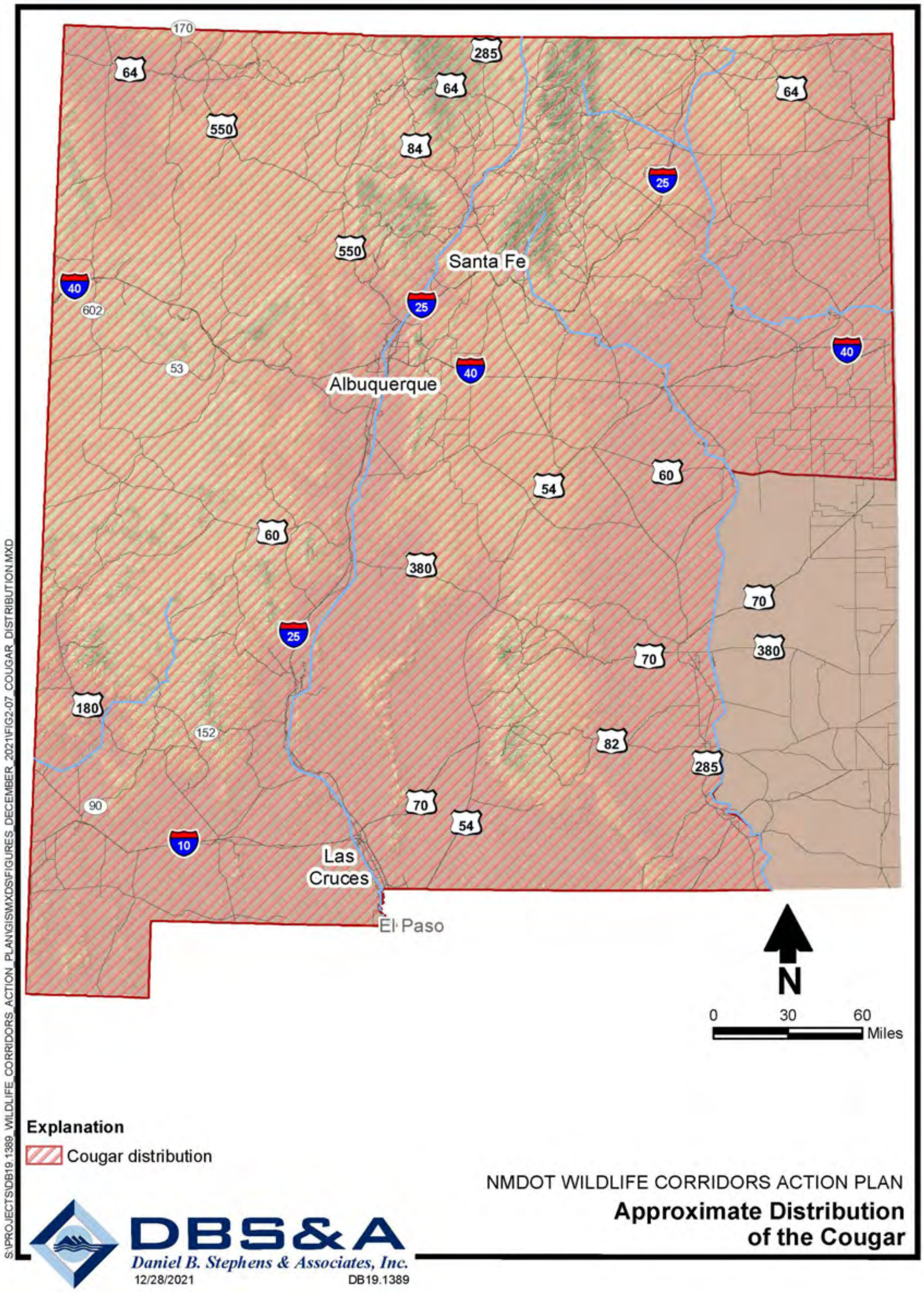

Figure 2-7. Approximate distribution of the cougar in New Mexico.

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2.1.7.3 *Impacts of Roads and Road Traffic*

Roads impact cougars through direct (and likely indirect) mortality, road avoidance, and decreased habitat quality (Fahrig and Rytwinski, 2009). From 1979 to 1991, almost 50 percent of the documented mortalities of Florida panthers (*P. c. coryii*) was caused by road traffic (Hansen, 1992), and each year there are consistently 20 or more of these animals killed in vehicle collisions out of a population of less than 200 animals. In Utah and Arizona, radio-collared cougars appeared to exhibit both second- and third-order avoidance of improved dirt and hard-surfaced roads (Van Dyke et al., 1986). Compared to unimproved dirt roads, improved dirt and hard-surfaced roads were less likely to be crossed by cougars (third-order avoidance), while at the same time they were less likely to occur in their home ranges (second-order avoidance). In California, cougars did not avoid roads that occurred within their home ranges, but home ranges tended to be located away from high- and low-speed two-lane paved roads (Dickson and Beier, 2002). In northwestern Mexico, cougar density is known to be lower in the El Cuervo mountain range compared to Sierra Blanca (Hernàndez and Laundré, 2003; Laundré et al., 2009). Lower cougar density in El Cuervo was correlated with lower abundance of two key prey species—mule deer (*Odocoileus hemionus*) and collared peccary (*Tayassu tajacu*)—and with higher road (and town) densities (Laundré et al., 2009). Lower cougar density in El Cuervo appeared to be linked to higher human presence and accessibility increasing hunting pressure on both cougars and their prey.

In New Mexico, a total of 135 cougar-vehicle collisions were recorded throughout most of the state from 2009 through 2018. A large portion of these collisions occurred along I-25 from north of Albuquerque to the Colorado stateline, along the eastern slopes of the Sangre de Cristo Mountains, in and around the Sacramento Mountains, and along US 180 from just east of Silver City west and north to near Reserve in Catron County. No collisions involving cougars occurred in the southeastern part of the state. Cougars are known to use underpass structures to cross roads in New Mexico (AZGFD, unpublished data).

2.1.7.4 *Legal Status/Species Designations and Relevant Conservation Initiatives*

The cougar is considered a big game species in New Mexico (NMDGF, 2021b).

2.1.8 Kit Fox (*Vulpes macrotis*)

2.1.8.1 Distribution and Abundance in New Mexico

The kit fox occurs at elevations of up to 3,280 feet (2,300 m) msl throughout much of the state (Figure 2-8). To the east, the limit of its distribution is the Pecos River Valley through Torrance, De Baca, Guadalupe, Chaves, and Eddy Counties. It is absent farther east, where it is replaced by the swift fox (*V. velox*), as well as in the northern mountains and much of west-central New Mexico (Dunnum and Cook, in press). Population numbers are unknown in New Mexico.

2.1.8.2 Habitat Associations

Kit foxes inhabit desert scrub, chaparral, and semi-desert grasslands of the state (Dunnum and Cook, in press).

2.1.8.3 Impacts of Roads and Road Traffic

Roads are a factor of mortality among kit foxes, and are also considered potential barriers to their movements (Bremner-Harrison, 2007; Gerrard et al., 2001). Reports of kit foxes killed by road traffic in Utah (Smith, 1978) and South Dakota (Hines, 1980) were linked to animals being hit by vehicles while searching for carrion. In California, Cypher et al. (2009) did not find differences in San Joaquin kit fox (*V. m. mutica*) survival probabilities, reproductive success, litter size, nocturnal movements, and den placement among three road-related risk categories.

However, kit foxes in Arizona showed a negative correlation of space-use with increases in road network density for off-highway vehicles (OHVs) (Jones et al., 2017). Bremner-Harrison et al. (2007) documented San Joaquin kit fox roadkills, but no use of existing road crossing structures by foxes. They concluded that San Joaquin kit foxes may associate at least the smaller crossing structures (and the relatively confined space within them) with an increased predation risk.

2.1.8.4 Legal Status/Species Designations and Relevant Conservation Initiatives

The kit fox is included among New Mexico's protected furbearers (Dunnum and Cook, in press). No conservation initiatives have been launched in the state specifically for the species.

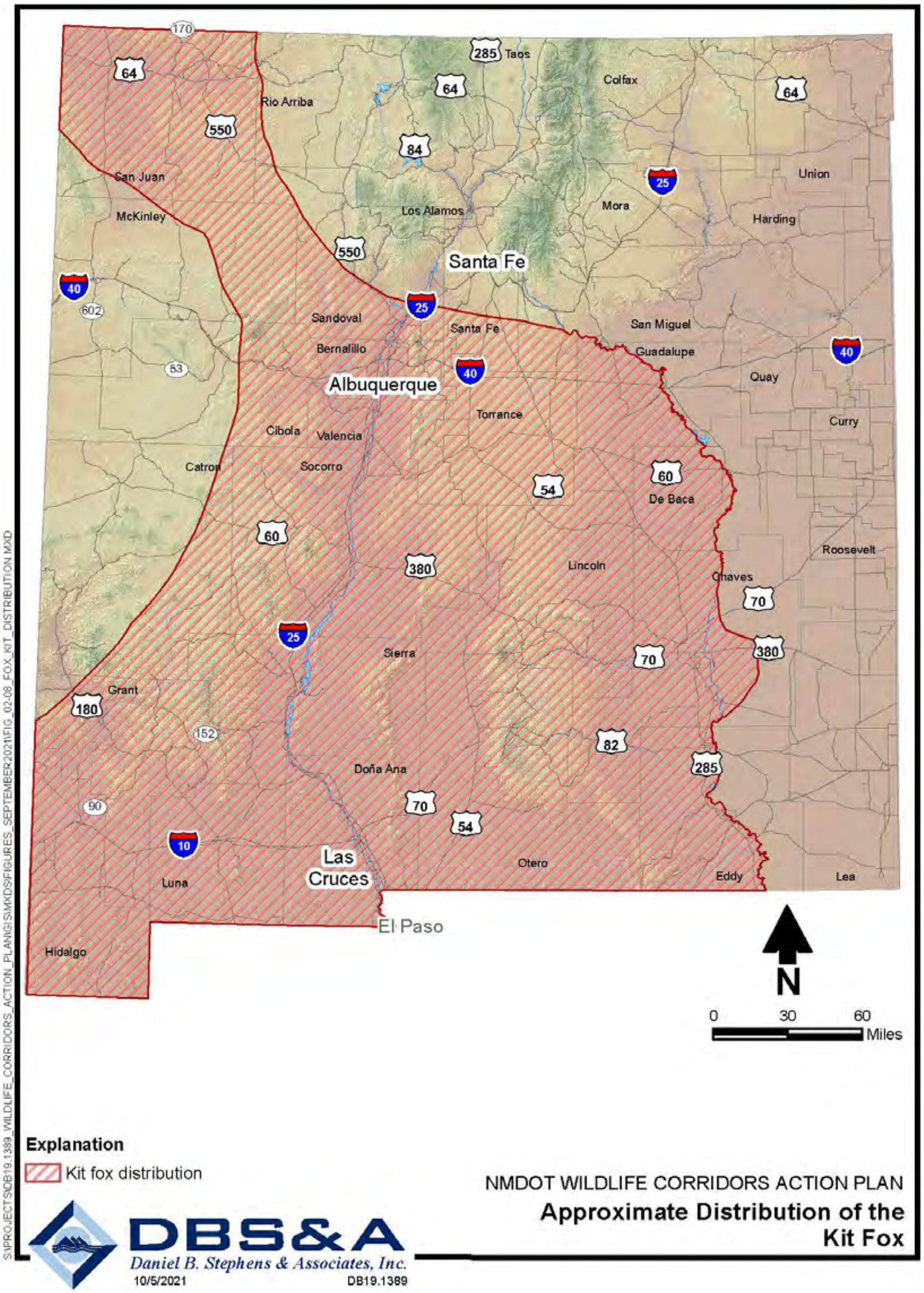

Figure 2-8. Approximate distribution of the kit fox in New Mexico.

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2.1.9 Swift Fox (*Vulpes velox*)

2.1.9.1 Distribution and Abundance in New Mexico

Swift foxes are found across New Mexico's eastern plains (Harrison et al., in press) (Figure 2-9). The distributions of the closely related kit fox (*Vulpes macrotis*) and swift fox meet along the Pecos River, with hybridization between the two species documented. The swift fox now appears absent in the more intensive agricultural areas of its historical distribution (in eastern Quay, Curry, Roosevelt, and Lea Counties). There are no estimates of swift fox population for New Mexico.

2.1.9.2 Habitat Associations

Swift foxes occur in shortgrass and mixed grass prairies (Harrison et al., in press). Low slope, short vegetation, and loamy soils are all correlates of swift fox habitat. Swift foxes are absent in dense shrublands within their historical range in New Mexico (in southeastern Quay County).

2.1.9.3 Impacts of Roads and Road Traffic

Numerous studies have established that swift fox dens tend to be located near roads or closer to roads than expected by chance alone (Hines and Case, 1991; Pruss, 1999; Olson, 2000; Harrison, 2003; Russell, 2006; Butler et al., 2019). In a study in northeastern New Mexico (Harrison, 2003), swift foxes were found to choose den sites closer to roads compared to random points. Also in northeastern New Mexico, Kintigh and Andersen (2015) indicated a positive association between swift fox dens and higher road densities (rather than proximity to roads).

Proposed explanations for the association between swift foxes and roads include (1) greater availability of carrion and small mammals (Hines and Case, 1991; Klausz, 1997), (2) avoidance and/or enhanced detection of coyotes (*Canis latrans*), which are a main predator of swift foxes (Russell, 2006; Butler et al., 2019), and (3) use of roads as travel corridors (Hines and Case, 1991; Pruss, 1999). At the same time, roads represent a significant source of mortality in some swift fox populations (Sovada et al., 1998; Kamler et al., 2003). In western Kansas, Sovada et al. (1998) showed that vehicle collisions were one of the leading causes of mortality among juveniles in one area dominated by cropland fields. In northwestern Texas, Kamler et al. (2003) monitored a total of 42 swift foxes, with the leading cause of mortality represented by vehicle collision (42 percent), ahead of coyote predation (33 percent).

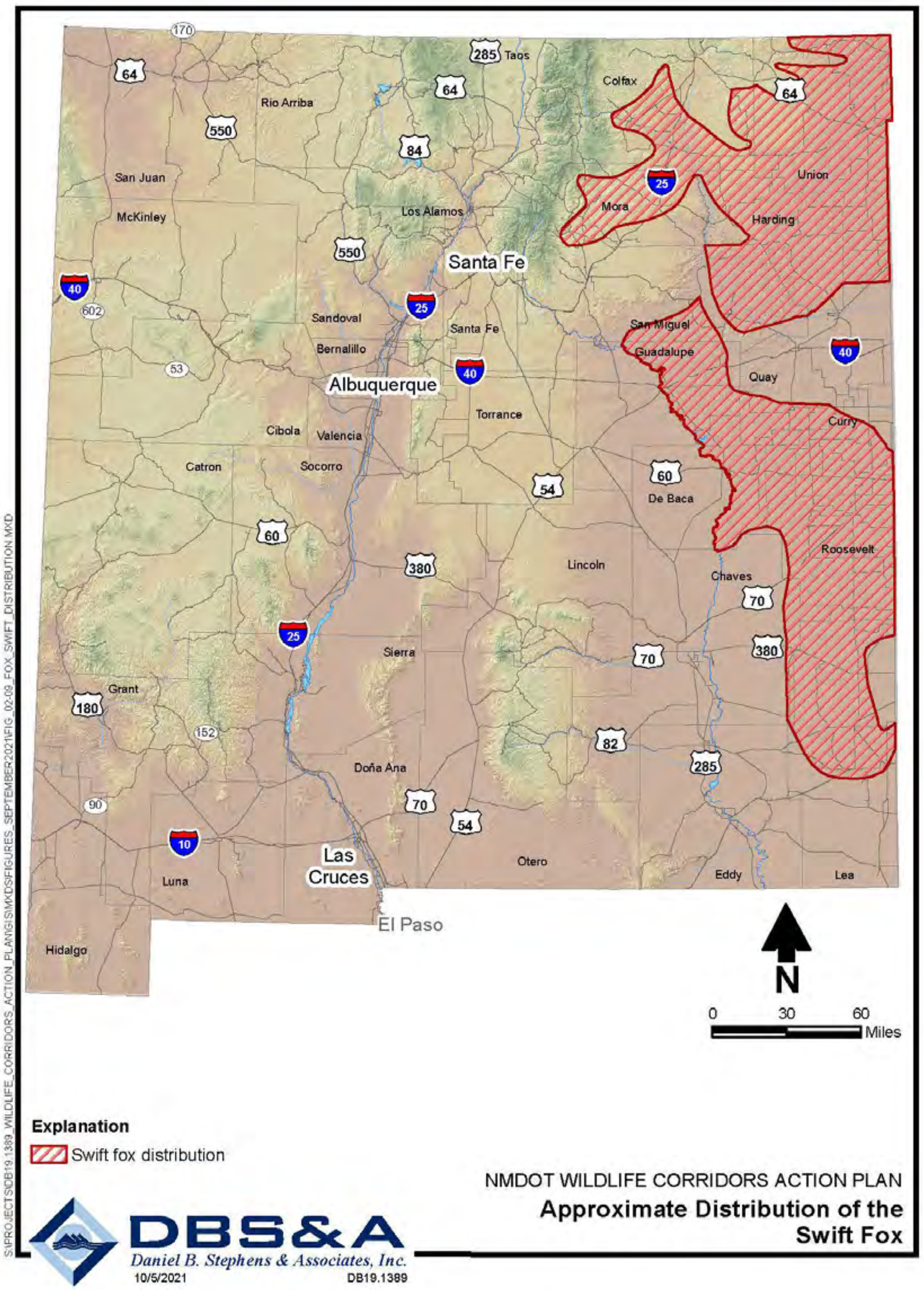

Figure 2-9. Approximate distribution of the swift fox in New Mexico.

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2.1.9.4 *Legal Status/Species Designations and Relevant Conservation Initiatives*

Over much of its distribution (but not in New Mexico), the swift fox is listed as a species of greatest conservation need as reported in State Wildlife Action Plans (USGS, 2020). It has full protection under New Mexico Statutes Chapter 17, with no hunting season.

2.1.10 Red Fox (*Vulpes vulpes*)

2.1.10.1 *Distribution and Abundance in New Mexico*

Red foxes occur throughout much of New Mexico, particularly in the northern and eastern parts of the state (Frey, 2004) (Figure 2-10). Records are available from most of the state's eastern counties, particularly on the Llano Estacado in Curry and Roosevelt Counties and in the Pecos River Valley from Eddy County northward to at least De Baca County, with additional scattered records in Colfax and Union Counties in the northeast (Frey, 2004). Red foxes are also known to occur near towns located west of Albuquerque along I-40, in mountain ranges particularly in the north (San Juan and Sangre de Cristo Mountains), but also including the San Andres and Sandia Mountains, and in the San Juan River Basin in the northwest (Frey, 2004). Red foxes in eastern New Mexico are likely the product of introductions in Texas, but the subspecies (from the San Juan, Sangre de Cristo, Sandia, and San Andres Mountains) is native (Frey, 2004). No information is available about red fox abundance in New Mexico.

2.1.10.2 *Habitat Associations*

In New Mexico, red foxes are associated primarily with mountains and croplands (Findley et al., 1975).

2.1.10.3 *Impacts of Roads and Road Traffic*

Road traffic is a significant factor of mortality in the red fox in Europe (e.g., Valerio et al., 2021), and red fox roadkills have been recorded in New Mexico (Harrison et al., 2003; Ubelaker et al., 2013). Research in Asia further suggests that roadways may attract red foxes in at least parts of their distribution, with findings that the likelihood of den occurrence was negatively correlated with distance to roads (Zaman et al., 2020). In New Mexico, various camera-monitoring studies have documented the use of underpasses by the red fox, including along US 64 west of Chama and US 550 near Aztec (Loberger et al., 2021).

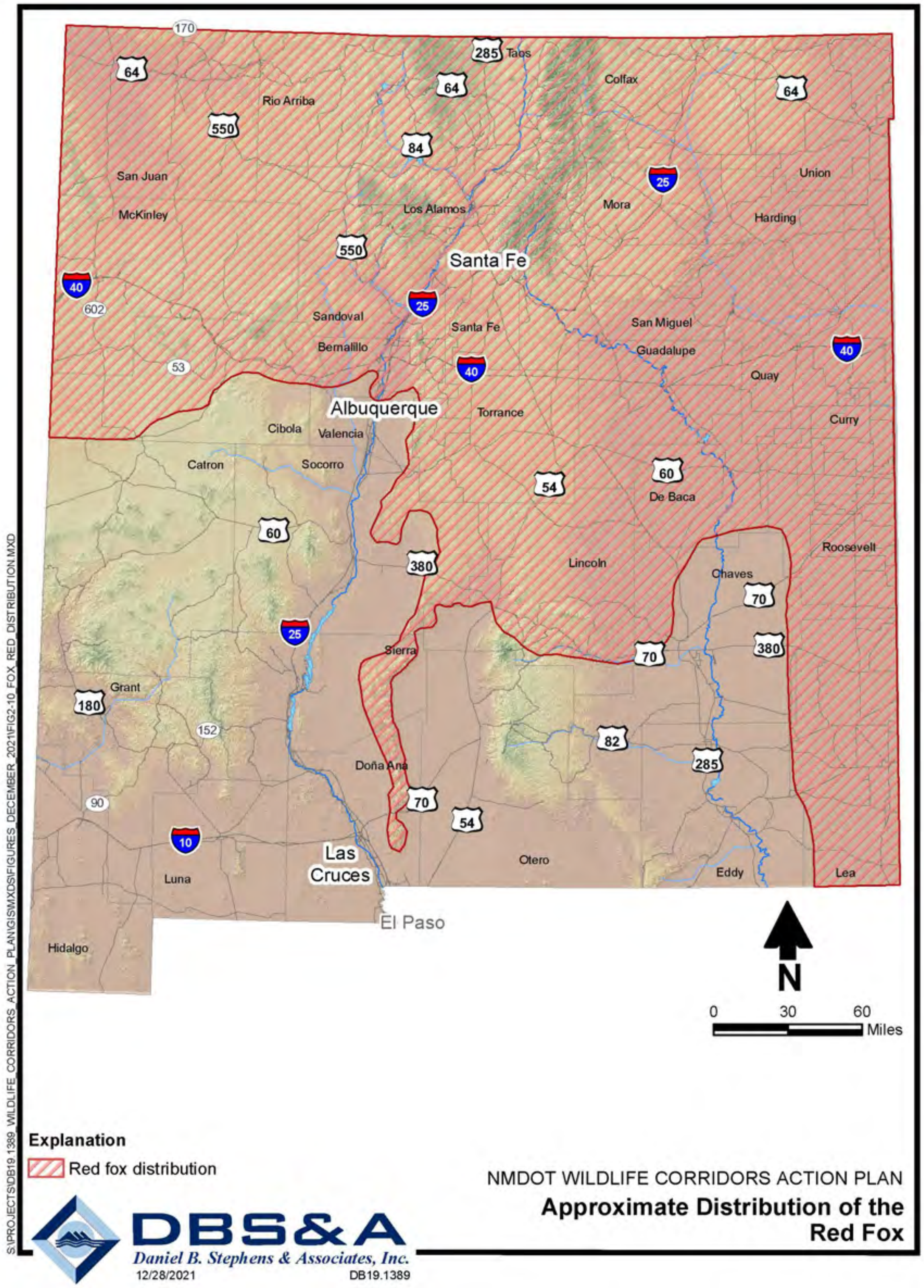

Figure 2-10. Approximate distribution of the red fox in New Mexico, subject to change.

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2.1.10.4 Legal Status/Species Designations and Relevant Conservation Initiatives

The red fox is designated as a protected furbearer in New Mexico.

2.1.11 Black Bear (*Ursus americanus*)

2.1.11.1 Distribution and Abundance in New Mexico

In New Mexico, the black bear occurs in all the forested mountain ranges of the state (Costello, in press) (Figure 2-11). Black bears are typically absent from the large expanses of lower-elevation desert separating those mountain ranges, and their elevational range extends mainly from about 4,500 to 11,000 feet (1,370 to 3,350 m) msl. New Mexico's black bear population is currently estimated at 8,000 individuals more than 1 year old (Costello, in press).

2.1.11.2 Habitat Associations

Black bears are primarily associated with closed-canopy, mid to upper-elevation forests (Costello, in press). Pinyon-juniper woodlands are also important where they are connected or interspersed with higher-elevation forests. Black bears prefer to remain within 1,600 feet (500 m) of forest edges, but may disperse through open vegetation communities between mountain ranges (Costello, in press).

2.1.11.3 Impacts of Roads and Road Traffic

Roads impact black bear populations directly through mortality from collisions with vehicles, as well as indirectly by modifying black bear behavior and habitat quality (Reiffenberger, 1974; Hamilton, 1978; Brown, 1980; Villarrubia, 1982; Brody and Pelton, 1989). Road avoidance in particular has been reported in areas open to hunting, as well as in association with high road traffic (Brody and Pelton, 1989). Research in Canada (Gilhooly et al., 2019) demonstrated the effectiveness of fencing and road-crossing structures for reducing black bear mortality along high-traffic highways.

A total of 508 black bear vehicle collisions were recorded in New Mexico from 2009 through 2018. Most of these collisions occurred in mountainous areas of the north-central and northeastern parts of the state, with other problem areas located in and around the Sacramento Mountains and in the vicinity of Silver City and northwest into Catron County. Among the top 30 wildlife-vehicle collision hotspots in New Mexico, one stands out with a total of 49 collisions involving black bears during the 10-year record period: the I-25 corridor from just south of Raton north to the Colorado border.

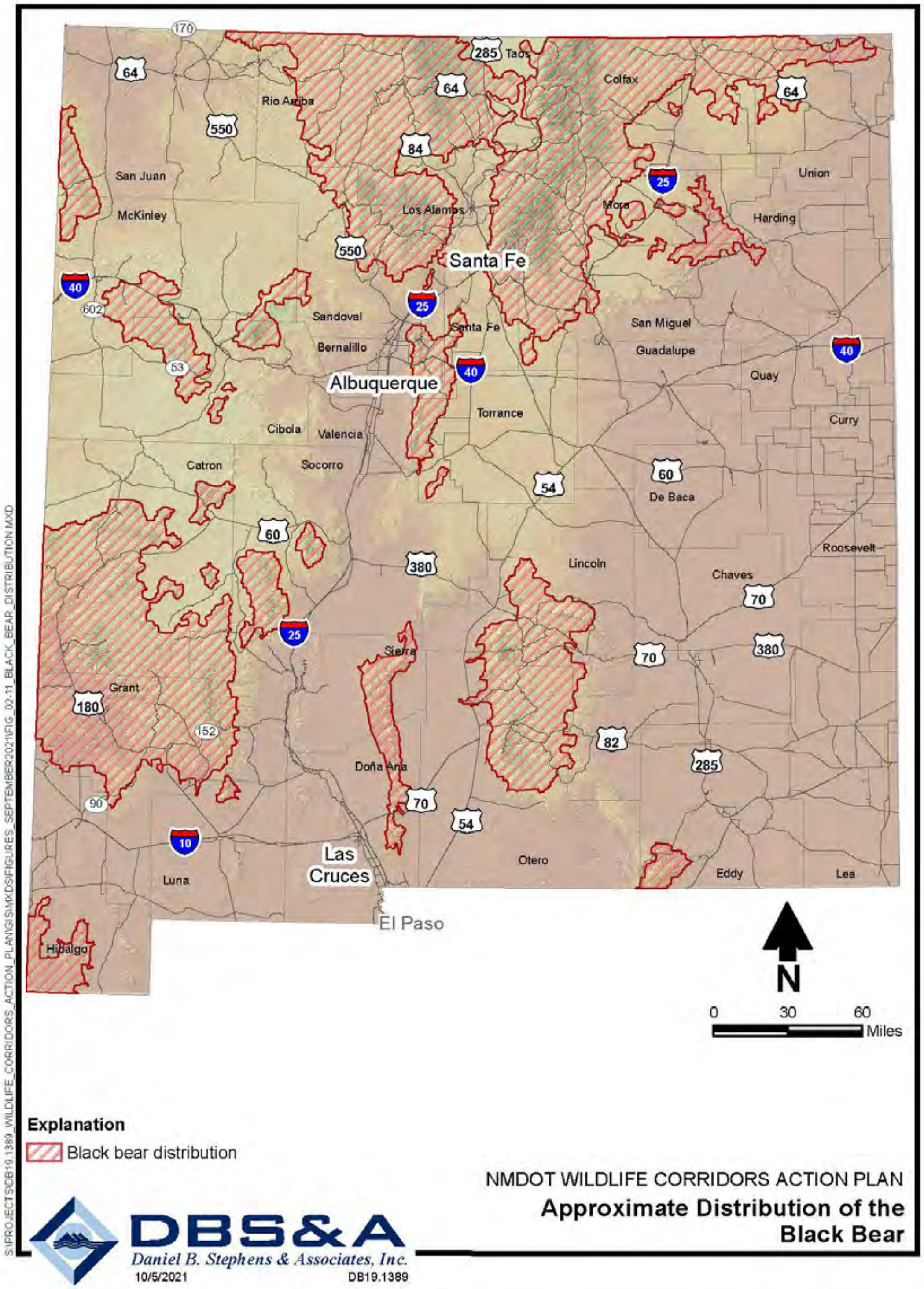

Figure 2-11. Approximate distribution of the black bear in New Mexico.

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Other top hotspots with higher numbers of black bear-vehicle collisions include US 64/US 84 just south of Chama (7 collisions), I-25 at/near Glorieta Pass (6 collisions), Tijeras Canyon along I-40 (6 collisions), and I-25 south of Wagon Mound (5 collisions). AZGFD and NMDOT researchers have documented 169 cases of black bears using underpasses, mostly small to medium sized concrete box culverts (Loberger, et al., 2021).

2.1.11.4 Legal Status/Species Designations and Relevant Conservation Initiatives

The black bear is classified as a big game species in New Mexico (NMDGF, 2021b).

2.1.12 American Badger (*Taxidea taxus*)

2.1.12.1 Distribution and Abundance in New Mexico

The American badger is found throughout New Mexico, though densities seem lower in the west-central counties of Cibola and Catron and on the northeastern plains (Harrison and Cartron, in press) (Figure 2-12). The upper limit of its elevational range is at least 3,000 feet (10,000 m) msl in the state (Harrison and Cartron, in press), with some older reports of badgers reaching alpine tundra in summer (Bailey, 1931). No estimates of population numbers are available for American badgers in New Mexico.

2.1.12.2 Habitat Associations

In New Mexico as elsewhere, the American badger occurs primarily in association with grasslands and other treeless areas (Bailey, 1931; Harrison and Cartron, in press). Friable soils and high concentrations of burrowing rodents are key environmental drivers of badger abundance. Research on the Armendaris Ranch in south-central New Mexico (Gould and Harrison, 2018) suggests that water sources per se are not critical to American badgers in desert environments.

2.1.12.3 Impacts of Roads and Road Traffic

Roads affect American badgers at multiple scales and through both direct mortality and road avoidance (Sunga et al., 2017). Badgers are particularly susceptible to mortality from collisions with road traffic because (1) they have large home ranges and (2) roadsides tend to have quality forage (grass) and friable soils, which in turn attract large numbers of burrowing rodents, the main prey of badgers (Weir et al., 2004). The badgers' defense mechanism to turn and confront a perceived threat may also be a factor in their deaths from collisions.

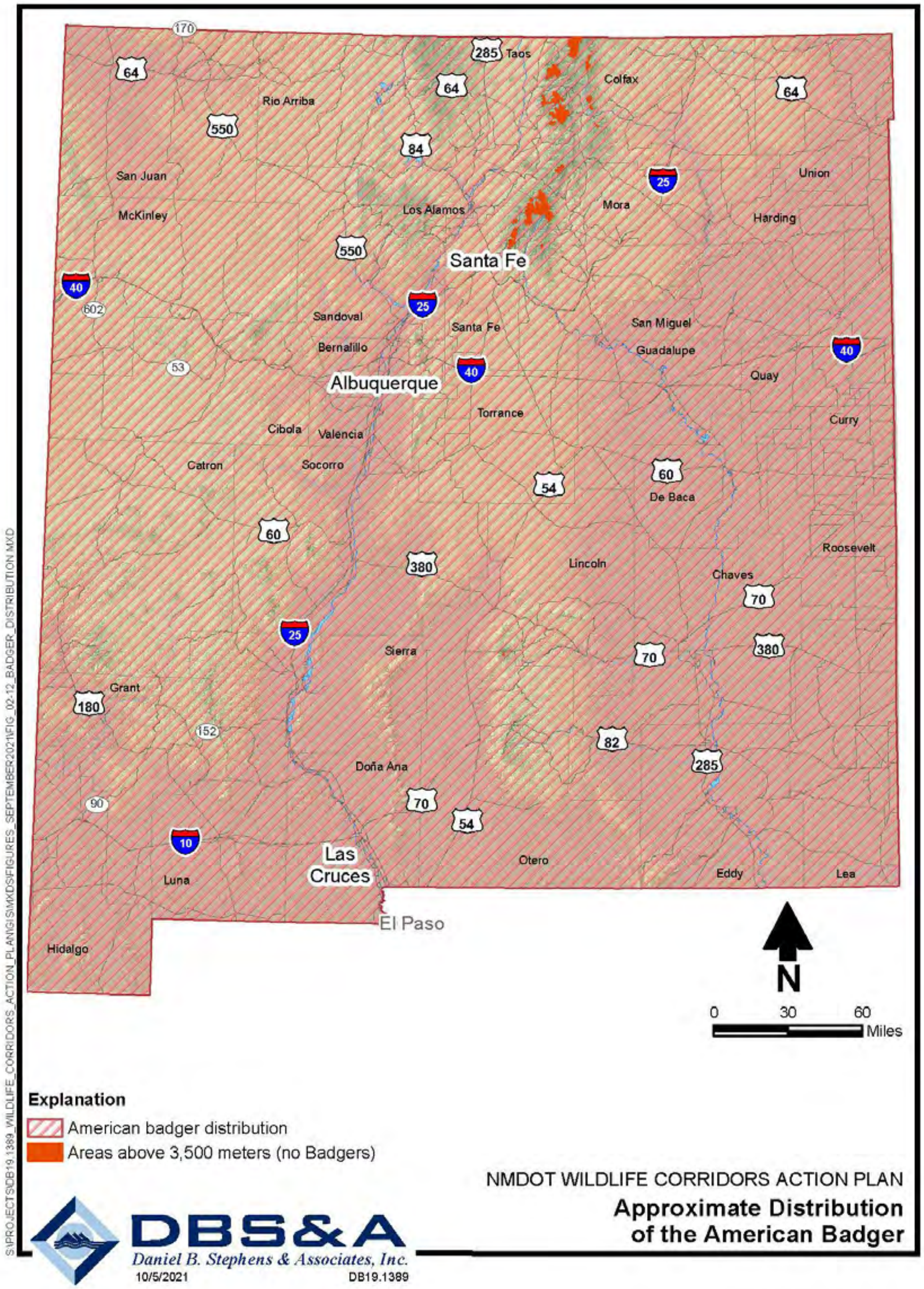

Figure 2-12. Approximate distribution of the American badger in New Mexico.

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Along with habitat loss, roads represent the most important threat in particular to American badger populations across Canada (COSEWIC, 2012). Weir et al. (2004) radio-tagged and monitored 13 individuals in a British Columbia endangered badger population and, over the course of a 3-year study, documented 7 mortality events, of which 6 (86 percent) were caused by road traffic. Adult males are at greatest risk of being killed by road traffic during the breeding season while searching for potential mates (Sunga et al., 2017). Juvenile American badgers typically disperse during their first summer, at which time they may cross seemingly unsuitable habitat and major physiogeographic barriers, including roads (Messick and Hornocker, 1981). Messick and Hornocker (1981) reported a maximum dispersal distance of 32 miles (52 kilometers [km]) for females and 68 miles (110 km) for males. In New Mexico, no study has focused on the impact of roads on American badgers, but roadkill carcasses are frequently observed (Harrison and Cartron, in press).

2.1.12.4 Legal Status/Species Designations and Relevant Conservation Initiatives

The American badger is considered a protected furbearer in New Mexico (Harrison and Cartron, in press). No conservation initiatives have been launched in the state specifically for badgers.

2.1.13 White-Backed Hog-Nosed Skunk (*Conepatus leuconotus*)

2.1.13.1 Distribution and Abundance in New Mexico

White-backed hog-nosed skunks occur most reliably in the southern half of New Mexico, with records of occurrence in particular from Hidalgo, Grant, Catron, Cibola, Doña Ana, Sierra, Socorro, Valencia, Otero, Lincoln, Chaves, and Eddy Counties (Dragoo and Hass, in press) (Figure 2-13). They also occur farther north, through the central part of the state and reaching the Colorado stateline in the northeast at Raton Pass in Colfax County. The species is absent in northwestern and most of north-central New Mexico. There are only a few records of occurrence from the northeastern quadrant of the state (Dragoo and Hass, in press).

2.1.13.2 Habitat Associations

Hog-nosed skunks occupy a wide variety of habitats ranging from low-elevation deserts to pine-oak forest (Findley et al., 1975; Dragoo and Hass, in press). They have been found at elevations as high as 9,000 feet msl within coniferous forests (NMDGF, 2021c). Habitat types include canyons, streambeds, and rocky terrain; most records of occurrence are associated with woodlands and forests, less commonly with savannas, grasslands, and scrublands, and least frequently with urban and agricultural areas (Dragoo and Hass, in press).

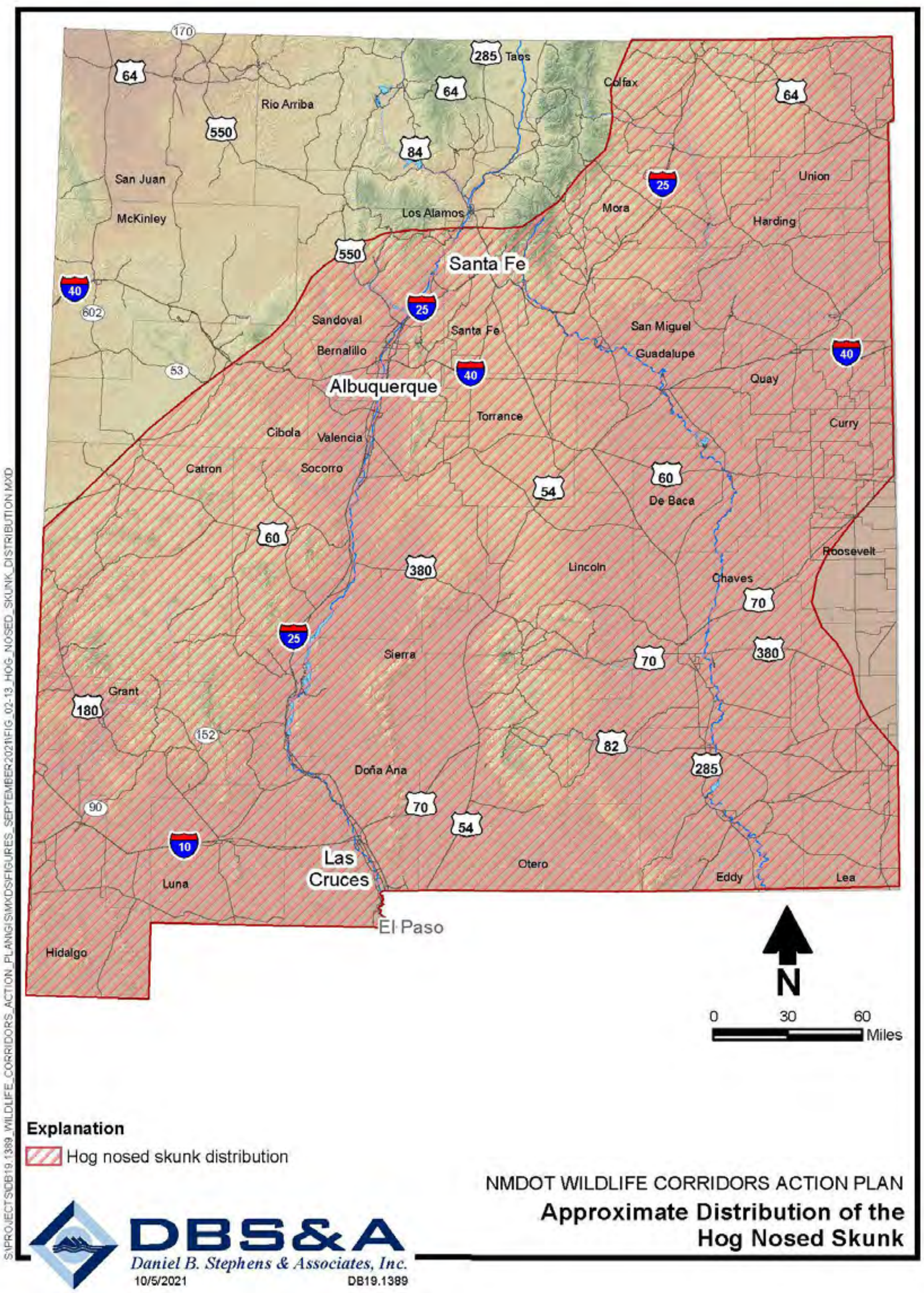

Figure 2-13. Approximate distribution of the hog-nosed skunk in New Mexico.

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2.1.13.3 Impacts of Roads and Road Traffic

Skunks in general experience significant mortality from collisions with road traffic, with hog-nosed skunks particularly so as a result of their deliberate, rather than quick, movements (Meaney et al., 2006) when encountering a perceived threat, such as an oncoming vehicle; they are known as pausers when encountering road-based dangers (Jacobson et al., 2016). The high representation of skunks among roadkill carcasses has long been known (e.g., Wilford and Wilford, 1936). A study in Illinois (Gehrt, 2005) showed that vehicle collisions represented the most frequent cause of mortality in a rural skunk population in summer and fall. In the urban skunk population also under study, many skunks were found to avoid roads with high traffic volume. They did not cross those roads, which instead served as the boundaries of their home ranges (Gehrt, 2004 and 2005).

2.1.13.4 Legal Status/Species Designations and Relevant Conservation Initiatives

In New Mexico, the hog-nosed skunk is considered a non-game species, and therefore does not benefit from the protection afforded to furbearers.

2.1.14 White-Nosed Coati (*Nasua narica*)

2.1.14.1 Distribution and Abundance in New Mexico

In New Mexico, the white-nosed coati occurs mainly in the state’s southwestern mountains east to the Rio Grande Valley and north into southern Catron County in the Mogollon Mountains (Frey, in press) (Figure 2-14). It is found primarily in the Peloncillo, Animas, and Hatchet Mountains of southern Hidalgo County and the Big Burro Mountains of western Grant County, as well as in canyons along the Gila and San Francisco Rivers of western Grant County. Elevation range is most frequently between 5,250 and 6,890 feet msl (NMDGF, 2021d). Occasional records exist from south-central and central New Mexico, including the Rio Grande valley (Doña Ana, Sierra, and Socorro Counties), the Organ Mountains (Doña Ana County), and the Guadalupe Mountains (Eddy County). No information is available on white-nosed coati abundance in New Mexico (Frey, in press).

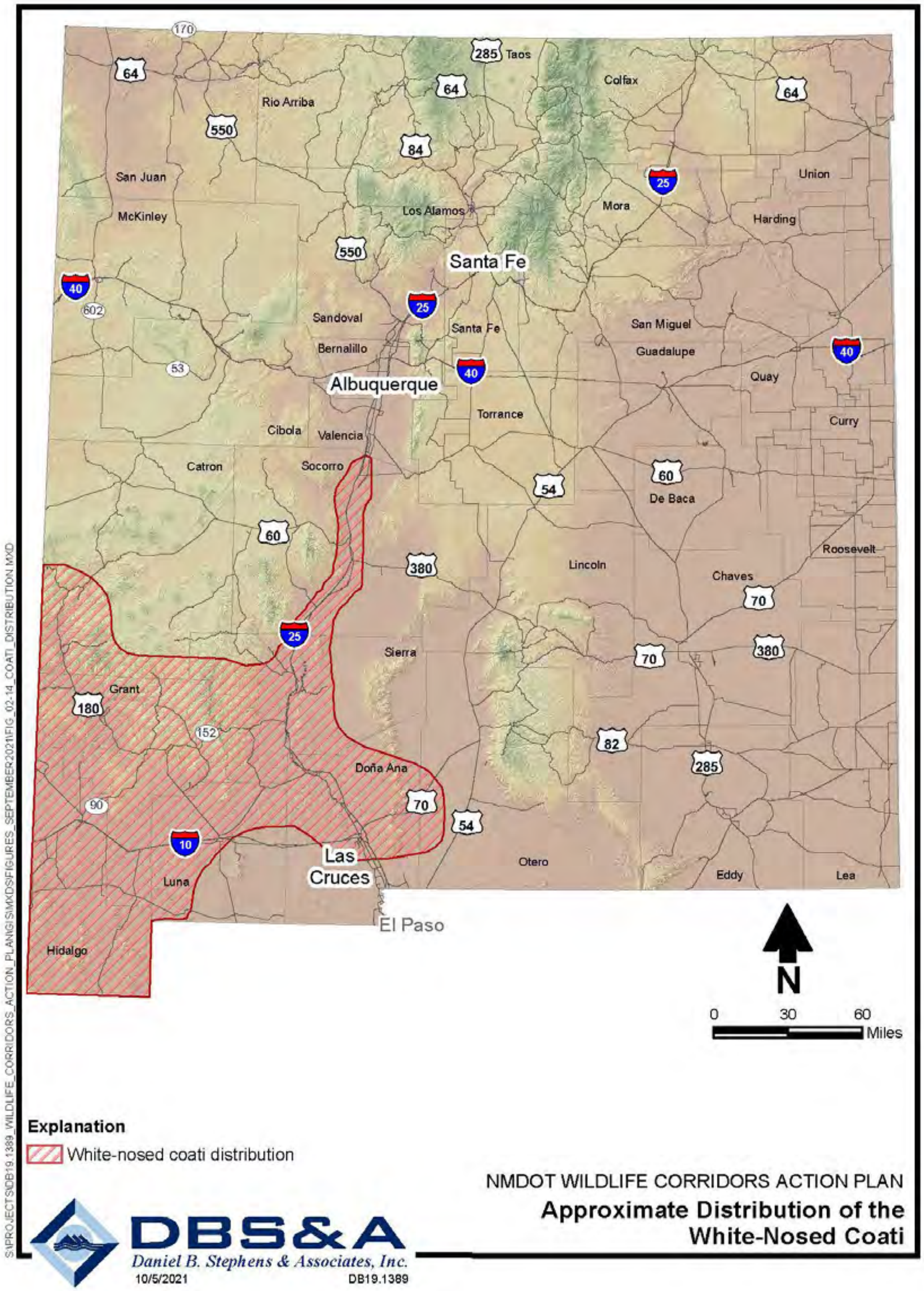

Figure 2-14. Approximate distribution of the white-nosed coati in New Mexico.

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2.1.14.2 Habitat Associations

In the southwestern U.S., the white-nosed coati is primarily associated with enclaves of Madrean pine-oak woodlands and other middle-elevation montane woodlands and forests (Wallmo and Gallizioli, 1954; Brown, 1994). In the Animas Mountains of New Mexico, coatis seemingly occur in greater numbers in oak and pinyon-juniper woodland (Cook, 1986). In Arizona, encinal grasslands, encinal and conifer woodlands, and pine-dominated conifer forests constitute primary habitat, but coatis also occur in desert and desert grasslands within the same mountain ranges occupied by the species (Wallmo and Gallizioli, 1954). In the Huachuca Mountains in particular, most observations of coatis were from canyon bottoms dominated by oaks, sycamore, walnut, and maple, and, at higher elevations, oaks and pines (Wallmo and Gallizioli, 1954). Water availability is a key requirement (Frey, in press).

2.1.14.3 Impacts of Roads and Road Traffic

Frey et al. (2013) used several models to examine the relative importance of several environmental variables to accurately predict the location of coati records in southwest New Mexico. Road density was an important predicting variable according to one of the two conservative models (with only verified records consisting of specimen records and photographs), and response curves indicated an increasing probability of coati occurrence with increasing road density. However, Frey et al. (2013) concluded that the association of coati records with density of roads in their conservative model was likely a spurious result caused by small sample size. Coati mortality from collisions with road traffic has been documented in Arizona.

2.1.14.4 Legal Status/Species Designations and Relevant Conservation Initiatives

In 2006, the coati was listed under the New Mexico Statutes Chapter 17, which provides full protection with no hunting season (NMDGF, 2006).

2.1.15 Collared Peccary (*Tayassu tajacu*)

2.1.15.1 Distribution and Abundance in New Mexico

In New Mexico, the collared peccary (also known as javelina) was typically found in the extreme southeastern and southwestern parts of the state (Figure 2-15). In recent years, the southwestern population (sub-species *T. t. sonoriensis*) has become common, spreading through Hidalgo County, east to the Tres Hermanas in Luna County, and north into the Gila and San Francisco drainages (NMDGF, 2021a).

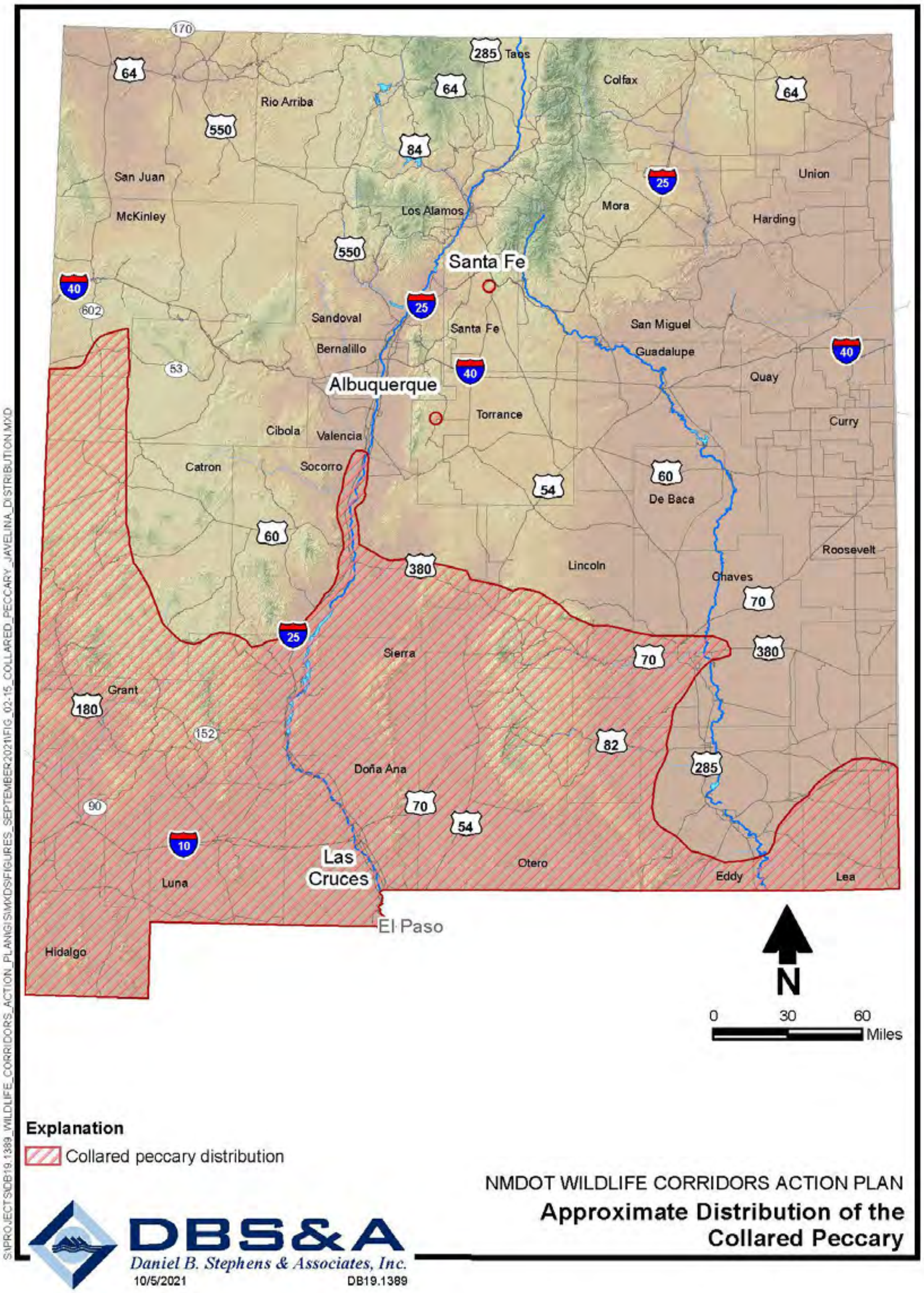

Figure 2-15. Approximate distribution of the collared peccary in New Mexico.

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The southeastern population (subspecies *T. t. angulatus*) is documented within Lea and Eddy Counties in the Pecos watershed, including the Bitter Lake National Wildlife Refuge near Roswell in Chaves County (NMDGF, 2021a). The collared peccary has been increasing its range in New Mexico beyond the southeastern and southwestern parts of the state, with documented locations on the Zuni reservation in McKinley County, the Bosque del Apache National Wildlife Refuge in Socorro County, Clines Corners in Torrance County, and near Santa Fe (NMDGF, 2021a). It is also expanding its range into south-central New Mexico with documented populations in Doña Ana County, leading to the suggestion of genetic flow between the two sub-species (Lamit and Hendrie, 2009). The more recent observations of collared peccary near Santa Fe may represent a rebounding of this species in areas where they were historically (NMDGF, 2021a). New Mexico's peccary population numbers have not been estimated. The species elevational range might reach approximately 6,700 feet (2,040 m) msl or higher in the state, based on Santa Fe County records.

2.1.15.2 Habitat Associations

The collared peccary occurs in a range of diverse habitats from central South America to the southwestern U.S. In New Mexico, it is commonly found in Chihuahuan desert shrubland and grasslands in lower elevations and in higher elevation desert mountains, where it can also be found in oak and pinyon-juniper woodlands and rarely in pine and fir forest. In its desert range, the peccary inhabits creosote (*Larrea tridentata*) shrubland and black grama (*Bouteloua eriopoda*) grasslands, preferring to stay within the arroyos or rocky canyons of desert mountains (Lamit and Hendrie, 2009). Thickets of cacti are essential in some places, as these provide a source of food and moisture (NMDGF, 2021a).

2.1.15.3 Impacts of Roads and Road Traffic

No studies were found relating impacts to peccaries in New Mexico due to road collisions. A review of iNaturalist records of collared peccaries included roadkill incidents that are widespread within their range, including San Antonio, Socorro County near the Middle Rio Grande, Organ Mountain pass and Dripping Springs in the Organ Mountains, I-10 near the New Mexico/Arizona border, NM 80 near the Peloncillo Mountains, and NM 176 near Eunice (iNaturalist, 2021). Based on these records, roads are a source of peccary mortality in New Mexico, but further studies would be needed to determine the degree of impact on peccary populations. NMDGF cites one of the population effects as direct mortality, in part due to vehicle collisions. In southern Arizona, collared peccary have been documented using both underpasses and overpasses to cross roads, but appear to have a preference for underpasses (AZGFD, 2021).

Other species of peccary have had traffic impact determinations. The chacoan peccary (*Catagonus wagneri*) was included in a literature review of 131 species, and traffic impacts on the species were negative (Fahrig, 2009).

2.1.15.4 Legal Status/Species Designations and Relevant Conservation Initiatives

The collared peccary is listed as a big game species by the NMDGF and as "demonstrably secure" in global heritage ranking from the New Mexico Natural Heritage.

2.1.16 Pronghorn (*Antilocapra americana*)

2.1.16.1 Distribution and Abundance in New Mexico

During surveys in 2015-2017, an estimated 47,000 to 49,000 pronghorn were counted across 13 pronghorn management units in New Mexico (NMDGF, 2017b). Pronghorn herds occur throughout most of the state's grassland ecosystems at elevations ranging from 4,000 to 7,000 feet (1,220 and 2,130 m) msl. They can be found in particular on the eastern plains (especially in the northeast) and in grasslands in other parts of the state (e.g., Plains of San Agustin in west-central New Mexico [Jones, 2016]; Sevilleta National Wildlife Refuge in Socorro County [Harris et al., 2015]; White Sands Missile Range in the south-central part of the state [Cain et al., 2017]; the Deming Plain in Luna County [Jones, 2016]) (Figure 2-16). Atypically for the state, one herd in north-central New Mexico moves upslope to spend the spring and summer in montane meadows east of Chama near the Colorado border, at an elevation above 11,000 feet msl (Henry, 2019).

2.1.16.2 Habitat Associations

Core habitat in New Mexico consists typically of shortgrass prairie and desert grassland (Findley et al., 1975; Cain et al., 2017; Wan et al., 2018). In some areas such as the Ladder Ranch in Sierra County, pronghorn also occur in desert scrubland (Jones, 2016). The herd that moves up in elevation in the north-central New Mexico area east of Chama travels through woodlands before reaching the high elevation montane meadows, where they remain for the spring and summer (Henry, 2019).

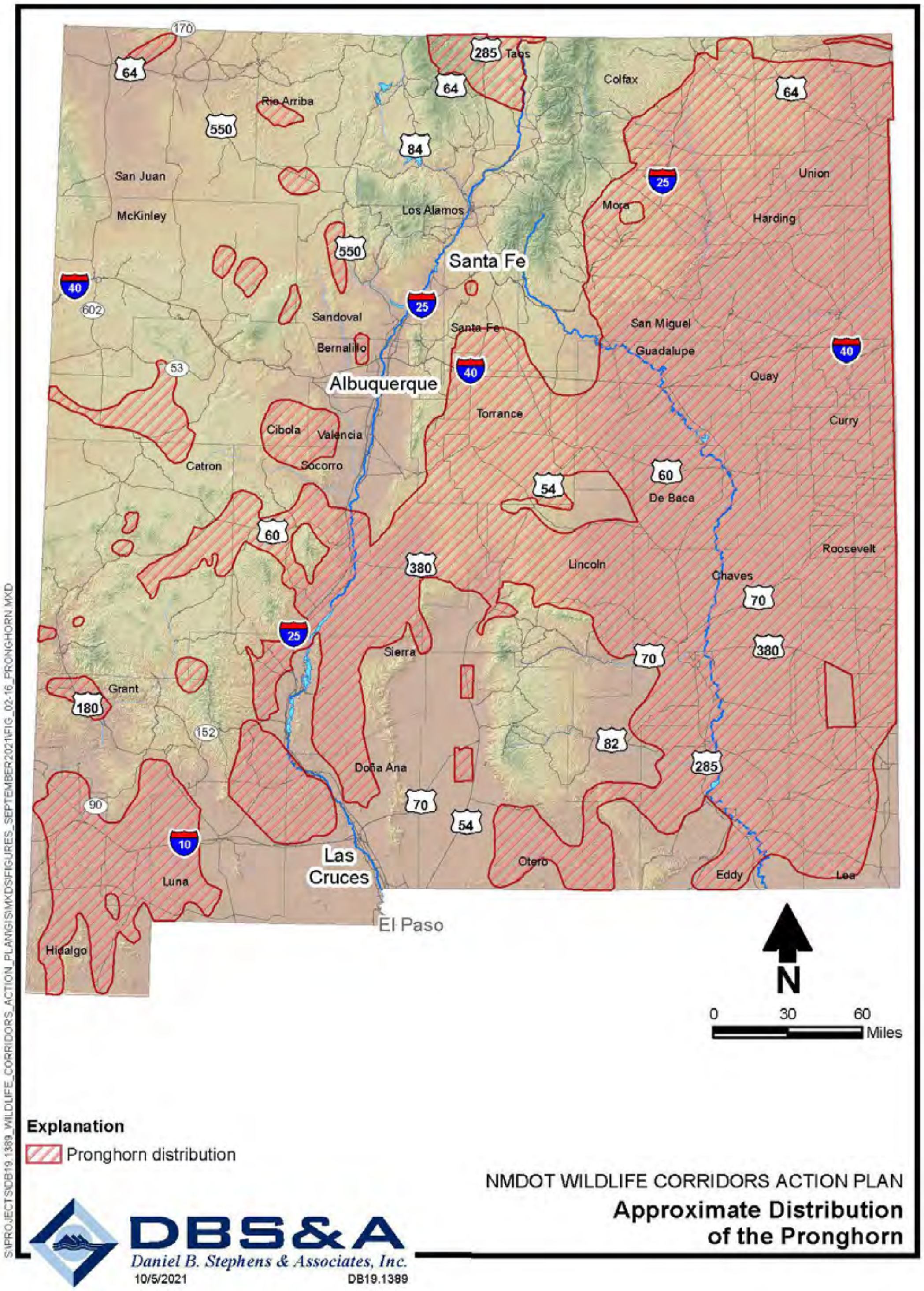

Figure 2-16. Approximate distribution of the pronghorn in New Mexico.

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2.1.16.3 Impacts of Roads and Road Traffic

Roads, traffic, and right-of-way fences affect pronghorn through direct mortality and by affecting their behavior, while fences along roads and even traffic restrict or alter their movements (Berger et al., 1983; vanRiper and Ockenfels, 1998; Gavin and Komers, 2007; Xu et al., 2020; Sprague et al., 2013). Fragmented pronghorn herds caused by fenced right-of-way in northern Arizona showed genetic differences across roads, with those differences increasing with traffic volumes (Theimer et al., 2012). Pronghorn prefer to crawl under fences rather than jump over them, and they struggle with multiple strand fences when the bottom wire is too low. In western Wyoming, Xu et al. (2020) found that (1) pronghorn on average encountered fences twice as frequently as mule deer (*Odocoileus hemionus*) and (2) in 40 percent of cases of fence encounters, pronghorn altered their normal movements, typically quickly retreating (referred to as "bounce" behavior). There are pronghorn-friendly fencing options including rail fences or even wire fences if 18-20 inches of clearance beneath the lowest fence rail or wire is allowed (Dodd et al., 2011; Gagnon et al., 2021). Attempts to help mitigate low bottom wires have been met with mixed results (Sprague, 2013; Jones et al., 2018 and 2020).

Even with the documented barrier effect of roads on pronghorn, collisions still occur. A total of 221 wildlife-vehicle collisions involving pronghorn were recorded in New Mexico from 2002 to 2018—138 of them from 2009 to 2018. Pronghorn mortality caused by road traffic was recorded in many areas of the state, including in Colfax County south of Raton, near Roswell in Chaves County, and along US 64 in Union County. In Canada, Gavin and Komers (2007) showed that pronghorn perceived roads as presenting a higher risk of predation, particularly for their young. Pronghorn exhibited higher vigilance when in close proximity to roads regardless of vehicle traffic levels. In the spring, they also exhibited higher vigilance and spent less time foraging along roads with high-traffic compared to roads with low traffic (Gavin and Komers, 2007).

Mitigation of road-caused fragmentation and mortality is possible with the use of overpasses. Because of their keen eyesight and use of distance for predator avoidance behavior, pronghorn prefer overpasses to underpasses when crossing roads. Sawyer et al. (2016) documented nearly 20,000 pronghorn crossings, with 93 percent at overpasses rather than underpasses.

2.1.16.4 Legal Status/Species Designations and Relevant Conservation Initiatives

Pronghorn are considered a big game species in New Mexico.

2.1.17 Bighorn Sheep (*Ovis canadensis*)

2.1.17.1 Distribution and Abundance in New Mexico

As of November 2020, New Mexico was home to a total of 1,300 desert bighorn sheep (*O. c nelsoni*) across 8 herds (NMDGF, 2019a) and around 1,700 Rocky Mountain bighorn sheep (*O. c. canadensis*) across 11 herds (NMDGF, 2019b). The 8 desert bighorn sheep herds are located in mountain ranges of the central, south-central, and southwestern portions of the state: (1) Peloncillo Mountains, (2) Little Hatchet Mountains, (3) Big Hatchet Mountains, (4) Caballo Mountains (east of Caballo Reservoir), (5) Fra Cristobal Range in Sierra County, (6) Ladrón Mountains, (7) San Andres Mountains, and (8) Sacramento Mountains (NMDGF, 2019a). The 11 herds of Rocky Mountain bighorn sheep occur in (1) the Latir Peak, Pecos, and Wheeler Peak wilderness areas and in the Rio Grande Gorge in the north-central part of the state, (2) the Dry Cimarron River in the extreme northeast, and (3) Turkey Creek and the San Francisco River in southwestern New Mexico (NMDGF, 2019b) (Figure 2-17). The elevational range of the Rocky Mountain bighorn sheep reaches 13,000 feet (3,960 m) msl in summer in the Pecos and Wheeler Peak wilderness areas (USFS, 1987). In winter, Rocky Mountain bighorn sheep typically remain below an elevation of 10,830 feet (3,300 m) msl.

2.1.17.2 Habitat Associations

Rocky Mountain bighorn sheep herds are found in two types of settings: (1) in alpine tundra above the timberline and (2) at lower-elevation, in open canyons (e.g., Rio Grande Gorge) and on open slopes below forests and woodlands (NMDGF, 2004). Desert bighorn sheep occur in association with rugged, open escape terrain such as rocky slopes and cliffs (e.g., Karsch et al., 2016; Mckinney et al., 2003). In the Peloncillo Mountains, Karsch et al. (2016) found that parturition sites were located in association with intermediate rather than steep slopes, and with increased cover for concealment from predators such as cougars and coyotes.

Typical plant species in desert bighorn sheep habitat include various sclerophyllous (hard-leaved), succulent, and semi-succulent trees, shrubs, and semi-shrubs, as well as grasses and forbs; proximity to water is important (NMDGF, 1988).

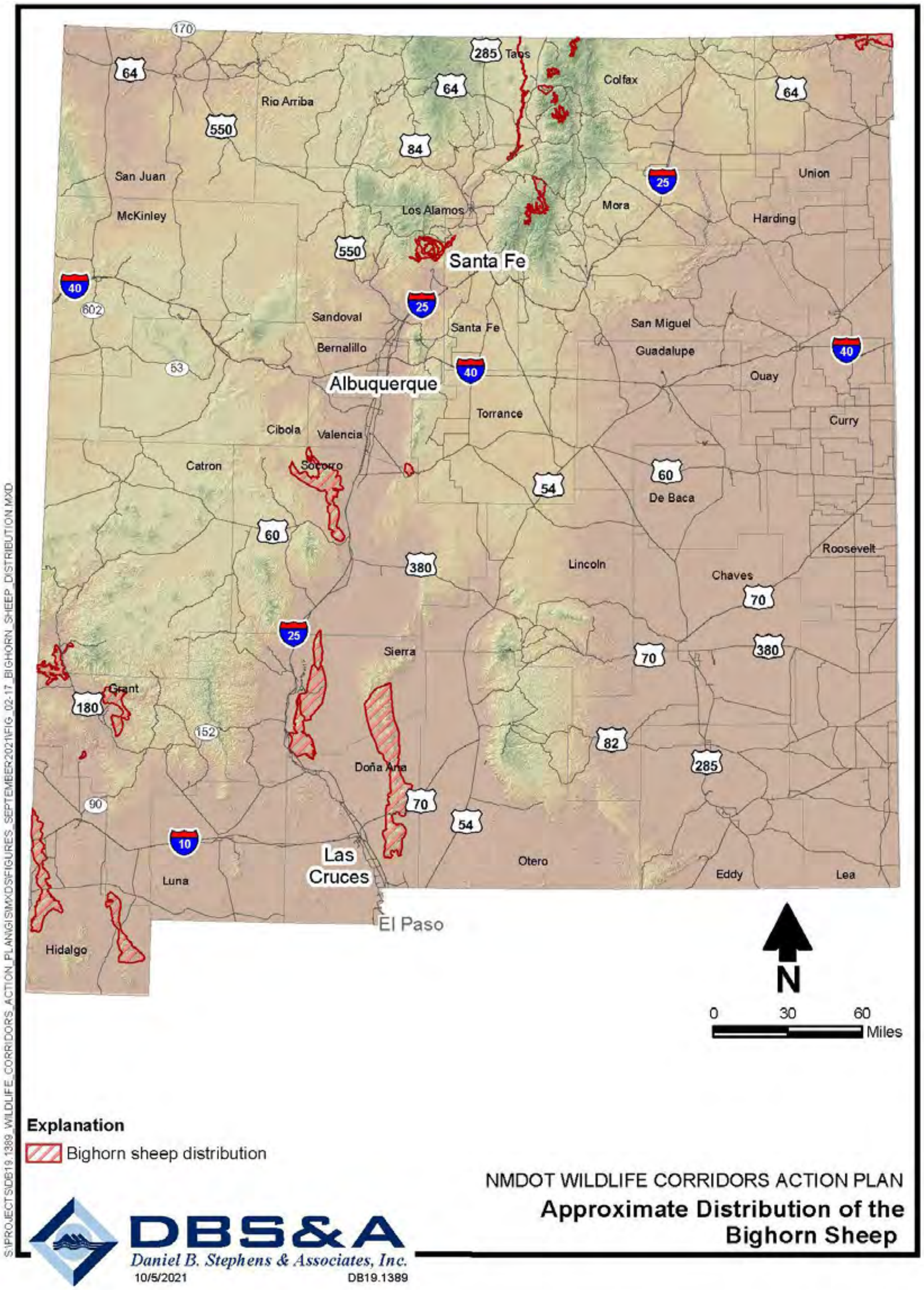

Figure 2-17. Approximate distribution of the bighorn sheep in New Mexico.

2.1.17.3 *Impacts of Roads and Road Traffic*

Impacts of roads and road traffic on bighorn sheep include mortality from collisions with vehicles (Campbell and Remington, 1979; Cunningham and deVos, 1992; McKinney and Smith, 2007; Rubin et al., 2002), physiological stress (MacArthur et al., 1982), decrease in range use (Campbell and Remington, 1979; Leslie and Douglas, 1979), reductions of movements (Rubin et al., 1998), and lower gene flow (Epps et al., 2005). A total of 16 wildlife-vehicle collisions involving bighorn sheep were recorded in New Mexico during 2009–2018. Most of these collisions occurred in Taos County, primarily along NM 38 between Questa and Red River. In southwestern New Mexico, I-10 is an important barrier separating two herds on either side of the road corridor, preventing gene flow (E. Rominger, personal communication; NMDGF, unpublished data; AZGFD, unpublished data). Bighorn sheep reside in rocky areas with easily accessible escape terrain and visibility from high points. During two research projects in Arizona, AZGFD and ADOT documented minimal use of underpasses by only rams along SR 68 leading to the inclusion of overpasses on US 93 in the same mountain range to the north (Bristow and Crabb, 2008; McKinney and Smith, 2007). Following construction of the overpasses on US 93, researchers documented nearly 6,000 bighorn sheep crossings of all ages and both sexes at the overpasses and showed a 1,367 percent increase in passage rates by collared sheep and a 97 percent reduction in sheep-vehicle collisions (Gagnon et al., 2017a).

2.1.17.4 *Legal Status/Species Designations and Relevant Conservation Initiatives*

Once listed as endangered under New Mexico's Wildlife Conservation Act, the desert bighorn sheep was delisted by the New Mexico Game Commission in November 2011. Bighorn sheep (both subspecies) are now considered big game animals with a hunting season. Hunters must obtain a sheep tag, which is sold in highly competitive auctions (desert bighorn) or distributed by draws (Rocky Mountain bighorn), with the proceeds used for bighorn sheep conservation efforts.

2.1.18 Mule Deer (*Odocoileus hemionus*) and White-Tailed Deer (*O. virginianus*)

2.1.18.1 *Distribution and Abundance in New Mexico*

Mule deer and white-tailed deer both occur in New Mexico, and are both considered species of concern. Mule deer numbers are thought to have declined in New Mexico since the 1960s, down to about 80,000 to 100,000 at present (Bender et al., 2007 and 2012; WAFWA, 2020). The Rocky Mountain mule deer (*O. hemionus hemionus*) is the subspecies found in the northern twothirds of the state, while the desert mule deer (*O. hemionus eremicus*) occupies the southern third (Bender, 2020) (Figure 2-18).

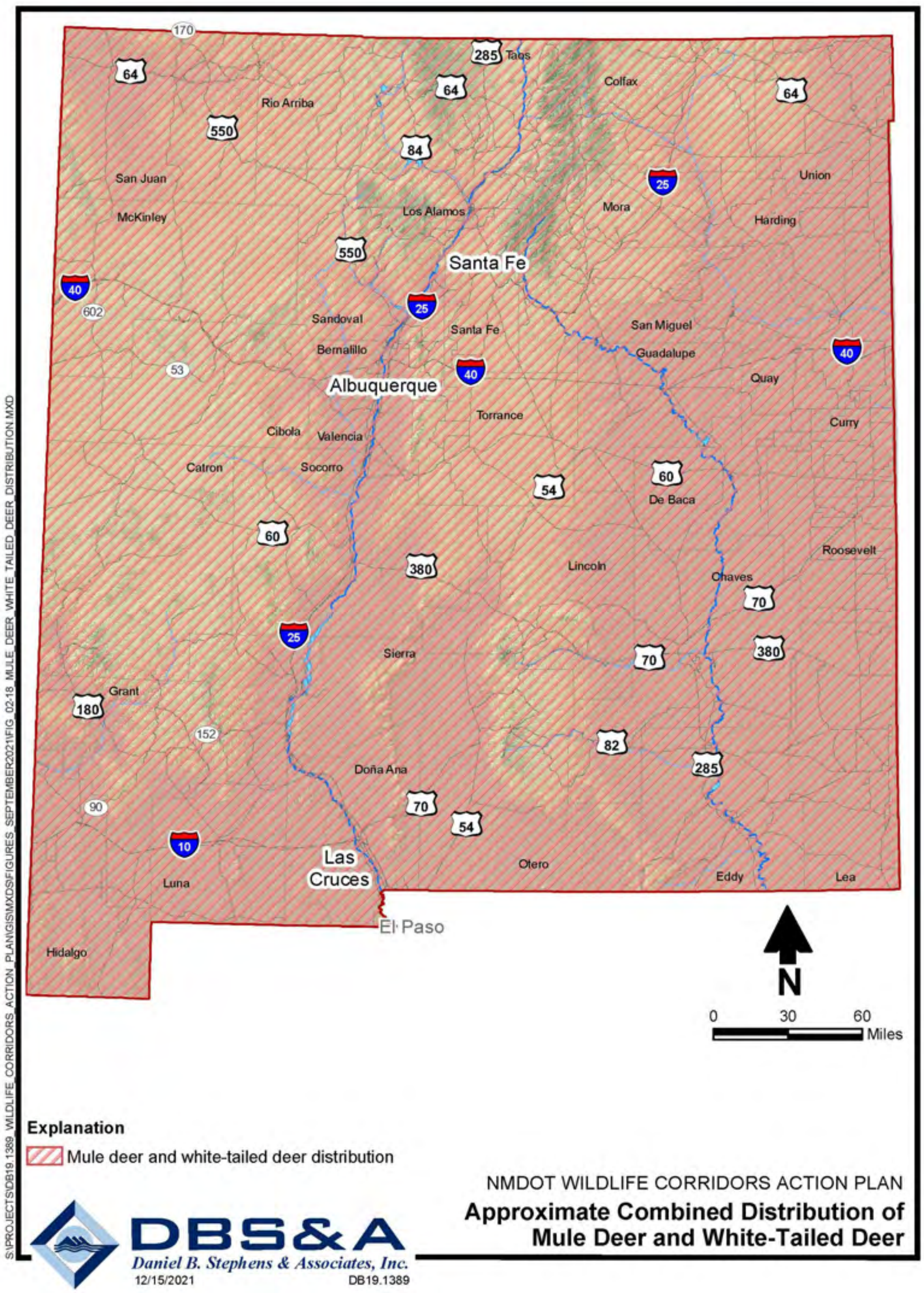

Figure 2-18. Approximate combined distribution of the mule deer and white-tailed deer in New Mexico.

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Rocky Mountain mule deer occur along a broad elevational gradient, with seasonal movements for those populations spending the growing season near or above the timberline. For example, some Rocky Mountain mule deer have their winter range near and around Heron and El Vado Reservoirs in north-central New Mexico, and they cross US 64/84 south of Chama to higher-elevation fawning habitat in the Tusas/South San Juan Mountains (NMDGF, unpublished data). Desert mule deer are found in desert mountain ranges and foothills, or along arroyos in arid desert flats. Unlike Rocky Mountain mule deer, they typically remain in the same general area throughout the year (Bender, 2020). The mule deer is only one of two deer species found in New Mexico.

White-tailed deer (*Odocoileus virginianus*)—both Coues (*O. v. couesi*) and Texas (*O. v. texanus*)—number approximately 10,000 to 15,000 in the state. Coues white-tailed deer occur primarily in the southwestern portion of New Mexico (NMDGF, 1993). Texas white-tailed deer is known to occur in scattered locations throughout New Mexico's eastern plains and the Llano Estacado, especially in the sandhills region of Chaves, Lea, and Roosevelt Counties, and in the Sangre de Cristo and Sacramento Mountains (Frey, 2004).

2.1.18.2 Habitat Associations

Rocky Mountain mule deer are found from low-elevation shortgrass prairie through pinyon-juniper woodland and montane forests to subalpine meadows, and may also occur in urban areas. Desert mule deer prefer shrublands and woodlands (Cook, 1986). Mule deer habitat requirements generally include an abundance of herbaceous forage in association with vegetative and other hiding and thermal cover, in addition to access to sources of water. Mule deer are limited in their ability to digest fibrous roughage, and instead require soft, high-protein, easily digestible forage, such as mast, leaves, forbs and grasses, and the stems of trees and shrubs, in addition to succulents in arid regions. Much of that forage is seasonal and vulnerable to drought (Bender, 2020).

In comparison with mule deer, white-tailed deer are less tolerant of xeric conditions (e.g., Cook, 1986). In the southwestern U.S., they are largely restricted to areas receiving more than 10 inches (25 centimeters [cm]) of annual precipitation; their numbers are highest where annual precipitation reaches about 16 inches (40 cm) (Smith, 1991). Irrigation helped Texas white-tailed deer expand their range in western Texas and beyond (Smith, 1991). Riparian deciduous forests and Madrean woodlands constitute key Coues white-tailed deer habitat islands in an otherwise unsuitable landscape; riparian areas further serve as dispersal corridors between habitat patches (Smith, 1982; Evans, 1984). Some habitat segregation has been observed in Hidalgo County between white-tailed and mule deer (Findley et al., 1975). Whereas white-tailed deer inhabit the oak woodlands and upper slopes of the Animas Mountains, mule deer typically occur in lower, more arid habitats (Findley et al., 1975).

2.1.18.3 Impacts of Roads and Road Traffic

In New Mexico, a total of 11,404 wildlife-vehicle collisions involving mule and/or white-tailed deer were recorded from 2002 to 2018, 7,109 of which occurred from 2009 to 2018 (NMDOT, unpublished data). Rocky Mountain mule deer seem especially vulnerable on their winter ranges, when herds are usually most compressed in limited areas and have exposure to vehicle-collision mortality, and during spring and fall seasonal movements across road corridors. High deer mortality from collisions with road traffic has been recorded in particular (1) along NM 516 from Farmington northeast to Aztec and along US 550 from Aztec north to the Colorado border, (2) from Raton north to the Colorado border along I-25, (3) along US 180 and NM 90 in and around Silver City, (4) along US 285 north of Carlsbad, and (5) along NM 48 in the vicinity of Ruidoso in the Sacramento Mountains. Both overpasses and underpasses of various sizes appear to work well to get mule deer safely across roads; however, shorter and wider underpasses are preferred by mule deer (Cramer et al., 2013; Sawyer et al., 2016; Simpson et al., 2016). In Arizona, the Coues subspecies was not affected by traffic while using underpasses (Dodd and Gagnon, 2011).

2.1.18.4 Legal Status/Species Designations and Relevant Conservation Initiatives

Mule deer and white-tailed deer are both listed as game animals in New Mexico.

2.1.19 Elk (*Cervus canadensis*)

2.1.19.1 Distribution and Abundance in New Mexico

The elk, or wapiti, population in New Mexico is estimated at 90,000 to 100,000 animals (NMDGF, unpublished data), although this is a rough estimate, as NMDGF quantifies elk populations by regional herds and not statewide (N. Tatman, personal communication). Throughout much of New Mexico, elk populations are stable or increasing slightly (NMDGF, 2021b). Historically, elk (specific nomenclature changed from *C. elaphus* to *C. canadensis*) inhabited all major mountain ranges in New Mexico, with Rocky Mountain elk (*C. c. nelsoni*) occurring in the northern mountains and Merriam's elk (*Cervus canadensis merriami*) occurring in the southern mountains of New Mexico (Findley et al., 1975; Findley, 1987) (Figure 2-19). Originally, Merriam's elk was considered to be a separate species, but it is now extinct. Although it is now impossible to determine the systematic status of Merriam's elk, it seems highly unlikely that it was more than a

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geographic race of "*C. elaphus*" (Findley et al., 1975; Findley, 1987). Both subspecies of elk were extirpated in the state by the early 1900s (Findley et al., 1975; Findley, 1987). In 1910, a privately sponsored reintroduction project was completed that transplanted 15 elk from Yellowstone National Park to northeastern New Mexico. In 1911, 12 animals from Routt County, Colorado were released near Raton and Las Vegas, and 50 animals from Yellowstone National Park were released in San Miguel County. During the next 50 years, NMDGF conducted approximately 45 elk transplants involving more than 1,000 elk. As a result of these efforts, Rocky Mountain elk have been successfully restored to all historical ranges in the state (NMDGF, undated fact sheet).

2.1.19.2 Habitat Associations

Elk are considered habitat generalists (Peek, 2003). During the summer, elk occupy mountain coniferous forests and meadows, and in winter they move to lower-elevation pinon-juniper woodland, mixed conifer forest, or plains grassland (Hoffmeister, 1986). Habitat selection by elk is driven by forage plant density and distribution, distance to roads, and cover. Elk prefer areas near the grassland/forest edge, and commonly choose areas with little human disturbance, regardless of the availability of water (NMDGF, undated fact sheet). Studies conducted at the Starkey Experimental Forest and Range for the Starkey Project at the Pacific Northwest Research Station have shown that elk avoid heavily trafficked roads. Road avoidance by elk increases as traffic rates and noise increase (Ager et al., 2005).

2.1.19.3 Impacts of Roads and Road Traffic

From 2002 to 2018, 3,041 elk were reported killed from collisions with vehicles in New Mexico (NMDOT, unpublished data). Highway segments where elk-vehicle collisions were notably high include (1) NM 48 and County Road 532 (CR 532) near Alto (119 collisions), (2) NM 48 near Ruidoso (95 collisions), (3) US 82 east of Cloudcroft (86 collisions), (4) US 70 at Bent (70 collisions), and (5) US 82 west of Cloudcroft (40 collisions).

2.1.19.4 Legal Status/Species Designations and Relevant Conservation Initiatives

Elk are protected as game animals in New Mexico.

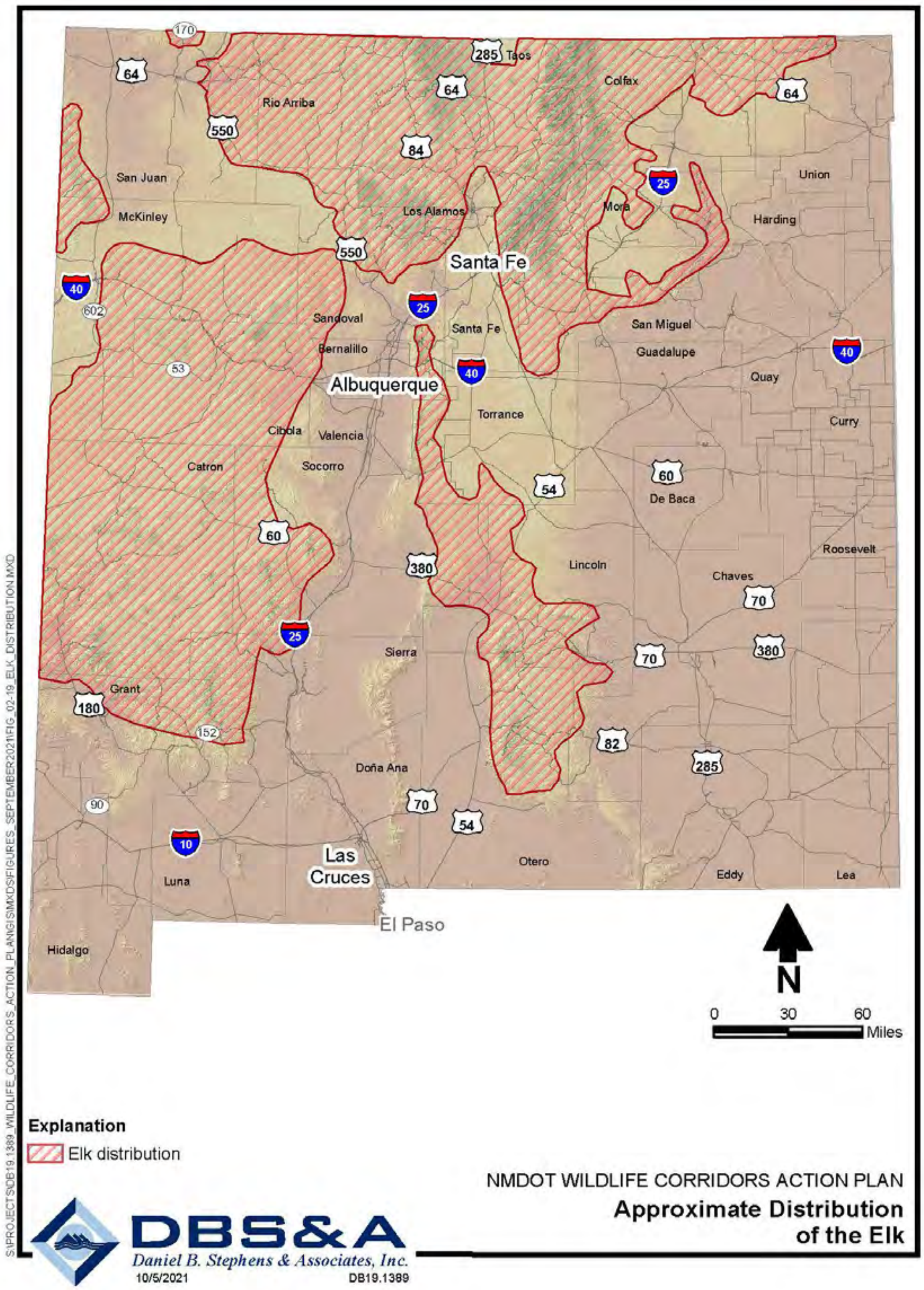

Figure 2-19. Approximate distribution of elk in New Mexico.

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2.2 Documented Use of Road-Crossing Structures

A number of published studies have evaluated wildlife use of overpasses and underpasses (e.g., box culverts, span bridges) to cross roadways (e.g., Cramer 2012 and 2014; Plumb et al., 2003; Ng et al., 2004; Dodd and Gagnon, 2011; Sawyer et al., 2012 and 2016). These and other studies reveal that elk, deer, pronghorn, and other species tend to prefer one type of road-crossing structure over another, often as a result of their habitat associations and life histories. Pronghorn and desert bighorn sheep, for example, are associated with open habitats, where their keen vision allows them to spot potential predators from far away. Although pronghorn and desert bighorn sheep occasionally use underpasses (Plumb et al., 2003; Sawyer et al., 2012; Bristow and Crabb, 2007), they show a strong preference for overpasses, where their vision is not impaired (Sawyer et al., 2016; Gagnon et al., 2017a).

Similar to pronghorn and desert bighorn sheep, elk also have a preference for structure type. Although elk will use an overpass, they do not require one to successfully cross roads, and will use underpasses. For crossing under roads, elk prefer large open bridges, void of ledges where predators can lurk, and they tend to avoid culverts (Dodd et al., 2007; Gagnon et al., 2007a, 2011, and 2015; Cramer, 2014).

Other research has documented the potential for traffic volume and/or traffic noise to reduce the effectiveness of wildlife road-crossing structures for elk; however, it appears that increasing traffic volumes do not tend to hinder elk use of underpasses. For example, at four underpasses along a 17-mile (27-km) stretch of SR 260 in Arizona, Gagnon et al. (2007a) found that elk passage rates were not lower in association with continuous high vehicle traffic. In contrast, elk that attempted to cross the highway at-grade along the same stretch of roadway were increasingly repelled as traffic volumes increased, reducing highway permeability (Gagnon et al., 2007b). These findings further point to the utility of properly designed wildlife crossings for elk, even in areas with high traffic volume, in helping reduce elk-vehicle collisions and maintaining habitat connectivity for this species.

Table 2-2 lists all of the species of concern identified for the Action Plan, and their potential to use different wildlife crossing structures based on past studies of the species or similar, closely related wildlife. The table also summarizes limiting factors for the species. References are limited to nearby states: Arizona, California, Colorado, Nevada, New Mexico, and Utah.

Table 2-2. Use of road-crossing structures by species of concern in the southwestern U.S. (Arizona, California, Colorado, Nevada, New Mexico, and Utah).

Species	States where Use of Overpasses has been Documented	States where Use of Underpasses has been Documented	Notes on Preferences and Limiting Factors	References
Ornate box turtle (*Terrapene ornata*)	Not documented	Not documented	No preferences or limiting factors documented.	
Gila monster (*Heloderma suspectum*)	Not documented	AZ	No preferences or limiting factors documented.	
Mexican gartersnake (*Thamnophis eques*)	Not documented	NA	No preferences or limiting factors documented.	
Western massasauga (*Sistrurus tergeminus*)	Not documented	Not documented	No preferences or limiting factors documented.	
White-sided jackrabbit (*Lepus callotis*)	Not documented, but use of overpasses by black-tailed jackrabbits has been documented in AZ; use of overpasses by jackrabbits in CO.	Not documented, but use of underpasses by black-tailed jackrabbits has been documented in AZ; use of underpasses by jackrabbits also documented in CO and UT.	Black-tailed jackrabbits documented in AZ and NM may be considered surrogates. No known limiting factors for these two species. Jackrabbits also known to use crossing structures in CO and UT.	Black-tailed jackrabbits in AZ: Gagnon et al., 2020a and 2020b; Grandmaison et al., 2012 Jackrabbits in UT: Cramer and Hamlin, 2019a, 2019b, and 2021 Jackrabbits in CO: Cramer and Hamlin, 2021; Kintsch et al., 2021

Table 2-2 (cont.)

Species	States where Use of Overpasses has been Documented	States where Use of Underpasses has been Documented	Notes on Preferences and Limiting Factors	References
White-tailed jackrabbit (*Lepus townsendii*)	Not documented, but use of overpasses by black-tailed jackrabbits has been documented in AZ; use of overpasses by jackrabbits in CO.	Not documented, but use of underpasses by black-tailed jackrabbits has been documented in AZ; use of underpasses by jackrabbits also documented in CO and UT.	Black-tailed jackrabbits documented in AZ and NM may be considered surrogates. No known limiting factors for these two species. Jackrabbits also known to use crossing structures in CO and UT. Photos of jackrabbits under US 160 near Durango.	Black-tailed jackrabbits in AZ: Gagnon et al., 2020a and 2020b; Grandmaison et al., 2012 Jackrabbits in UT: Cramer and Hamlin, 2019a, 2019b, and 2021 Jackrabbits in CO: Cramer and Hamlin, 2021; Kintsch et al., 2021
Cougar (*Puma concolor*)	CO	AZ, CO, MT, NM, and UT	Important use of underpasses in CO and UT. Seven successful passages over overpass in CO. Larger underpasses seem to be used more frequently than smaller ones. Adaptable species.	AZ: Gagnon et al., 2011 and 2015 CO: Kintsch et al., 2021 UT: Cramer, 2012 and 2014 NM: Loberger et al., 2021 CA: Beier, 1993 and 1995
Kit fox (*Vulpes macrotis*)	AZ	AZ	No preferences or limiting factors documented.	AZ: Gagnon et al., 2017a, 2020a CA: Cypher et al., 2009
Swift fox (*Vulpes velox*)	Not documented	Not documented. In eastern New Mexico, anecdotal reports of the species using small culverts as den sites.	Not documented.	
Red fox (*Vulpes vulpes*)	CO	CO, MT, NM, and UT	Use of overpass in CO documented over 150 times. Use of culverts and under bridges documented in multiple western state studies.	CO: Kintsch et al., 2021; Cramer and Hamlin, 2021 NM: Loberger et al., 2021 UT: Cramer, 2012 and 2014; Cramer and Hamlin, 2019a and 2019b

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Table 2-2 (cont.)

Species	States where Use of Overpasses has been Documented	States where Use of Underpasses has been Documented	Notes on Preferences and Limiting Factors	References
Black bear (*Ursus americanus*)	CO	AZ, CO, MT, NM, and WA	Black bears appear to prefer underpasses either due to cover needs or propensity for underpasses to occur in riparian areas and/or along drainages. Cover likely a factor. In CO, black bears used overpasses 7 times.	AZ: Gagnon et al., 2011 and 2015 CO: Kintsch et al., 2021 NM: Loberger et al., 2020 UT: Cramer, 2014; Cramer and Hamlin, 2019a
American badger (*Taxidea taxus*)	CO	AZ, CO, and UT	Tends to prefer culverts (reflecting its semi-fossorial life).	CO: Kintsch et al., 2021 AZ: Gagnon et al., 2020a and 2020b UT: Cramer, 2012 and 2014
Hog-nosed skunk (*Conepatus leuconotus*)	Not documented	AZ Striped skunks, which use culverts in AZ, CO, NM, and UT, may be considered surrogates for hog-nosed skunks.	Hog-nosed skunk use of culverts in AZ. Striped skunk use of culverts in AZ, CO, NM, and UT may be considered a surrogate for hog-nosed skunk.	Hog-nosed AZ: Grandmaison et al., 2012 Striped AZ: Gagnon et al., 2011, 2015, 2020a, and 2020b CO: Kintsch et al., 2021; Cramer and Hamlin, 2021 NM: Loberger et al., 2021 UT: Cramer, 2012 and 2014; Cramer and Hamlin, 2019 and 2020
White-nosed coati (*Nasua narica*)	Not documented	AZ	No preferences or limiting factors documented.	AZ: Gagnon et al., 2020b
Collared peccary (*Tayassu tajacu*)	AZ	AZ	Based on a study of adjacent underpass and overpass along SR 77 in AZ, collared peccaries appear to prefer underpasses, likely due to greater cover.	AZ: Gagnon et al., 2011, 2015, 2020a, and 2020b; Grandmaison et al., 2012

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Table 2-2 (cont.)

Species	States where Use of Overpasses has been Documented	States where Use of Underpasses has been Documented	Notes on Preferences and Limiting Factors	References
Pronghorn (*Antilocapra americana*)	CO and NV	CO	Evidence of preference for overpasses in Wyoming for American pronghorn. CO study showed some bucks using underpass, and does and bucks using overpass. Pronghorn also documented using overpass in NV. Anecdotal evidence of Sonoran pronghorn crossing under I-8 in AZ, probably at an underpass/bridge but not enough data to verify or recommend underpasses as useful. Overpasses are likely the only real option to move this species in herds rather than singular animals.	AZ: AZGFD, unpublished data WY: Sawyer et al., 2016 NV: Simpson et al., 2016 CO: Kintsch et al., 2021
Bighorn sheep (*Ovis canadensis*)	AZ and CO	AZ and CO	Much higher preference for overpasses unless underpasses are extremely large viaduct/bridges. Some use of culverts/small underpasses, but minimal in relation to overpasses. In CO in particular, evidence of bighorn use of underpass and overpass, with a clear preference for overpass. In NM, Rocky Mountain bighorn sheep used railroad trestles to cross under a major railroad.	AZ: Bristow and Crabb, 2008; Gagnon et al., 2017a and 2017b CO: Kintsch et al., 2021 NV: Gagnon et al., 2021 NM: NMDGF, unpublished data

Table 2-2 (cont.)

Species	States where Use of Overpasses has been Documented	States where Use of Underpasses has been Documented	Notes on Preferences and Limiting Factors	References
Mule deer (*Odocoileus hemionus*)	AZ, CO, NV, and UT (every southwestern state with overpasses for wildlife)	AZ, CA, CO NM, NV, and UT.	Underpasses work but overpasses appear to be preferred based on a few studies in AZ, NV, and especially CO. A WY study showed the opposite, but recent research in CO documented 112,000 successful passages using 2 overpasses and 5 underpasses, with a preference for overpasses. If underpasses are used, the length the animal traverses below the highway is more important than height, length should not exceed 140 feet where possible, and potential for successful passage diminishes greatly when length is 200 feet or more.	AZ: Gagnon et al., 2011 and 2015 NM: Gagnon et al., 2020a and 2020b CO: Cramer and Hamlin, 2021; Kintsch et al., 2021 UT: Cramer 2012 and 2014; Cramer and Hamlin, 2019a and 2019b NV: Simpson et al., 2016 CA: Ng et al., 2004

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Table 2-2 (cont.)

Species	States where Use of Overpasses has been Documented	States where Use of Underpasses has been Documented	Notes on Preferences and Limiting Factors	References
Elk (*Cervus canadensis*)	CO and UT	AZ, CO, NM, and UT. In NM,	Some studies indicate preference for overpasses. If underpasses are used, they must be quite large and natural in appearance. Evidence of elk using underpasses and overpasses in CO in particular (about 300 successful passages on overpasses documented in CO); some underpass use and definite overpass use in UT (dozens of passages documented). In AZ, large open span bridges passed nearly 8,000 elk. All used underpass structures had dimensions of over 30 feet wide, which allows for escape from potential predators. Even larger more open structures like those in AZ that exceeded 100 feet wide at their widest point passed large herds of elk regularly.	AZ: Gagnon et al., 2011 and 2015 NM: Loberger et al., 2021 UT: Cramer, 2012 and 2014; Cramer and Hamlin, 2019a and 2019b CO: Kintsch et al., 2021

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Chapter 3. Public Outreach and Data Sharing Partnerships

Public involvement and data sharing partnerships have been essential components in the development of the Action Plan. As part of the commitment to involve the public early in the Action Plan development process, a Public Involvement Plan (PIP) was prepared for the project in late 2019 to early 2020 in collaboration with NMDOT and NMDGF. The PIP identified strategies to ensure meaningful public engagement in the development of the Action Plan and to build public trust and support through transparency and dialogue. An important initial step identified in the PIP was to hold eight public outreach meetings across New Mexico. These meetings were planned to allow the NMDOT and NMDGF to present the concept of the Action Plan to stakeholders and the public, answer questions regarding project goals and the development process, and document any information that the public may have regarding wildlife-vehicle collision (WVC) problem areas. As part of the public involvement process, stakeholders will again be notified and a second round of public meetings will be held in conjunction with the release of the draft Action Plan.

3.1 Initial Public Involvement

In accordance with the PIP, a list of stakeholders was developed with input from agencies and non-government organization (NGOs), and planning began for a series of public meetings to be held around the state to gain input on the Action Plan.

3.1.1 Stakeholder Outreach

Between February 12 and 21, 2020, stakeholders received an e-mail or hard copy letter informing them of the start of the Action Plan development process. The stakeholder letter included an attachment listing eight planned public meetings to be held across New Mexico, along with information on event locations, dates, and times. The attachment also provided instructions for members of the public on how to provide written comments. The notice was sent in particular to all of New Mexico's National Forest district rangers for U.S. Forest Service (USFS) participation in the development of the Action Plan. Other federal stakeholders included the U.S. Fish and Wildlife Service (USFWS), the National Park Service (NPS), BLM, and all military installations. NMDOT's Environmental Bureau forwarded the letter and attachment to Tribal representatives across New Mexico.

Appendix B provides the PIP developed early in the Action Plan development process, the official letter sent to stakeholders, and the attachment to the letter detailing the meeting schedule.

3.1.2 Tribal Outreach

Tribal outreach was performed by NMDOT's Environmental Bureau. Tribes were invited to an Action Plan interest meeting, which the Pueblo of Santa Ana offered to host. However, due to the developing pandemic, the meeting had to be cancelled. A separate meeting with Kyle Tator (Jicarilla Apache Nation) was similarly cancelled. Since then, however, and in spite of pandemic-related constraints, consultation proceeded with individual Tribal members and wildlife biologists to the extent possible throughout the Action Plan development. Every Tribe in New Mexico was approached individually through e-mails and phone calls in February, March, and April 2021, in an effort to identify the proper contacts and discuss shared interests and potential partnerships with respect to wildlife corridors. NMDOT also sent out a status update on the Action Plan with an updated list of preliminary, top WVC hotspots and wildlife corridors to all New Mexico Tribes between May 4 and 10, 2021. All Tribes were invited to participate in meetings with NMDOT and members of the team regarding the development of the Action Plan. Several responses were received and meetings and/or correspondence took place in some form with the Pueblos of Santa Ana, San Felipe, and Tesuque, Navajo Nation, Jicarilla Apache Nation, and Mescalero Apache Tribe.

3.1.3 Initial Public Meetings

In addition to the stakeholder notifications and Tribal outreach, public meeting notices were advertised through various methods, including postings on agency websites and social media sites, radio advertisements, and a guest column published in the *Albuquerque Journal* (see Appendix B for a detailed description of notification methods).

As part of the agenda for the public meetings, a Microsoft PowerPoint presentation was prepared to introduce the Action Plan. The presentation included (1) a history of past efforts to identify, prioritize, and mitigate WVC problem areas in the state, (2) a short description of the proposed science to develop the Action Plan, and (3) a description of the purpose and goals of the Action Plan. Following the presentation, the meeting was opened up for questions and comments by meeting attendees.

After the question/comment period, the meetings were shifted to allow the public to review 22-inch by 34-inch, 1:633,600 statewide and regional maps showing WVC data (e.g., Figure 3-1). The maps were useful for the attendees to initiate one-on-one discussions with NMDGF and/or NMDOT representatives, ask questions, and provide annotations regarding areas of concern to them.

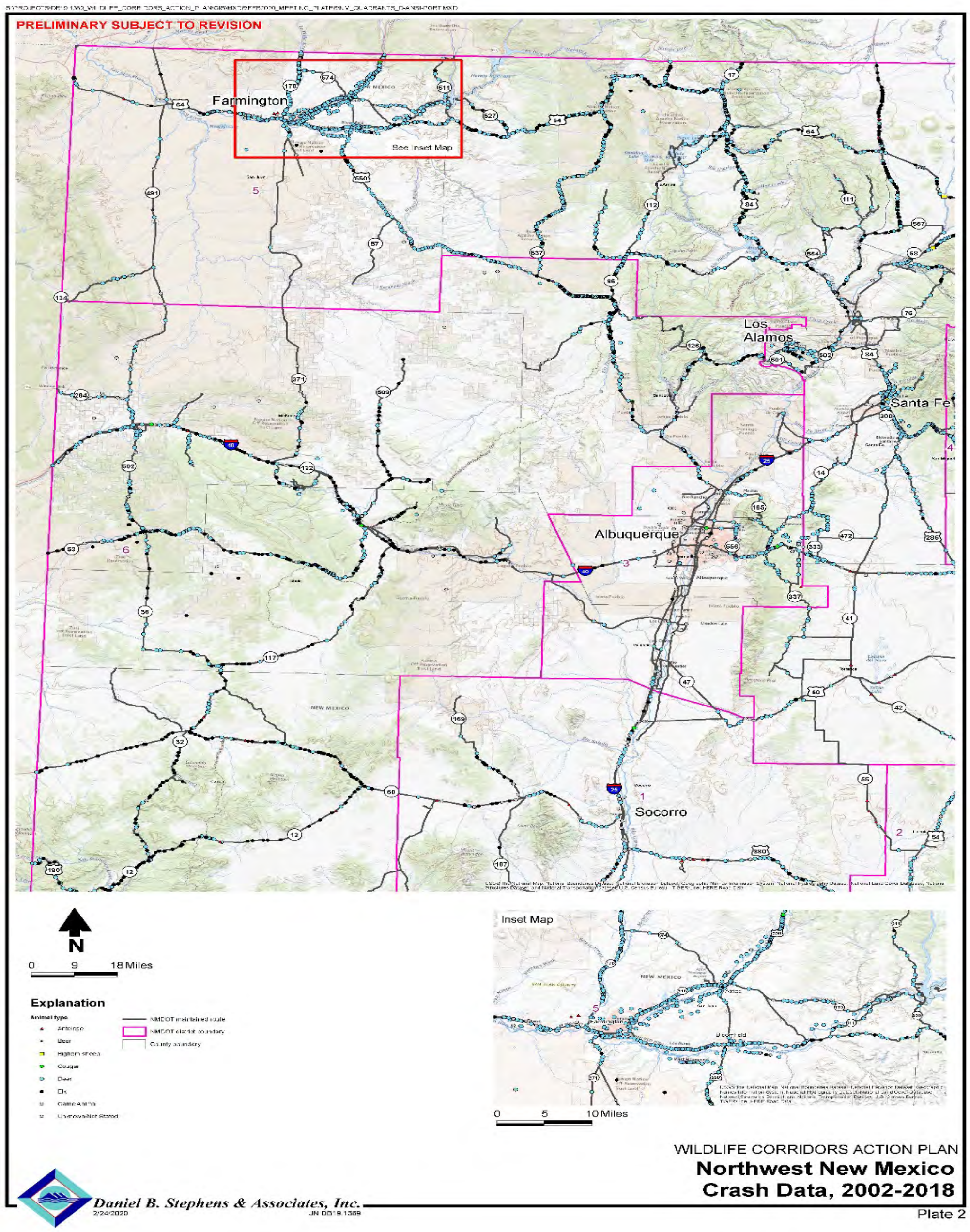

Figure 3-1. Map showing WVC data for northwestern New Mexico displayed at the public meeting held in Farmington on March 5, 2020.

Public meetings took place in Raton (February 25, 2020), Albuquerque (February 27, 2020), Santa Fe (March 3, 2020) (Figure 3-2), Farmington (March 5, 2020), and Las Cruces (March 10, 2020). Due to the developing pandemic, the last three public meetings (Silver City, Roswell, and Taos)

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and a Tribal meeting scheduled for March 2020 were cancelled; however, the PowerPoint presentation was made available on NMDOT's projects website <https://wildlifeactionplan.nmdotprojects.org/>, and public comments continued to be collected after the meetings. The five meetings conducted to introduce the Action Plan to the public are listed in Table 3-1.

Figure 3-2. Santa Fe public meeting, March 3, 2020.

Table 3-1. Public meetings conducted prior to the pandemic to introduce the Wildlife Corridors Action Plan and solicit input from the public.

Location		Date	Time
Raton	NMDGF Office, 215 York Canyon Road	February 25, 2020	6:30-8:00 p.m.
Albuquerque	NMDGF Office, 7816 Alamo Road NW	February 27, 2020	6:30-8:00 p.m.
Santa Fe	Santa Fe Higher Education Center, 1950 Siringo Road	March 3, 2020	6:30-8:00 p.m.
Farmington	McGee Park, 41 County Road 5568, Multi-Purpose Building (located south of Sun Ray Park & Casino)	March 5, 2020	6:30-8:00 p.m.
Las Cruces	NMDGF Office, 2715 Northside Drive	March 10, 2020	6:30-8:00 p.m.

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A total of 84 individuals participated in the five public meetings, many of them representing stakeholder groups. Comments received through the end of April 2020 are included in Appendix B. E-mails could be sent to NMDOT at Wildlife.Corridors@state.nm.us.

NMDOT and NMDGF both continue to post updates about the Action Plan on their websites at https://wildlifeactionplan.nmdotprojects.org/ and https://www.wildlife.state.nm.us/home/public-comment/.

3.2 Data Sharing Partnerships

The Action Plan development team greatly benefitted from data sharing partnerships with the following:

- NMDGF
- Academic researchers (Travis Perry, Ph.D., professor of biology and principal investigator in a cougar study at Kirtland Air Force Base, and James W. Cain, III, Ph.D., Assistant Unit Leader of the U.S. Geological Survey [USGS] New Mexico Cooperative Fish and Wildlife Research Unit and Affiliate Associate Professor at New Mexico State University [NMSU])
- Several of New Mexico's Tribes (the Jicarilla-Apache Nation, Pueblo of Santa Ana, Pueblo of Tesuque, Pueblo of San Felipe, Navajo Nation, and Mescalero-Apache Tribe), in addition to the Southern Ute Tribe in southern Colorado

Pronghorn (*Antilocapra americana*), elk (*Cervus canadensis*), bighorn sheep (*Ovis canadensis*), and mule deer (*Odocoileus hemionus*) GPS movement data were provided by NMDGF (collars and deployment for pronghorn, elk and mule deer funded by Secretarial Order 3362). Dr. Perry provided telemetry data for cougar in central and southern New Mexico. Dr. Cain shared telemetry data for elk from the Gila Region and for cougar, (*Puma concolor*), black bear (*Ursus americanus*), elk, and mule deer from the Jemez Mountains. Hall Sawyer of West, Inc. provided mule deer movement data for northwestern New Mexico.

The Action Plan acknowledges in particular the important contributions of Tribal partners, who have spent many years identifying wildlife corridors between Tribal and other lands to help manage their deer and elk populations. Kyle Tator, wildlife biologist and biological supervisor for the Jicarilla Apache Nation, provided maps of mule deer and elk movements from years of GPS data, including important heat maps for areas west of Chama. Glenn Harper, the Pueblo of Santa Ana's Range and Wildlife Division Manager, shared many maps of mule deer, elk, black bear, pronghorn and cougar movements representing important information north and west of Albuquerque. Aran Johnson, wildlife biologist for the Southern Ute Tribe in southern Colorado, sent maps of mule deer and elk movements—primarily in Colorado, but also extending into northern New Mexico. Through Senior Environmental Technician Ryan Swazo-Hinds, the Pueblo of Tesuque's Department of Environment and Natural Resources shared mule deer photographs and maps and data on mule deer movements and carcasses. Wildlife movement information was provided by the Navajo Nation's Gloria Tom, Director of the Fish and Wildlife Department, and Jessica Fort, Big Game Biologist. Navajo Nation WVC data were sent by Norma Bowman, Deputy Division Director of Navajo Division of Transportation. Thora Padilla, Director of the Mescalero Apache Tribe's Department of Natural Resources, along with Chief Conservation Officer Tyner Cervantes of the Mescalero Conservation Law Enforcement, sent important crash data for the Sacramento Mountains south of Ruidoso along US 70.

A number of other Tribes expressed interest in the Wildlife Corridors Action Plan. Pinu'u Stout, Director of the Pueblo of San Felipe's Department of Natural Resources, stressed in communications with Dr. Cramer the importance of the Action Plan to the Pueblo. Ms. Stout indicated that the Pueblo of San Felipe would contribute to the best of its ability, but was impacted by the pandemic at the time. The San Felipe Pueblo also shared a map showing important locations for observed wildlife movement under I-25. The Pueblo of Santa Clara similarly expressed interest in the Action Plan and welcomed receiving updates, indicating that they would contribute if they could. In addition to providing crash data, the Mescalero Apache Tribe indicated very strong support for the Action Plan, and is interested in working with NMDOT to build a wildlife crossing overpass or underpass on Tribal land. The Jicarilla Apache Tribe also expressed interest in assisting with the Action Plan as it moves forward into the future.

3.3 Public Involvement for the Release of the Draft Wildlife Corridor Action Plan

The Wildlife Corridors Act of 2019 states that NMDOT and NMDGF shall prioritize projects within the wildlife corridors project list by assessing, among other criteria, "local community support for proposed wildlife corridors infrastructure" and "surrounding land-use and ownership, especially Tribal lands, and an evaluation of the need for conservation easements or other real estate instrument necessary to maintain the viability of a proposed wildlife corridor." This emphasis on developing the project list in concert with public and agency input and support has been very important to the development of the Action Plan, and is a critical component to the successful implementation of the Act.

The PIP stresses the importance of public involvement—not only in the initial Action Plan development, but throughout the implementation process. As indicated above, data have been collected from other agencies, academic institutions, Tribal entities, and NGOs to help maintain that priority, while presenting and evaluating top hotspots and wildlife corridors in the draft Action Plan. Outreach beyond the initial public meetings has continued through 2020 and into 2021, not only to assist in the data collection but also to evaluate the potential for mitigation in hotspots and wildlife corridors. Continued outreach is further described in the following subsections.

3.3.1 Stakeholders

The stakeholder list (Appendix B) was continuously updated through September 2021, and stakeholders have been notified of updates to the Action Plan development and all opportunities to provide input.

In addition to the initial public outreach meetings conducted early in the process, stakeholders have been contacted during the process with a milestone progress report on the Action Plan. In January 2021, the NMDOT provided updates to the New Mexico State Legislature's Senate Transportation Committee through a progress report, as stipulated in the Wildlife Corridors Act. NMDOT also sent out a status update on the Action Plan on March 18, 2021 to 118 stakeholders, including the initial public meeting attendees. This annual report was made available on the NMDOT website: https://wildlifeactionplan.nmdotprojects.org/. NMDOT also sent out a status update on the Action Plan with an updated list of preliminary, top WVC hotspots and wildlife corridors to all New Mexico Tribes between May 4 and 10, 2021.

Team member Mark Watson (NMDGF) prepared a slide show that was presented to the State Game Commission on May 21, 2021 to provide an update on the Action Plan development.

Meetings have also been conducted with NGOs, including Pathways: Wildlife Corridors of New Mexico, an all-volunteer nonprofit organization, which provided valuable input on the Action Plan priority area #6 Bernalillo-Santa Ana-Jemez Linkage (see Chapter 5) during a meeting with the Team on June 14, 2021.

3.3.2 Public Meetings for the Draft Action Plan

The objectives of public outreach as outlined in the PIP for the Action Plan are two-fold:

- Provide transparency during the Action Plan development through public meetings, publications, and discussions of the scientific process methods used to identify top WVC hotspots and priority wildlife corridors and to recommend actions to take to address these priority areas along roads.
- Provide opportunities for public input on areas of concern for WVCs and potential wildlife corridors, the findings of the Action Plan, and strategies and/or tools to implement solutions in the priority areas.

The public outreach conducted as of the date of this report has implemented these objectives throughout the Action Plan development process, from the beginning of the plan development to the release of the draft Action Plan. By conducting the initial meetings early, providing continuing access to the slide presentation online, allowing comments throughout the process, and providing updates to and meeting with agencies, Tribes, and other interested parties throughout the process, the team has made continued efforts to provide opportunities for input and ensure transparency.

As indicated in the PIP, the public will have an opportunity to review the draft Action Plan and provide comments through various means, including another series of public meetings. All resulting meaningful input will be incorporated into the final Action Plan. Stakeholders will be notified for review of the draft Action Plan from contact information maintained in the current stakeholders list. The majority of stakeholders will be contacted by e-mail. The public meeting notices will be included in the notification. All coordination with Tribal entities for notification of the release of the draft Action Plan will be conducted by NMDOT. Public comments throughout the development of the Action Plan were collated and are available upon request to NMDOT via the e-mail address wildlife.corridors@state.nm.us.

Chapter 4. Hotspot Analysis

For Task 2, the Action Plan development team secured, prepared, and analyzed crash reports, along with other data and georeferenced sources, to evaluate the scope and extent of wildlife-vehicle reported crashes in New Mexico. In this chapter, we report four of the main subtasks that were completed under Task 2: (1) preparation of crash and roads data, (2) overall crash data analysis, (3) mapping of crashes involving wildlife, and (4) WVC hotspot analysis.

For the Action Plan, the team used the the software ArcMap 10.6.1 by ESRI Inc. for all data manipulation and analysis. We relied on both the NMDOT-administered road geographical information system (GIS) layer and the Getis-Ord Gi* tool to model New Mexico wildlife-vehicle crash data from 2009-2018. Analyses were conducted using the Universal Transverse Mercator (UTM) projection, Zone 13N, North American Datum 1983 (meters). Area and magnitude calculations were conducted in meters and relayed as equivalent imperial measurement values. Common conversions reported here include 0.5 mile = 804.672 meters (m), 1 mile = 1,609 m, and 2 miles = 3,218 m.

The hotspot analysis was conducted using the following steps:

1. Obtain most recent NMDOT Roads georeferenced files and crash data.
2. Collapse multi-lane roads into a single line feature.
3. Buffer roads by 500 feet.
4. Determine the center line of the road polygons.
5. Develop 0.5-mile aggregated polygons for all NMDOT roads.
6. Apply the Optimized Hot Spot Analysis (OHSA) tool to the road and crash data.
7. Interpret output data at different confidence intervals.
8. Interpret output data at different scales.
9. Generate statewide and NMDOT districts top 20 WVC hotspot maps and tables.

4.1 Preparation of Crash and Roads Data

The initial steps in the analysis of WVCs involved cleaning and combining data sources and preparing the information to be included in the crash modeling steps described in the following subsections.

4.1.1 Crash Data Preparation

The main data source used for the hotspot analysis consisted of records of all vehicle crashes from NMDOT. These were complemented by NMDGF reports of wildlife-vehicle collisions involving bighorn sheep (*Ovis canadensis*), in addition to NMDGF black bear (*Ursus americanus*) and cougar (*Puma concolor*) carcass data.

NMDOT provided five shapefiles with crash data recorded in New Mexico over a 17-year period (2002-2018):

- AnimalCrashes2002_2013
- AnimalCrashes2014_2015
- AnimalCrashes2016
- AnimalCrashes2017
- AnimalCrashes2018

The shapefiles were similar in structure; however, they were not identical. There was not complete consistency between field names, and in some years, data fields were included that were not included in other years. The various tables were reviewed to find the most common field names throughout the entire dataset. All relevant data were then extracted for each of the following years by selecting the "Crash Analysis" field/column and selecting for all 25 animal types involved in the crash according to the reporting officer. The data tables were then appended into a single shapefile of 18,977 wildlife-vehicle crash records.

The "Crash Analysis" field of the databases had an animal type for "Sheep," which was used to identify the animals in 21 crash records; however, there was no distinction between domestic sheep (*Ovis aries*) and bighorn sheep (*O. canadensis*). Copies of police reports for most of these crashes were obtained from the NMDOT Traffic Safety Bureau. Reviewing these incident reports helped determine if a crash record involved domestic sheep or bighorn sheep. A separate table in Microsoft Word was provided by NMDGF with bighorn sheep collisions based on carcass records, titled "Road Strikes." This sheet did not include geographic coordinates. Many of the records included highway names and mile markers, while some others only included a description, such as "West of Wedding Cake Ranch of SH456." These 30 entries were reviewed and the locations were identified within the GIS. Upon review of the geographic location information, 20 of the original 30 records were added to the final crash dataset. Field names were matched where applicable; however, there were far fewer details in the bighorn sheep road strike data than in the NMDOT wildlife-vehicle crash datasets.

A quality assurance/quality control (QA/QC) review was performed to ensure that none of these bighorn sheep entries were already included in the NMDOT dataset. Locations and dates for each record were compared to the NMDOT dataset to ensure that there was no duplication; no duplication was discovered.

Black bear and cougar crash data were included in the original NMDOT Microsoft Excel spreadsheets. However, a separate Excel file titled "Corridors_Initiative_bear_and_cougar_mort_data.xlsz," with multiple worksheets detailing black bear and cougar carcasses and pelts, was provided by NMDGF. The entries were coded in four categories for cause of death: "Dep" for depredation, "Rd" for road kill (carcass), "Sp" for sport harvest, and "BHS" for bighorn sheep protection. The data were queried to eliminate all causes of death except "Rd" for the roadkill deaths. The cougar carcass and pelt data included usable data from 2004 through March 2019. The black bear carcass/pelt data included usable data from 2004 through 2018. Black bear data included data from 2000, 2001/2002, and 2002/2003. However, these records did not contain populated geographic coordinates. Similarly, the cougar data contained data for 2001/2002 and 2002/2003 without any geographic coordinates. These years for NMDGF black bear and cougar carcass and pelt data were not included in the final crash dataset. Three black bear records and three cougar records did not include a date. These records were included in the geodatabase; however, there is a null value associated with their date attribute.

The black bear and cougar data were divided into 38 separate worksheets. The worksheets were similar in structure; however, they were not identical. There was not complete consistency between field names, and in some years, data fields were included that were not included in other years. The various tables were reviewed to find the most common field names throughout the entire dataset. The data tables were then appended into a single table of 133 cougar records and 431 black bear records.

The additional bighorn sheep, black bear, and cougar data were then appended to the NMDOT Crash Data shapefile. The final crash geodatabase feature class contains 19,561 records for between 2002 and March 2019 (Table 4-1), and is titled "Animal_Crashes_2002_2018." Table 4-2 summarizes the crash data for the six focal species of concern.

Table 4-1. Animal types, species, and numbers of crashes in New Mexico crash reports, 2002–2019.

Wild Animals				Domestic Animals	
Animal	Total Crashes	Animal	Total Crashes	Animal	Total Crashes
Pronghorn	221	Deer	11,404	Cat	11
Badger	2	Eagle	1	Cow/cattle	1,101
Black bear	650	Elk	3,041	Dog	606
Bighorn sheep	17	Game animal	412	Domestic – cattle, horse, etc.	287
Bird	27	Hawk	1	Goat	13
Buzzard	2	Other animal	133	Horse	264
Cougar	154	Porcupine	7	Pig	31
Coyote	211	Skunk	4	Sheep	21
Crow	6	Unknown	924		

Table 4-2. Number of crashes for the six focal species of concern, 2002–2019.

Year	Number of Crashes Reported					
	Deer [a]	Elk	Pronghorn	Bighorn Sheep	Black Bear	Cougar
2002	568	181	13	—	29	1
2003	572	169	16	1	9	2
2004	555	186	6	—	17	2
2005	623	149	5	—	10	1
2006	668	139	16	—	20	3
2007	644	154	7	—	24	2
2008	665	140	20	—	33	7
2009	762	167	18	—	36	7
2010	606	183	11	—	30	8
2011	662	207	17	—	72	16
2012	494	145	10	—	65	12
2013	489	132	7	—	72	10
2014	597	164	8	3	49	14
2015	686	156	9	6	35	15
2016	842	245	19	3	19	19
2017	980	235	21	1	79	14
2018	991	289	18	3	51	20
2019	—	—	—	—	—	1
Total	11,404	3,041	221	17	650	154

[a] Both mule deer and white-tailed deer

4.1.2 Roads Data Layer

NMDOT provided the roads shapefile "RouteMiPost_MiPoint_Hybrid." Several steps needed to be taken to develop a single, interconnected "spider web," minimizing roads that are not connected to the other roads in the network. Many of the roads identified as "State Park" in the tabular data were independent road slivers, not connected to the other roads in the network (orphans) (Figure 4-1). The state park roads are identified with an "SP" in the "Route_ID" field of the shapefile. At the direction of NMDOT, these state park roads were removed. After discussions with NMDOT's GIS Section, an NMDOT maintained roads geodatabase was also provided for guidance.

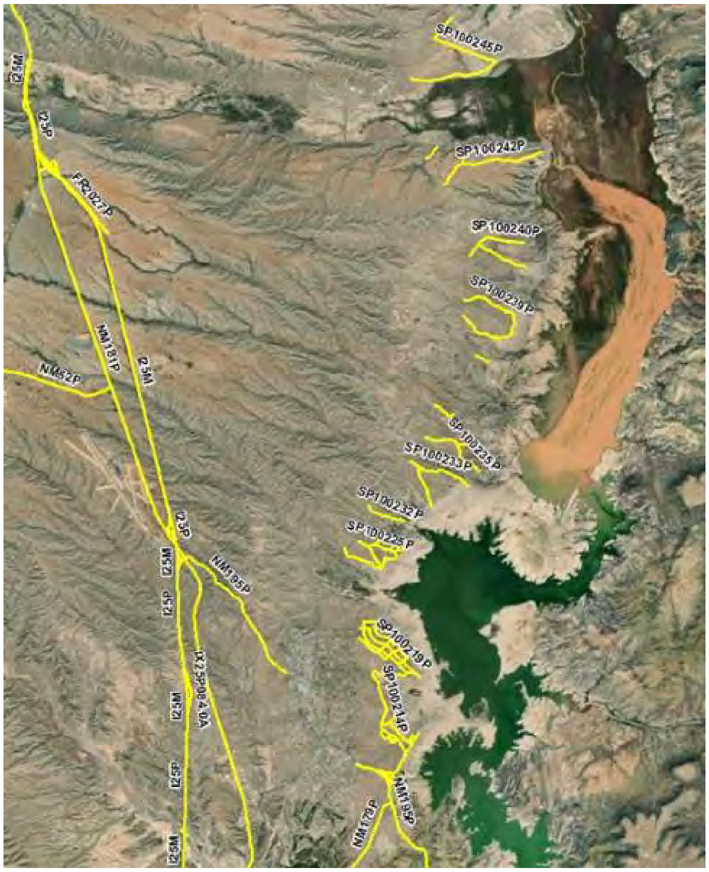

Figure 4-1. Example of orphan road segments: Elephant Butte Lake State Park.

A separate issue involved our proposed methodology for creating a single centerline for the divided highways. NMDOT requested that we not change the geometry of the highways so that they can more easily snap the road layers together in the future if necessary. The solution to this problem was to remove one of the directional lines on divided highways. NMDOT directed the Action Plan development team to use just the P sides of the roads as identified with a "P" in the "Route_ID" field of the shapefile. The "P" designates the positive side of a divided highway. The opposite sides of the divided highways, identified with an "M" in the "Field_ID" field of the shapefile, were removed. This process then created more road slivers that were not interconnected to the road network with many of the highway ramps and frontage roads. NMDOT instructed the Action Plan team to remove the highway ramps and frontage roads. Highway ramps are delineated with an X in the Route_ID and frontage roads are delineated with "e." This process did not alter the objective of our original plan, which was to merge roads that were located adjacent to each other.

After removal of the state park roads, negatively identified divided highway roads, frontage roads, and highway ramps, the resulting shapefile contained an interconnected road network that conforms to the original geometry of roads and maintains road name identifiers.

The example in Figure 4-2 shows negative parallel roads in green, frontage roads in yellow, and ramps in red; these were all removed from the final dataset. The remaining blue positive divided highway road lines were kept and used for the final dataset.

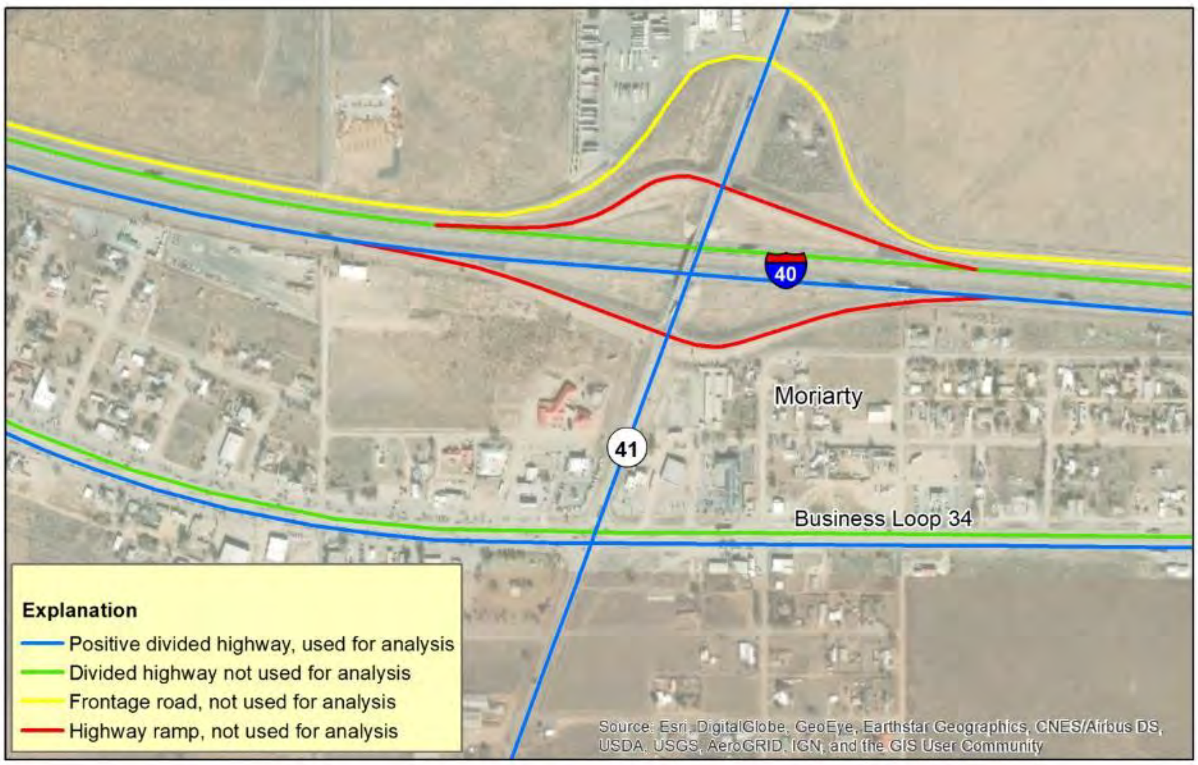

Figure 4-2. Example showing roads removed for analysis.

4.2 Mapping of Crashes by Wildlife Species

The shapefile for all past wildlife mitigation projects along NMDOT roads, "CollisionMitProjects," was delivered to our research and modeling team for inclusion in maps of crash locations for each species (Figure 4-3). Crash location points for the past five years (2014–2018) were mapped over NMDOT-administered roads for the six focal species of concern for this study: mule deer (*Odocoileus hemionus*) (Figure 4-4), elk (*Cervus canadensis*) (Figure 4-5), pronghorn (*Antilocapra americana*) (Figure 4-6), bighorn sheep (Figure 4-7), black bear (Figure 4-8), and cougar (Figure 4-9). White-tailed deer have been included with mule deer on Figure 4-4, as discussed in Chapter 2.

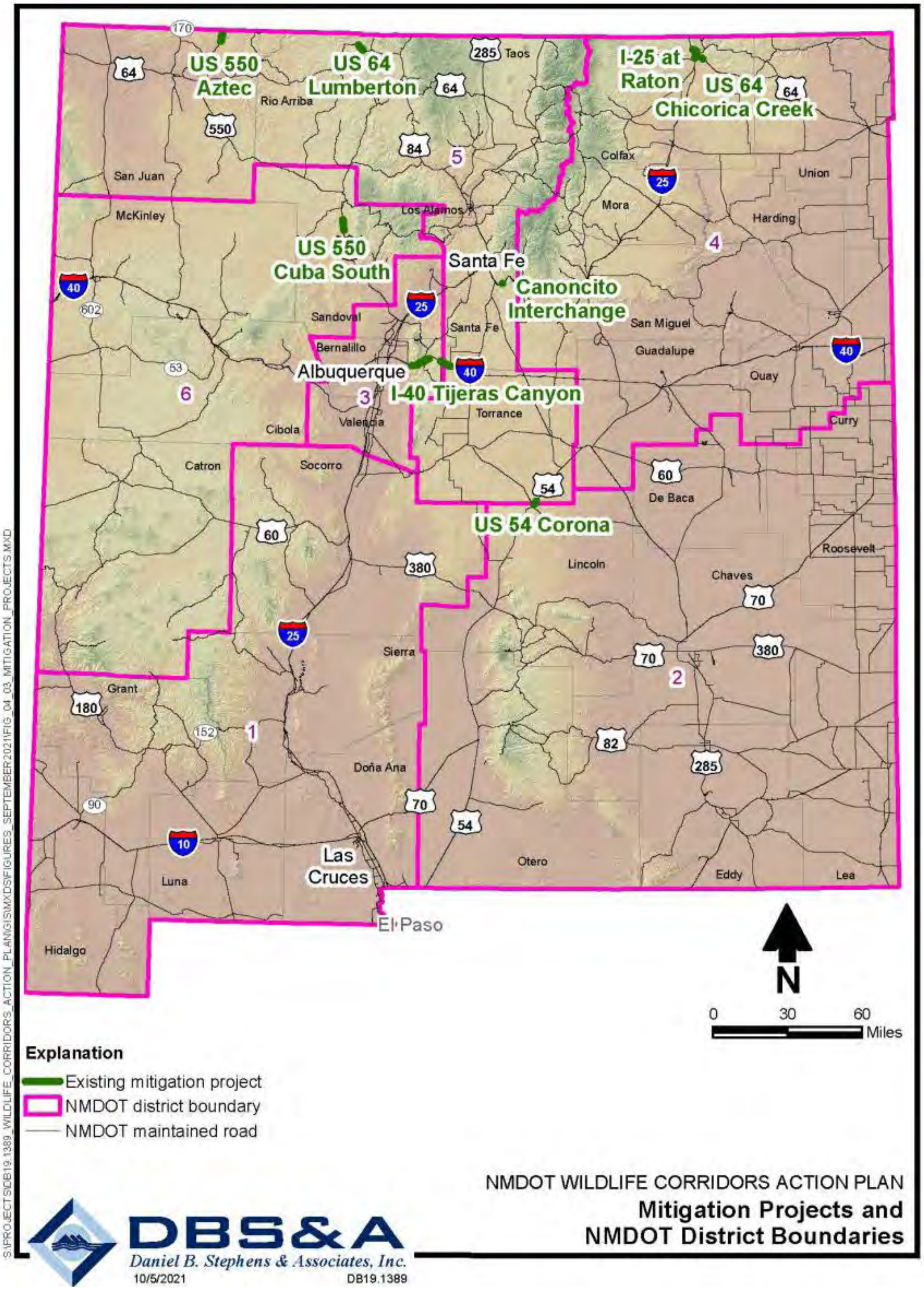

Figure 4-3. Statewide wildlife mitigation projects and NMDOT district boundaries.

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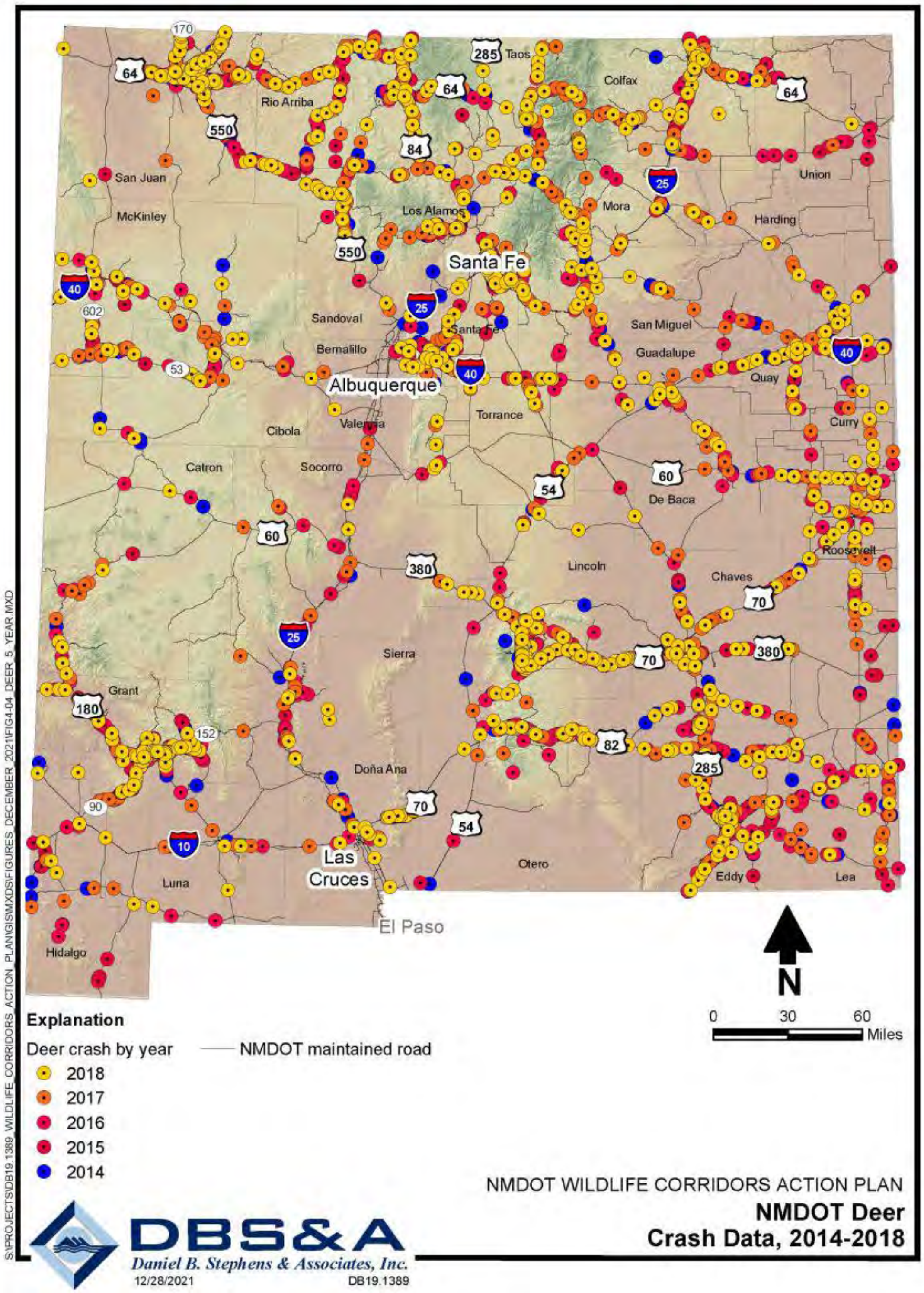

Figure 4-4. Reported crashes with mule deer and white-tailed deer, 2014–2018.

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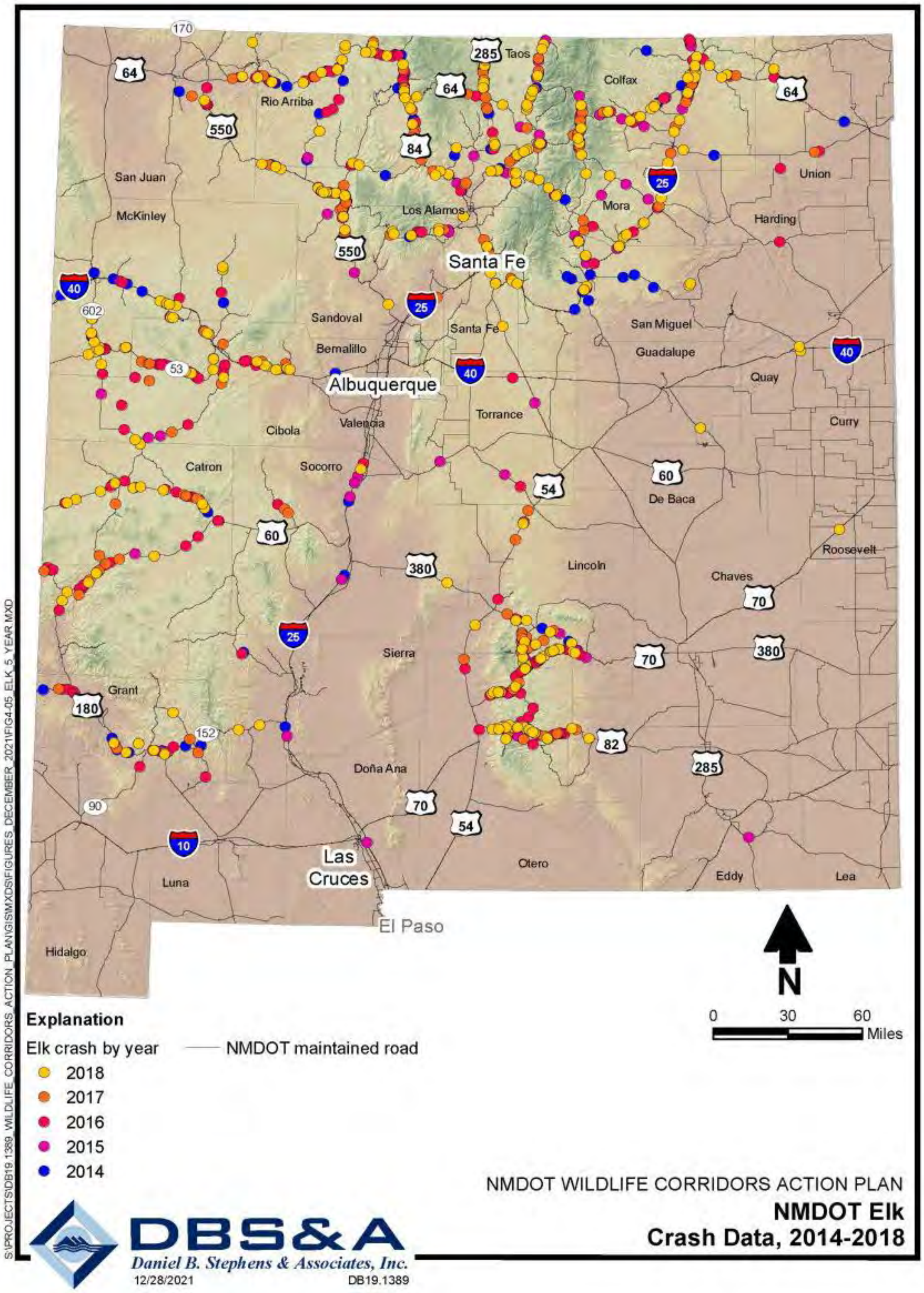

Figure 4-5. Reported crashes with elk, 2014–2018.

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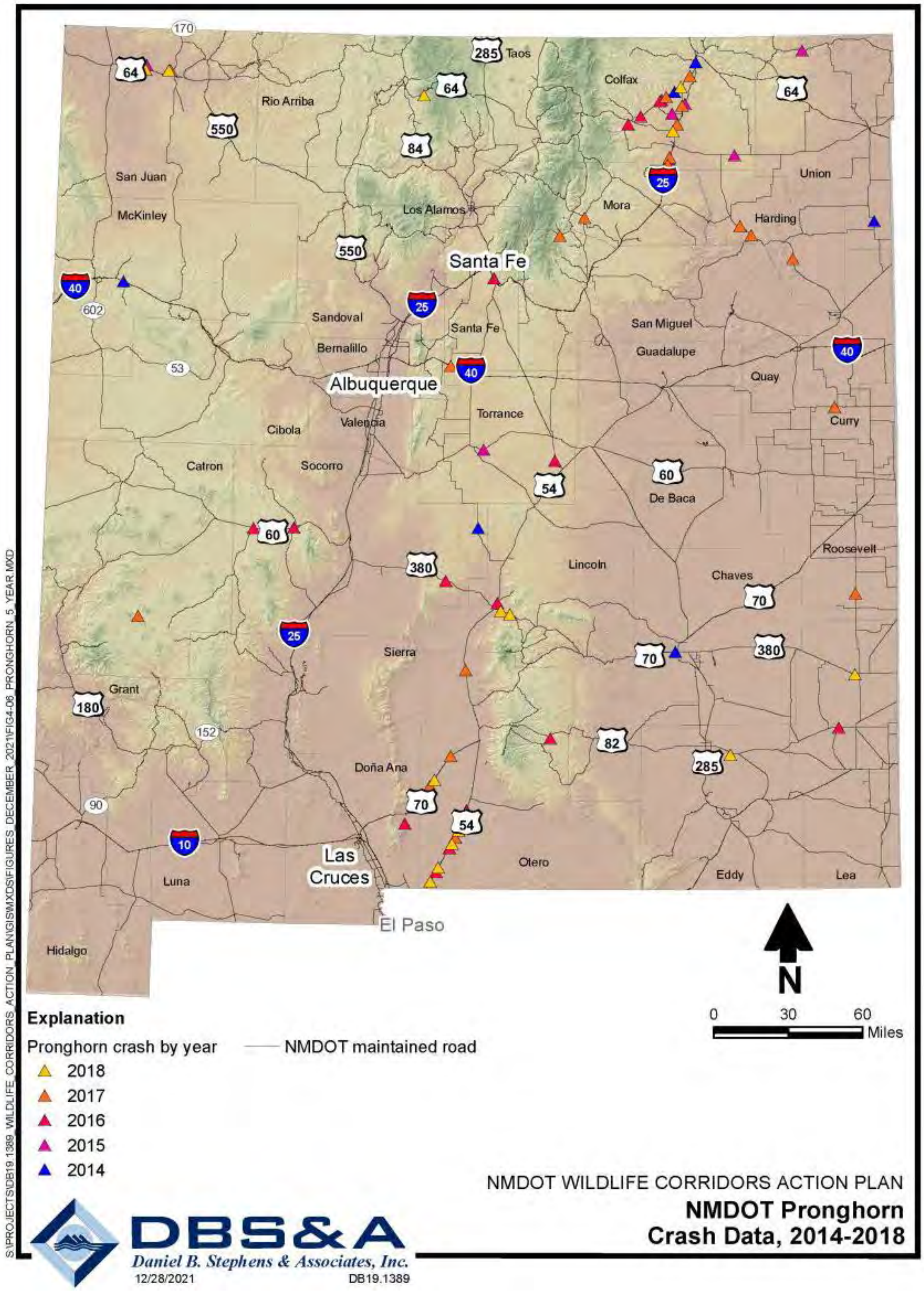

Figure 4-6. Reported crashes with pronghorn, 2014–2018.

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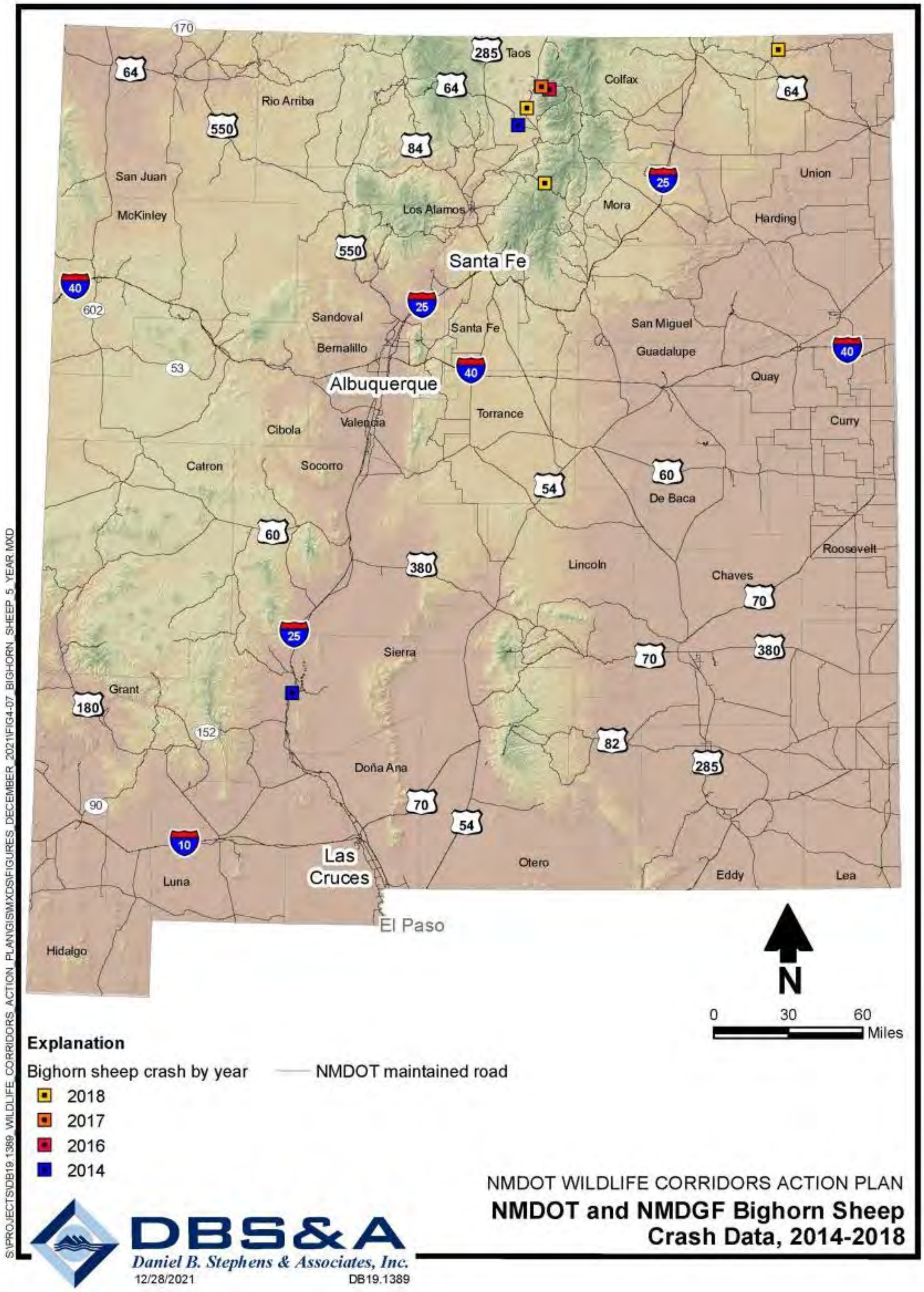

Figure 4-7. Reported crashes with bighorn sheep, 2014–2018.

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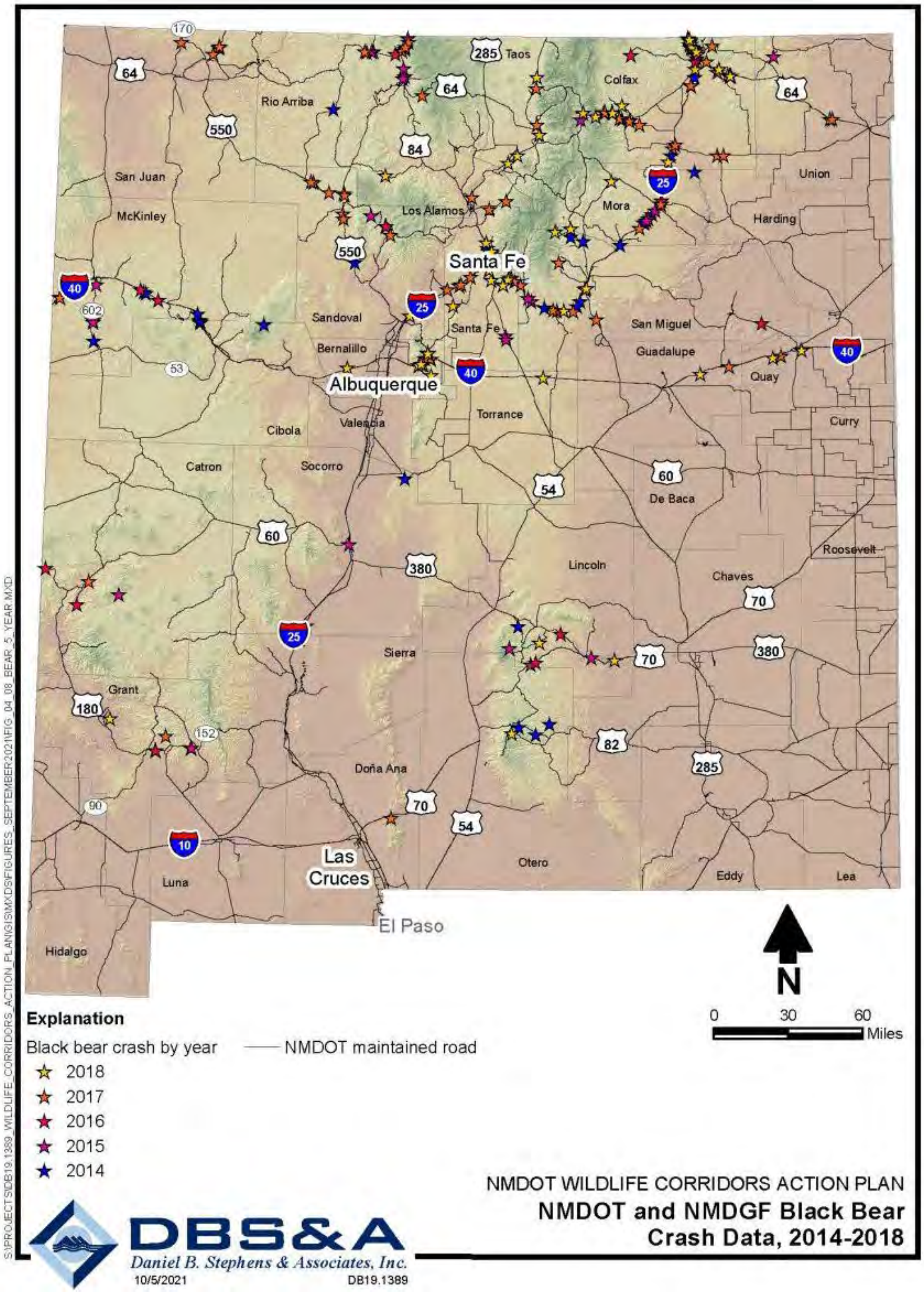

Figure 4-8. Reported crashes with black bear, 2014–2018.

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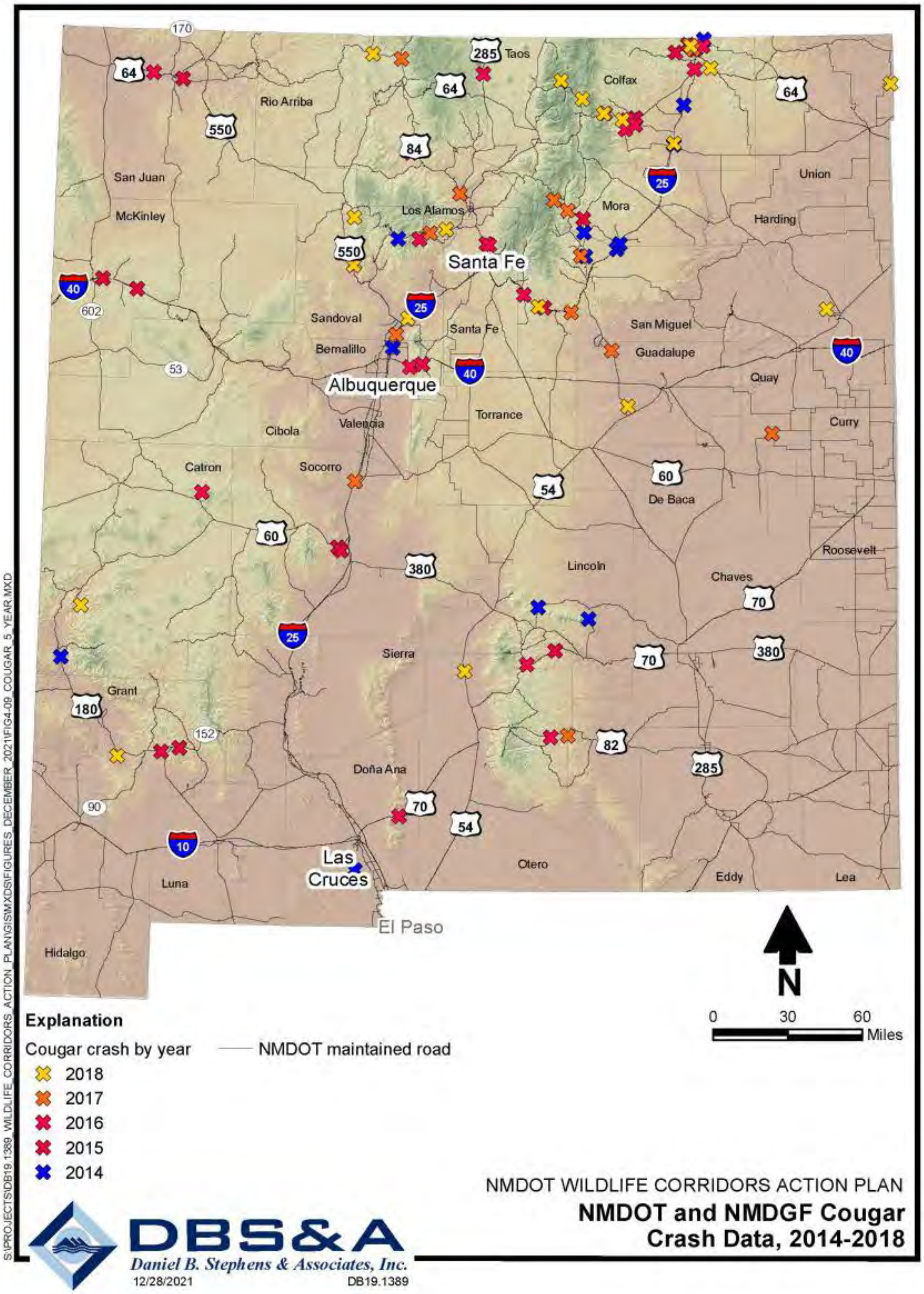

Figure 4-9. Reported crashes with cougar, 2014–2018.

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4.3 WVC Hotspot Analysis

Hotspot modeling using ArcGIS is a convenient, accurate, and statistically sound method to identify clusters of data points (Getis and Ord, 1992). Earlier DOT efforts to prioritize wildlife-vehicle conflict hotspots were based on analyzing raster data (Idaho: Cramer et al., 2014; South Dakota: Cramer et al., 2016). However, with the field of road ecology making substantial advances in recent years, the Hotspot Analysis tool using the ArcGIS Getis-Ord Gi* statistic has become the standard tool to evaluate and prioritize hotspots for linear infrastructures such as road networks (Kociolek et al., 2016; McClure and Ament, 2014; Shilling and Waetjent, 2015; Visinti et al., 2016). This method has been used in WVC hotspot analyses in Nevada (Cramer and McGinty, 2018), Utah (Cramer et al., 2019), and Arizona (Williams et al., 2021).

4.3.1 Methodology

The Getis-Ord GI* tool identifies statistically significant spatial clusters of high values (hotspots) and low values (cold spots). It creates a new output feature class with a z-score, p-value, and confidence level bin (Gi_Bin) for each feature in the input feature class. The z-scores and p-values are measures of statistical significance indicating, feature by feature, whether or not to reject the null hypothesis that the observed spatial clustering of high or low values is no more pronounced than one would expect in a random distribution of those same values. The z-score and p-value fields do not reflect any false discovery rate (FDR) correction. The Gi_Bin field identifies statistically significant hot and cold spots regardless of whether or not the FDR correction is applied:

- Features in the ±3 bins reflect statistical significance with a 99 percent confidence level.
- Features in the ±2 bins reflect a 95 percent confidence level.
- Features in the ±1 bins reflect a 90 percent confidence level.
- The clustering for features in bin 0 is not statistically significant.

Without FDR correction, statistical significance is based on the p-value and z-score fields. A high z-score (based on the randomization null hypothesis computation) and small p-value for a feature indicate a spatial clustering of high values. A low negative z-score and small p-value indicate a spatial clustering of low values. The higher (or lower) the z-score, the more intense the clustering. A z-score near zero indicates no apparent spatial clustering.

This hotspot analysis was conducted using the following steps:

1. Obtain most recent NMDOT Roads georeferenced files and crash data.
2. Collapse multi-lane roads into a single line feature.
3. Buffer roads by 500 feet.
4. Determine the center line of the road polygons.
5. Develop 0.5-mile aggregated polygons for all NMDOT roads.
6. Apply the OHSA tool to the road and crash data.
7. Interpret output data at different confidence intervals.
8. Interpret output data at different scales.
9. Generate statewide and NMDOT districts top 20 WVC hotspot maps and tables.

The Action Plan team conferred with agency team members on four variables of the WVC analysis: (1) the length of the road segment, (2) the width of the road segment, (3) search distance, and (4) years of crash data. The hotspots were ranked according to the number of crashes per mile over the time span modeled.

Road segment length was experimentally set at 0.25 mile and 0.50 mile. The team then decided to focus on 0.5-mile segments of road for the initial modeling iterations based on past work in Nevada (Cramer and McGinty, 2018) and Utah (Cramer et al., 2019). Road segment width was set at 400 m, or 200 m (656 feet, 0.12 mile) on either side of the road center line. This was the standardized width of segments from Python code developed in the Nevada project and used in the Nevada and Utah modeling of hotspots. Although the 200 m on either side allowed some segments of road to include nearby parallel roads, it was the best choice to allow for minimal loss of data. The issue was presented to the agency team members using I-40 and SR 333 as an example of closely parallel roads in Tijeras Canyon separating the Sandia Mountains from the Manzano Mountains east of Albuquerque. The agency team members concurred that (1) selecting road segments narrower than 200 m on either side presents its own issue in terms of data loss and (2) model results reflect ecological phenomena at the road(s) interface, and not necessarily reported WVC hotspots specific to one of several closely parallel roads.

The team modeled hotspots with search distances of 0.5 mile, 1 mile, and 5 miles. The use of a 5-mile search distance was quickly eliminated because it picked up crashes up to 5 miles from a segment, and moved WVC hotspots to locations that did not correspond with crash data. The

1-mile and 0.5-mile search distances remained the two possible options. The Silver City WVC hotspot was used as an example of the results with the different search distances. When the search distance was 0.5 mile, the Silver City hotspot was broken up into three different hotspots. When using a 1-mile search distance, it became a single 11-mile hotspot. It was decided that, for optimizing the benefit of ranking of WVC hotspots at the scale of New Mexico, a large single hotspot in Silver City would be better for meeting the objectives of the Action Plan. The 1-mile search distance was therefore selected for our modeling.

The Action Plan team also modeled different crash datasets. One modeling iteration modeled New Mexico wildlife crashes with the 5 most recent years of data (2014–2018), while another modeling iteration modeled 10 years of crash data (2009–2018). Our team used the I-25 Raton area modeling results to demonstrate how WVC hotspots are broken up into several different spots with the 5 most recent years of data, and those hotspots merge into a single long hotspot with 10 years of data. Changes in ecological conditions that occurred in the area with the 2011 Track Fire were partly the reason for the differences. This example convinced the team to use 10 years of data to better straddle ecological phenomena that may occur in an area and to help create one large hotspot in an area rather than multiple smaller ones.

In June 2020, the team modeled hotspots through several iterations. Python code was readjusted to merge adjacent hotspots, and the analysis was run several more times with small adjustments.

Values of the following five model variables were varied and selected for the final hotspot map:

- *Segment length:* The size of the "bins" or segments into which the NMDOT roads were broken up to help organize the WVC hotspots. A 1-mile segment length was selected as the appropriate scale for the modeling.
- *Buffer or segment width:* The width of the road segment. If the width is too narrow, it does not include opposing lanes of interstate. If the width is too wide, it brings in hotspots on other nearby roads. A 200-meter (656-foot) segment width or buffer was selected.
- *OHSA analysis buffer or analysis distance:* How far away from a crash data point the model looks out to see if there is a hotspot. If the distance is too long, the hotspots move away from actual clumps of crash points. If the distance is too small, many small hotspots emerge across the state. The optimal distance produces hotspot segment lengths according to the objectives of the study. A 1-mile analysis buffer or search distance was selected.

- *Crash data range:* The Action Plan team decided to use 10 years of crash data (2009–2018). As explained above, this range was determined to better straddle changes due to natural or human disturbances, such as the 2011 Track Fire north of Raton. This range of data, versus 5 years of data, helped to create one large hotspot in the North Raton area rather than multiple smaller ones, which better met the objectives of the study.
- *Confidence intervals:* Confidence intervals can be chosen to represent the hotspots of which the statistical model is most certain, such as the 99 percent, and also select for 95 and 90 percent confidence intervals to bring in additional hotspots. The 95 to 99 percent confidence intervals were chosen to best provide a full listing of top hotspots for New Mexico.

Table 4-3 presents the values of the five variables used for the final hotspot master map of these crashes.

Table 4-3. Optimized Hotspot Analysis (OHSA) model variable values used for final master wildlife-vehicle collision hotspot map, July 2020.

Segment Length	Buffer Width	OHSA Analysis Buffer/ Analysis Distance	Crash Data Year Range	Confidence Intervals
1 mile (5,280 feet)	200 meters (656.168 feet)	1 mile (1,609 meters)	10 years (2009–2018)	95 and 99 percent

4.3.2 Results

The WVC hotspot modeling resulted in 60 hotspots across the state, totaling 349 miles of NMDOT roads. The hotspots ranged in length from 1 to 34 miles. The number of wildlife crashes per mile per 10 years ranged from 17.6 for the top hotspot to 1.0 for the 50th to 60th hotspots. The hotspots were selected based on sheer numbers of wildlife-vehicle crashes. Deer (both mule deer and white-tailed deer) were overwhelmingly the top animal involved within the hotspots, with 2,579 reported crashes; thus, the hotspots were largely where these species were reported to be involved in crashes. Elk were the second most often involved wild animal within the hotspots, with 737 reported crashes in the database. There were 118 reported black bear mortalities and 13 cougar mortality data points in the 60 hotspots. There were 9 pronghorn crashes in the hotspots and no known bighorn sheep crashes in the top 60 hotspot locations.

The 60 WVC hotspots are mapped in Figure 4-10. Only the top 25 hotspots are numbered (see Appendix C for map with all 60 hotspots numbered). The lower ranked hotspots are represented by the yellow to green colors. The top WVC hotspots were prioritized, with the top 10 hotspots summarized in Table 4-10.

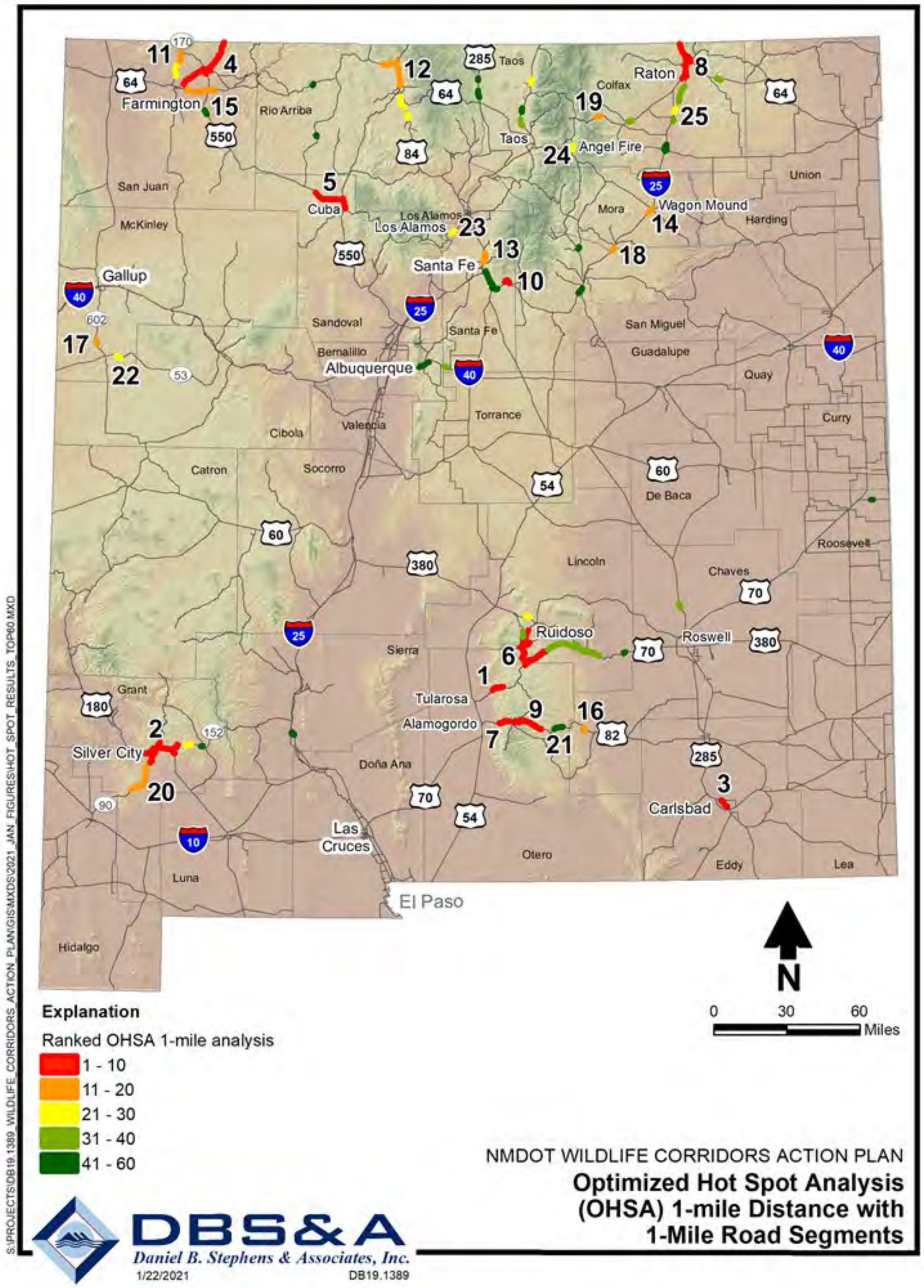

Figure 4-10. New Mexico's top WVC hotspots (2009–2018) on NMDOT roads. The top 25 hotspots are numbered and represented in red and orange. The lower-ranked hotspots are represented in yellow and green.

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Table 4-4. Top 10 WVC Hotspots in New Mexico

Rank	Name	Length (miles)	Total Wildlife Crashes	Crashes per Mile (10 years)	Number of Crashes for Each Species					
					Deer [a]	Elk	Black Bear	Mountain Lion	Pronghorn	Bighorn Sheep
1	US 70 Bent – Sacramento Mountains	5.0	88	17.60	18	70	0	0	0	0
2	US 180 NM 90 Silver City	27.6	471	17.05	455	13	2	1	0	0
3	US 285 North Carlsbad – Pecos River	4.00	66	16.50	66	0	0	0	0	0
4	NM 516 and US 550 Farmington to Aztec to CO	33.77	453	13.41	446	2	4	0	1	0
5	US 550 North of Cuba	17	205	12.06	81	12	4	0	0	0
6	US 70 SR 48 Ruidoso - Sacramento Mountains	33	358	10.85	256	97	4	1	0	0
7	US 82 West of Cloudcroft	5.0	54	10.80	13	40	0	1	0	0
8	I-25 North Raton to Colorado Border and South of Raton	26.5	280	10.58	183	42	49	3	3	0
9	US 82 East of Cloudcroft	13.0	134	10.31	46	85	3	0	0	0
10	I-25 Glorieta Pass	4.0	38	9.50	30	2	6	0	0	0

[a] Both mule deer and white-tailed deer

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Chapter 5. Habitat Linkage Modeling and Wildlife Corridors Selection

5.1 Introduction

Wildlife corridors in New Mexico were identified and prioritized by the Action Plan development team through a step-wise process of (1) modeling wildlife movements for each of the six focal species, (2) validation and recalibration of modeling results using WVC and traffic volume data, (3) expanding the applicability of past modeling efforts, and (4) agency, non-profit, Tribal, and public input. The final selection and prioritization results reflect not just the ecological importance of the corridors, but also the high potential for wildlife-vehicle conflict where they intersect roads.

The New Mexico Wildlife Corridors Act defined wildlife corridors as "those areas routinely used by wildlife to travel through their habitat and includes corridors used by migrating wildlife." In a narrow sense, they correspond to habitat-based predictions of wildlife-vehicle conflict areas.

In the Action Plan, habitat linkages are defined as broad landscape areas where wildlife is most likely to occur and move. In the development of the Action Plan, habitat linkages were identified through original modeling, then narrowed down to areas where the models and other data predict movement corridors for different wildlife species. The locations where wildlife corridors are bisected by roads are the focus of much of the Action Plan.

The Action Plan first identified the top 10 wildlife corridors in New Mexico, and then the top 6 priority wildlife corridors in need of immediate transportation mitigation projects. There were three major sources of information that informed this prioritization process: (1) habitat linkage modeling conducted as part of the Action Plan development, (2) NMDGF recommendations for the top 10 wildlife corridors, and (3) other sources ranging from Tribal, agency, non-profit, and general public input to past studies of wildlife movements and associated maps. The details of the selection and prioritization process are presented in this chapter in Sections 5.2 through 5.4, with the selection of the top 10 wildlife corridors discussed in Section 5.5.

5.1.1 Habitat Linkage Modeling

The objective of the wildlife habitat linkage modeling was to identify core movement habitats and linkages across New Mexico for the six focal species of concern: mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), pronghorn (*Antilocapra americana*), bighorn sheep (*Ovis canadensis*), cougar (*Puma concolor*), and black bear (*Ursus americanus*). These linkages were habitat-based predictions of where the populations of each species are centered. Where they intersect roads, they represent potential wildlife-vehicle conflict areas. These models were developed by members of the Action Plan development team.

5.1.2 NMDGF Selection of Wildlife Corridors

The Action Plan development team also examined 10 wildlife corridors, some of which represent NMDGF Secretarial Order 3362 (S.O. 3362) Action Plan priority landscapes (NMDGF, 2020), unpublished GPS radio-collar data on the six focal species from studies by NMDGF and the AZGFD, published and unpublished wildlife movement data provided by Tribal natural resource agencies, academic and U.S. Department of Defense (DOD) research on several of the focal species, and expert opinion from NMDGF biologists. NMDGF S.O. 3362 Action Plan priority landscapes selected were supported by model results.

5.1.3 Other Sources Used to Select Wildlife Corridors

Additional data sources, maps, models, and Tribal, agency, non-profit, and public input were considered to identify important wildlife corridor areas across New Mexico. All Tribes in New Mexico were contacted, and several of them provided wildlife movement data and maps to help identify the most important wildlife movement areas. This contribution helped identify several of the wildlife corridors. Previous modeling on wildlife corridors was also consulted, such as Menke (2008)'s predicted cougar corridor locations. Through public outreach conducted during the early phase of the Action Plan development, agencies, non-profit organizations, and members of the public provided input on areas that were of greatest concern for wildlife corridor protection. All of that information guided the prioritization of wildlife corridors and determined the top 6 recommendations for future transportation mitigation projects.

5.2 Habitat Linkage Modeling

5.2.1 Overview

Research team members Dr. S. Cushman and Dr. H.Y. Wan built upon their earlier work with the connectivity simulation tool Universal Corridor Network Simulator (UNICOR) (Landguth et al., 2011) for elk, bighorn sheep, and black bear in the first New Mexico wildlife linkages modeling project (Wan et al., 2018a) and for pronghorn in a second linkage analysis (Wan et al., 2018b). Core movement habitats and linkages were similarly developed for mule deer and cougar specifically for the Action Plan. The models were refined over months of various iterations.

Dr. Cushman and Dr. Wan used the following six main steps to model linkages for all six focal species:

1. Build habitat suitability maps
2. Build resistance maps
3. Build species distribution maps
4. Run connectivity simulations
5. Define core movement habitat and corridors
6. Prioritize core habitat patches and corridors

These steps are detailed in the following subsections, with highlights of predicted linkages that were corroborated or validated with empirical data and input from NMDOT and NMDGF.

5.2.2 Mule Deer and Cougar Linkage Modeling

5.2.2.1 Habitat Suitability Maps

The first step in the linkage modeling analyses was modeling habitat suitability for each of the six focal species. The elk, bighorn sheep, pronghorn, and black bear models were developed through the first five steps in the above process prior to the research on the Wildlife Corridors Action Plan (Wan et al., 2018a and 2018b).

5.2.2.1.1 Mule Deer

Five habitat suitability coefficients were applied to New Mexico to create habitat suitability maps for mule deer with a spatial resolution of 30 x 30 meters: (1) topography and water, (2) vegetative cover, (3) human development, (4) climate, and (5) soil. Four seasonal models (spring, summer, fall, and winter) were developed (Figure 5-1). The resulting maps were built upon for later steps in assessing mule deer linkages.

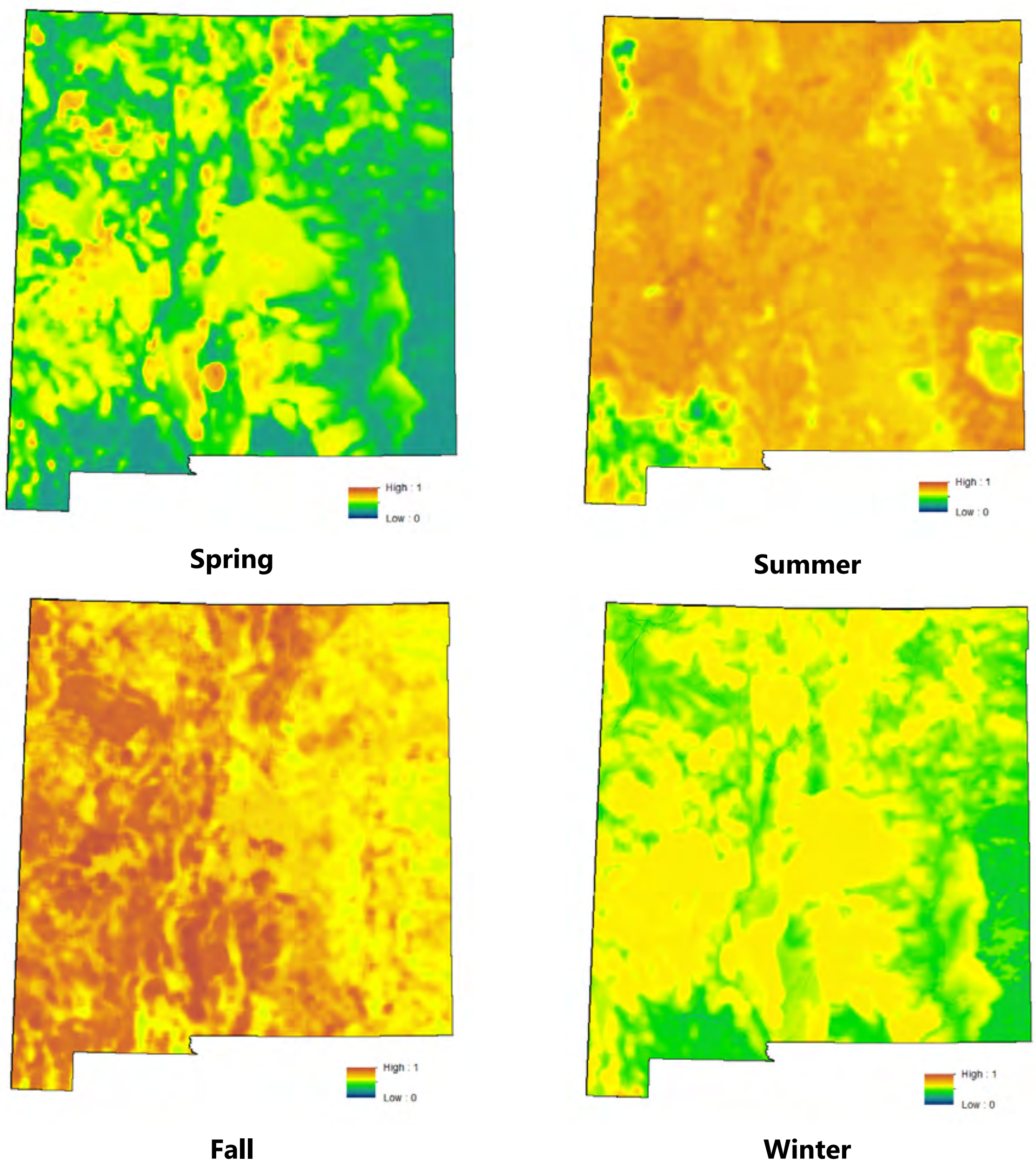


Figure 5-1. Habitat suitability for mule deer in New Mexico. Warmer colors represent higher suitability.

5.2.2.1.2 Cougar

The cougar habitat layer was based on the Zeller model for California (Zeller et al., 2017), which used a multi-scale, optimized path selection function to model movement habitat for cougars. The landscape factors modeled were elevation, percent slope, agriculture, chaparral, grassland, barren/open water, riparian, woodland, urban, and roads (Zeller et al., 2017). Due to elevational differences between Zeller's study area and New Mexico, the New Mexico elevation raster map was corrected. First, the mean elevation and standard deviation were determined in Zeller's study area. Then, the mean plus 3 standard deviations from Zeller's study area (4,800 feet) was used as the ceiling for correcting the elevation layer. That is, any pixel with an elevation greater than 4,800 feet was assigned an elevation of 4,800 feet. Everything else remained the same. Figure 5-2 shows the habitat suitability estimate map for New Mexico based on these methods.

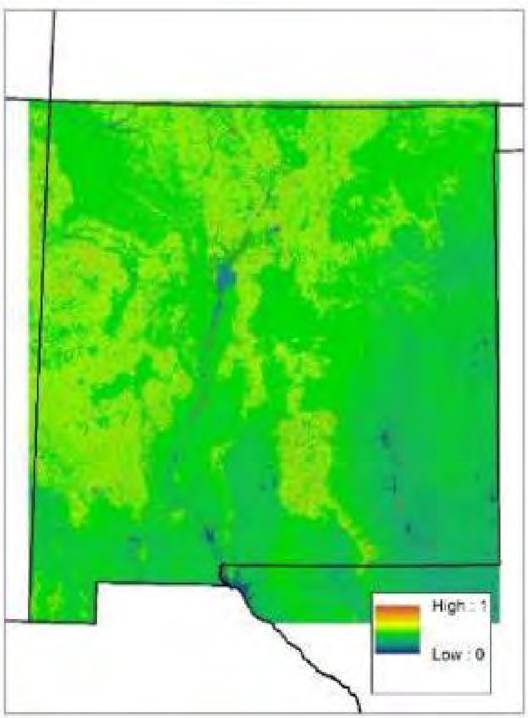


Figure 5-2. Cougar habitat suitability map for New Mexico. Habitat suitability increases as colors progress from green to red. Unsuitable areas are in blue.

5.2.2.2 *Resistance Maps*

The second step in modeling linkages was to build resistance surfaces that estimate landscape resistance to animal movements.

5.2.2.2.1 *Mule Deer*

A negative exponential decay function was used to convert habitat suitability in the previous step into cost resistance:

$$R = 1{,}000^{(-1 \times HS)} \tag{5-1}$$

where R = resistance
HS = habitat suitability

As a result of this conversion, areas with greater suitability had lower resistance to mule deer movement, and vice versa (Figure 5-3).

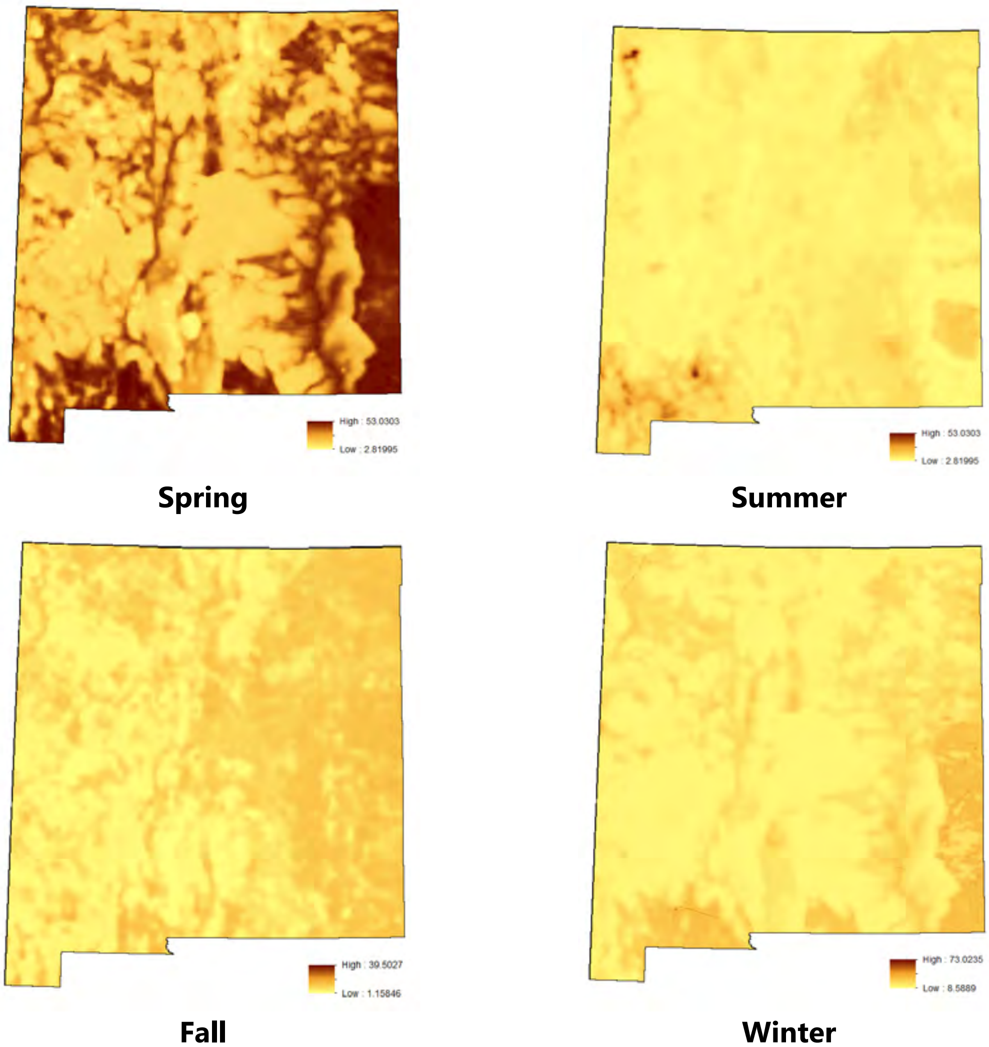


Figure 5-3. Resistance maps of mule deer movement in New Mexico. Darker colors represent higher resistance to movement.

5.2.2.2.2 Cougar

The research team subtracted the cougar output in Step 1 (Habitat Suitability) from 1 and then multiplied it by 100 to convert predicted habitat suitability for movement to resistance surface. The resulting cougar resistance map for New Mexico is depicted in Figure 5-4. Higher resistance suggests greater cost to movement, such as in the more human-populated areas like Albuquerque. Conversely, lower resistance indicates lower cost to movement. A buffer was added beyond the state's boundaries to deal with edge effects.

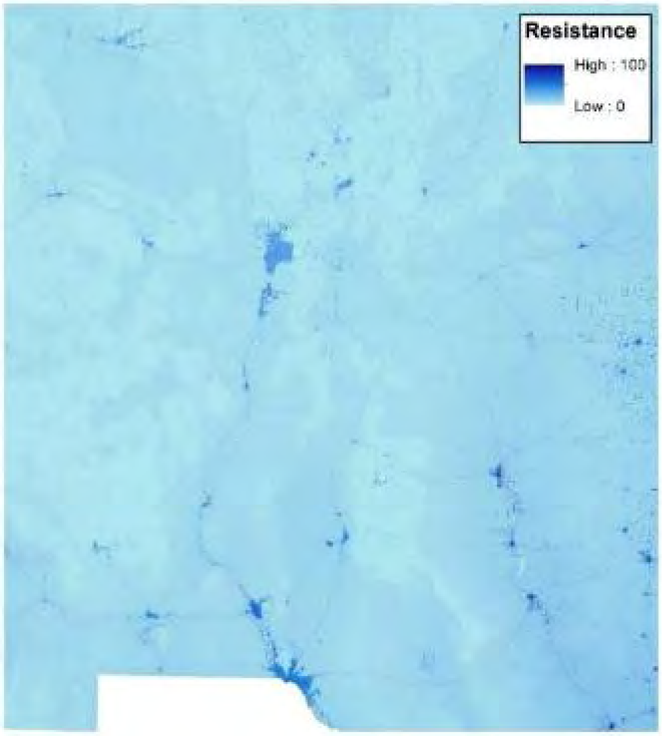


Figure 5-4. Resistance map for cougar in New Mexico.

5.2.2.3 *Species Distribution Map Generation*

5.2.2.3.1 *Mule Deer*

The third step in modeling mule deer habitat and linkages was to place theoretical individual animals in populations across the electronic landscape in the model. NMDGF provided hunting harvest data that can be used to roughly estimate the size of the mule deer population in each Wildlife Management Unit (WMU). The research team estimated how many mule deer were in each WMU as a percentage of the total mule deer population in New Mexico. Deer density for each unit was expressed as the number of deer per hectare (ha). Random points were placed across New Mexico's WMU maps following these estimates to present the hypothetical distribution of mule deer. However, because WMUs have set boundaries, these spatial points were confined in blocks. To create a smoother and continuous hypothetical distribution of mule deer, the Kernel Density tool in ArcGIS was applied to random points, and a raster map was created reflecting a continuous gradient of population estimates. Spatial points were populated using this gradient map as the probability layer.

5.2.2.3.2 Cougar

Empirical data were insufficient to depict the spatial distribution and population estimates of cougar in New Mexico; thus, cougar source points were created based on random locations that were weighted by habitat suitability. This was achieved by first creating a random raster with values ranging from 0 to 1 at any given cell. This random raster was then subtracted from the habitat suitability map, resulting in a map with values ranging from –1 to 1. All negatives were converted to zeros. The map was used as an input probability raster to randomly generate 3,000 spatially balanced points. As a result, cougar source points were more likely to be generated in areas with higher predicted habitat suitability.

5.2.2.4 Connectivity Simulations Using UNICOR

The species distribution maps generated in the previous steps were used to run UNICOR (Landguth et al., 2011) connectivity models to simulate maps of greatest habitat connectivity for mule deer and cougar. Two types of maps were generated using this approach. One type is based on factorial least cost path analysis and the kernel density estimation (KDE), while the other type is based on the use of the cumulative resistant kernel method.

Factorial least cost path analysis is commonly used for analyzing connectivity patterns. It quantifies pairwise optimal paths among all individuals on a landscape. To better estimate a general area and not just the paths of hypothetical animals, the research team incorporated a KDE by buffering all least cost paths with a 1-kilometer Gaussian smoothing kernel. This additional step smoothed the information to give a density surface of the most probable movement route connecting populations.

The cumulative resistant kernel method does not assume a single path between two individual source nodes in the simulation. It considers the dispersal ability of a species and estimates many directions of movement from each point of location—meaning that it calculates all possible paths in each run of the model. There is a dispersal threshold, after which all kernels are added together to produce a density map predicting connectivity strength at each location on the landscape.

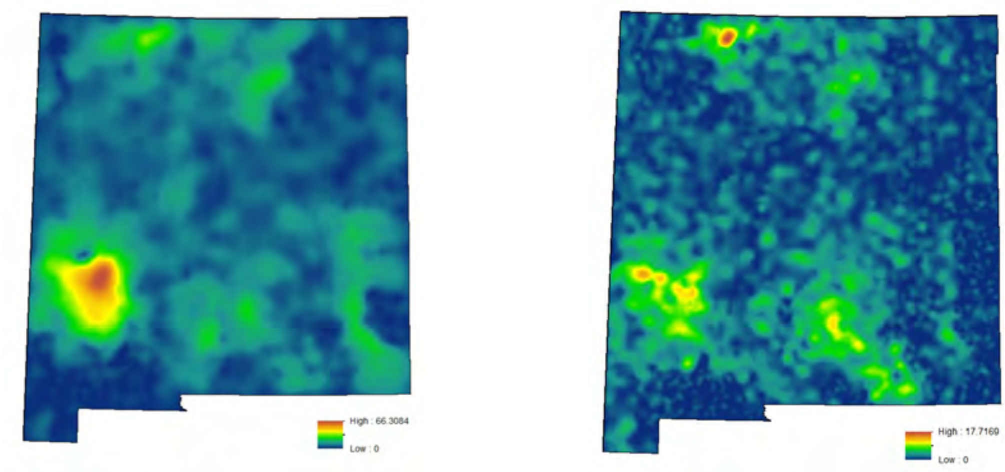
The resulting outputs were maps of raster cells that displayed the expected density of dispersing individuals of the species of interest. The inputs were the resistance surfaces in Step 2 and the species distribution maps with spatial points generated in Step 3.

5.2.2.4.1 Mule Deer

Two types of corridors were mapped for mule deer: one using KDE on least cost paths and the other based on the cumulative resistant kernel method.

The habitat linkages modeling team experimented with different dispersal thresholds for mule deer. The simulation was populated with different resistance surface maps to test different hypotheses regarding how the species interacted with the environment. The most appropriate distance for mule deer dispersal thresholds was selected. This process produced density surfaces that predict core habitat areas for mule deer movements.

UNICOR connectivity simulations were run using the cumulative resistant kernel approach for summer and winter population locations predicted for mule deer in New Mexico (Figure 5-5).



Summer **Winter**

Figure 5-5. UNICOR cumulative resistant kernel connectivity simulations of mule deer predicted occupancy in New Mexico. Predicted locations for mule deer are in hotter colors, such as yellow and red.

5.2.2.4.2 Cougar

For cougar simulations, the cumulative resistant kernel simulation was run and the factorial least-cost paths with Gaussian estimates were modeled (Figure 5-6). In both maps in Figure 5-6, hotter (red) colors delineate the most suitable habitat. In the factorial least cost path approach, the lines are not roads but predicted corridors of movement for cougar to move among the larger habitat patches in the mountain ranges.

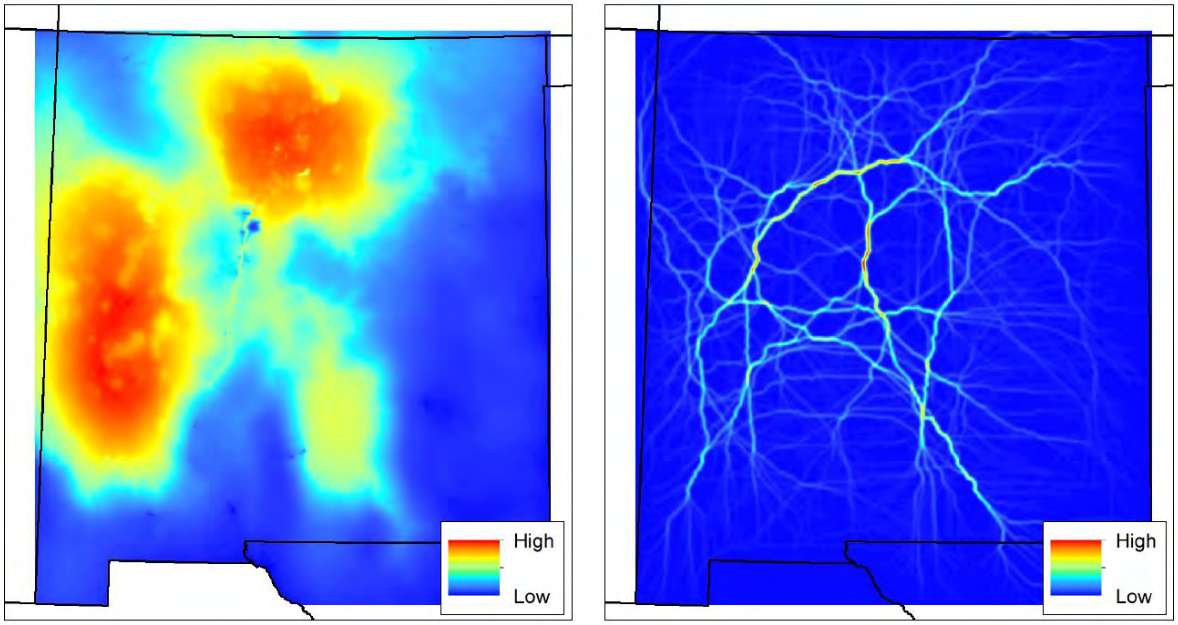


Figure 5-6. Predicted cougar connectivity based on the resistant kernel modeling approach (left) and predicted cougar connectivity using the factorial least-cost paths approach (right). Hotter colors delineate areas with higher probability of cougar presence.

5.2.3 Habitat and Highway Crossing Linkage Modeling for the Six Focal Species

Once the UNICOR modeling was complete for mule deer and cougar, the connectivity maps for these two species were created, similar to those for elk, bighorn, black bear, and pronghorn models in previous studies. The focus of the next steps was on refining the predicted connectivity networks for all six focal species of concern and a combined network for all species jointly. Maps were produced showing where the top connectivity networks for each species, and then for all species jointly, intersected with roads. The models must be regarded as aspirational, as there was limited calibration and validation due to a lack of GPS collar data across the state for all species, and also due to the limitations of the overall model and study.

Two general types of models were generated to continually refine where the most important wildlife corridors were predicted for New Mexico. The first models created predicted connectivity surfaces for each species and all species combined. Maps were drafted with and without consideration of the road networks. In the second and final set of models, road networks, traffic volume, wildlife-vehicle crash data, and GPS data on collared mule deer, elk, pronghorn, and other focal species, were compared with model results to help create more accurate representations of the landscape and potential wildlife corridors.

The first models are presented in Section 5.2.3.1 under the heading "First Models of Wildlife Highway Crossing Locations and Connectivity." These models were generated and presented to the rest of the Action Plan development team in August and September 2020. In October and December 2020, the second set of models was generated and described in internal reports on October 5, October 24, October 28, and December 17, 2020. These model results are presented in Section 5.2.3.2 under the heading "Wildlife Linkages and Road Networks."

5.2.3.1 First Models of Wildlife Highway Crossing Locations and Connectivity

Connectivity modeling was conducted to predict the top road segments across the state that all species, individually and collectively, were expected to cross or approach while moving through habitat linkages. This modeling effort did not take into account traffic volume, and also included roads other than those under NMDOT jurisdiction, such as U.S. Forest Service roads. These modeling efforts were conducted from June through September 2020.

5.2.3.1.1 Methods

The first step in this process was to produce a single normalized connectivity surface for each species and for all species jointly. For individual species, this step was conducted by adding together the normalized resistance kernel and factorial least cost path predictive surfaces produced earlier in the base analyses. Resistance kernel analysis predicts the incidence function of how frequently individuals of any given species are expected to move into each pixel across the state. Factorial least cost path analysis predicts the concentrated, low-cost routes that can connect population segments for each species across the state. The normalization was conducted by dividing all values of the connectivity surface by the standard deviation, producing a surface where units are the number of standard deviations each location was above zero. For the joint analysis of all species together (the multi-species analysis), the normalized predictions for kernel and path modes for all six species were summed, producing a full multi-species connectivity surface.

The second step intersected the individual species and multi-species connectivity surface models with the road network. The road traffic volume was not included at this time. Thus, the results should be considered a prediction of how frequently animals will encounter roads at each road-linkage intersection. They are also not indicative of the degree to which roads prevent animal movements (barrier impermeability) or result in traffic-related mortality. A 1-mile scale of analysis was selected. The connectivity surfaces for each of the six species and multi-species layers were sampled for each 1-mile length of road.

In the third step, the 1-mile road segments were ranked for each species and for all species jointly, based on associated total connectivity values calculated as the equally weighted sum of factorial least cost path and cumulative resistant kernel surfaces. This sum of connectivity surfaces is expected to reflect the frequency of individual animals of that species (or all species jointly) encountering the road. For each species, ranking based on this value produced a list of the locations that show the highest rate of predicted movement encountering roads.

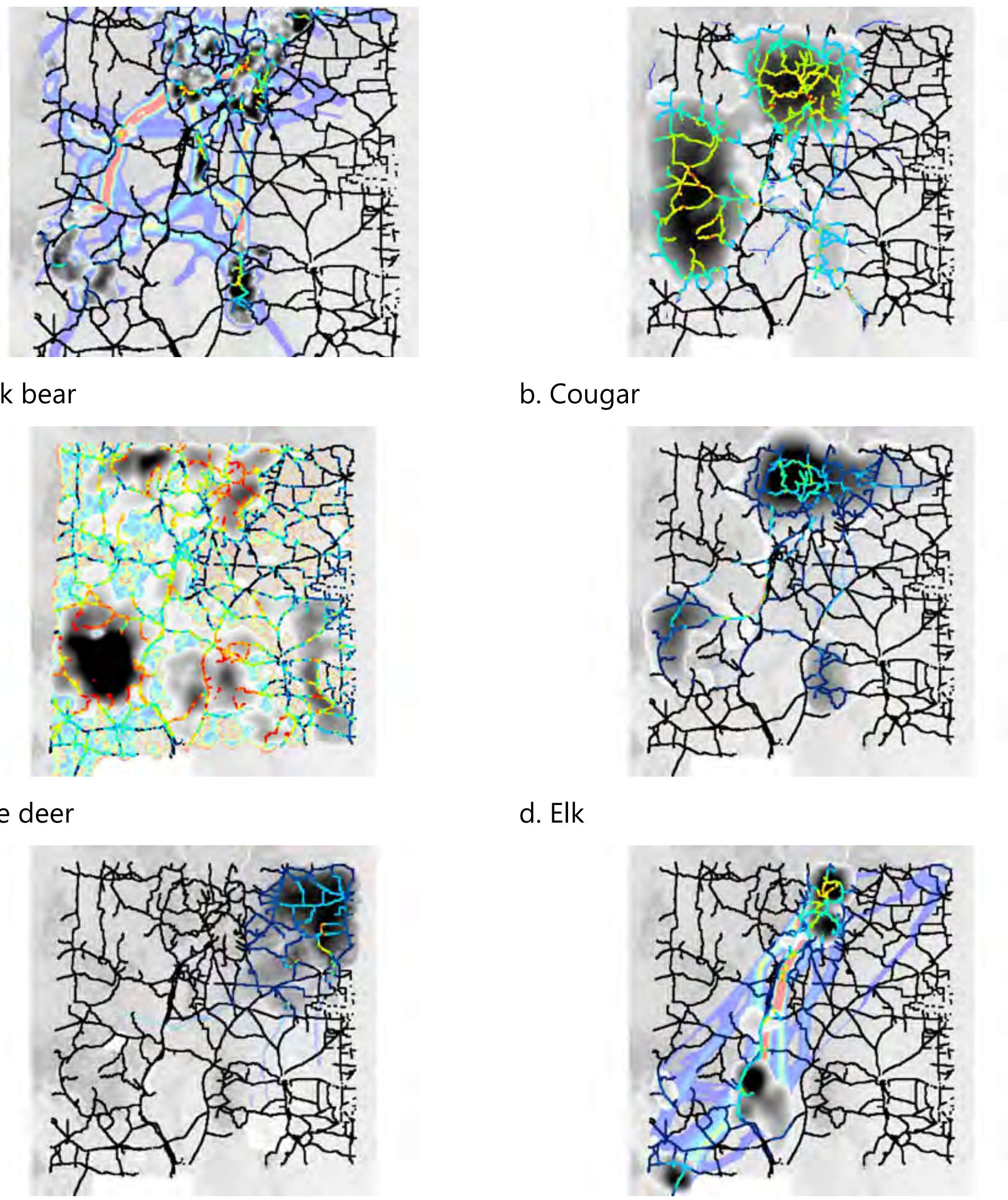
For the fourth step, the adjacent 1-mile segments in the top 500 were then merged into polygons to produce delineated hotspot areas that can extend for more than 1 mile (if several adjacent 1-mile segments had high predicted connectivity ranking). This was done by merging adjacent segments into composite polygons, including only adjacent segments if they were ranked in the top 500 for all 1-mile segments in the state.

The fifth step was to measure the connectivity value, or score, of these merged, adjacent high-connectivity segments and rank them. That score was calculated as the sum of all the pixel normalized connectivity values in each highway segment (or agglomerated highway crossing segment). This connectivity score was calculated for each agglomerated highway crossing segment for each species and the multi-species connectivity surfaces. These highway-crossing segments were species-specific or modeled for all species combined.

The final step ranked the connectivity sums for each species and the multi-species model segments. The top 25 agglomerated highway crossing segments for each species were represented as individual polygons.

5.2.3.1.2 Results

This modeling effort produced three different types of maps: (1) pixel-level patterns of connectivity values for linkages intersected with roads for each individual species and all species combined, (2) the 25 polygons representing the linkages with the highest connectivity intersecting roads for each and all species together, and (3) high-resolution images of the top 10 intersected roads and connectivity models for each species and all species jointly. Presented below are the pixel-level connectivity value maps for each species (Figure 5-7), all species jointly (Figure 5-8), and each species with the top three segments of road where the connectivity models predict the highest connectivity values bisected by those roads (Figure 5-9). The top three linkage polygons for all six species were mapped together (Figure 5-10).



a. Black bear

b. Cougar

c. Mule deer

d. Elk

e. Pronghorn

f. Bighorn sheep

Figure 5-7. Maps of the six focal species of concern predicted connectivity values in 1-mile pixels, overlain on the resistance kernel (gray) and factorial least cost paths, and the intersection of those connectivity areas with roads in New Mexico.

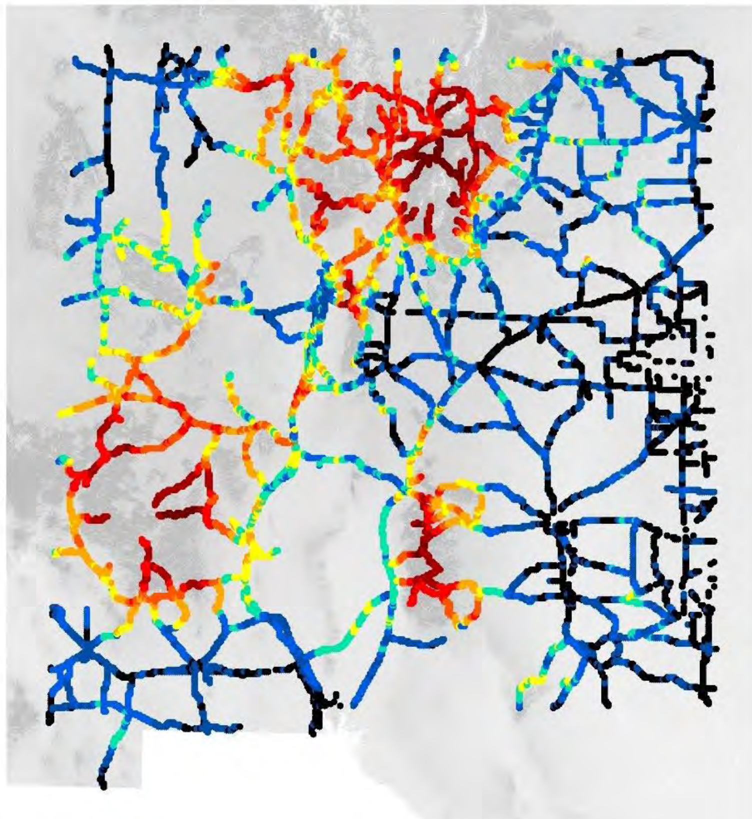


Figure 5-8. All-species connectivity surface intersected with roads. No connectivity across roads is displayed in black, to increased connectivity represented with hotter colors, with red as the highest predicted connectivity across roads for all species.

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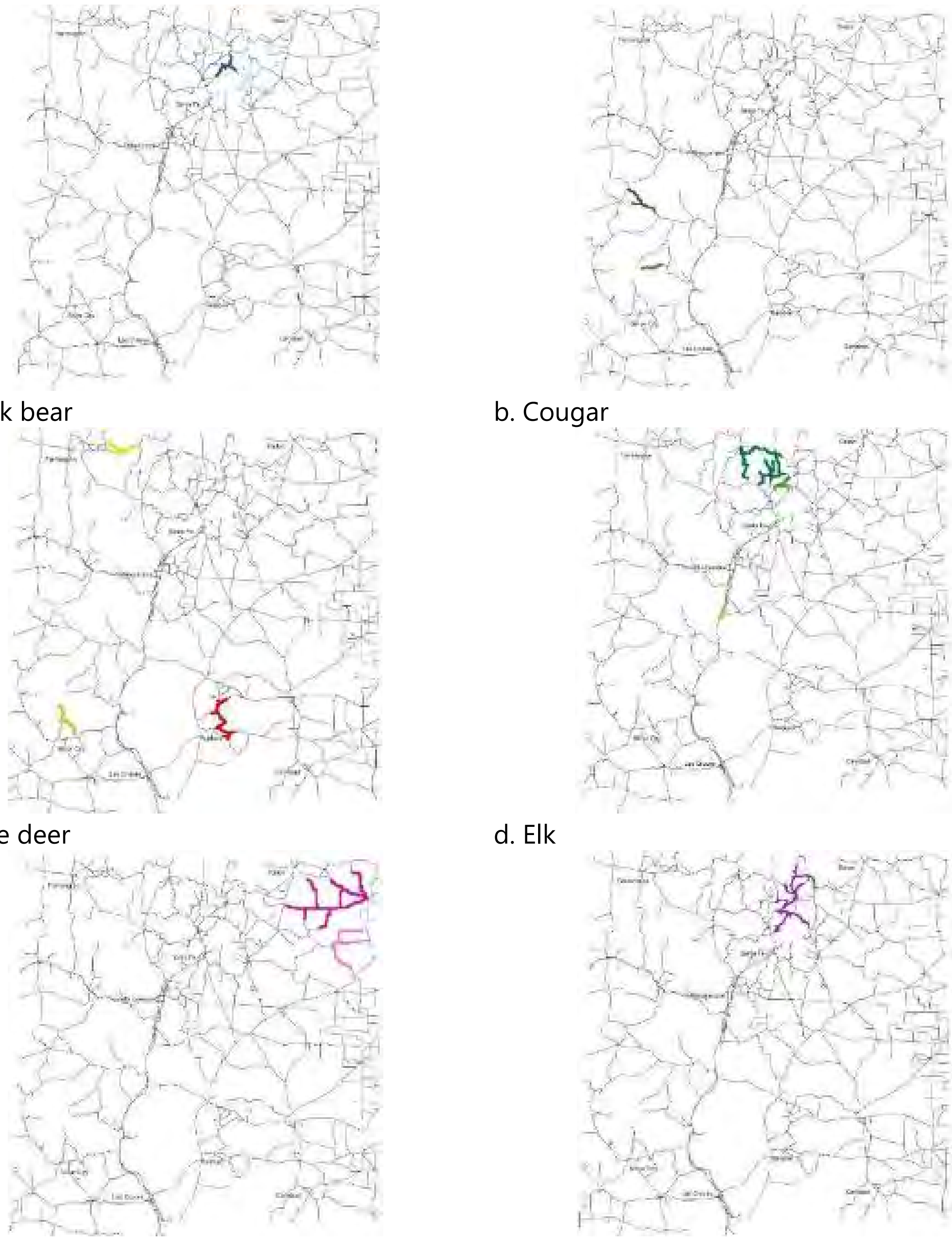

a. Black bear

b. Cougar

c. Mule deer

d. Elk

e. Pronghorn

f. Bighorn sheep

Figure 5-9. The top three predicted linkages bisected by roads in New Mexico, with darker colors rated higher.

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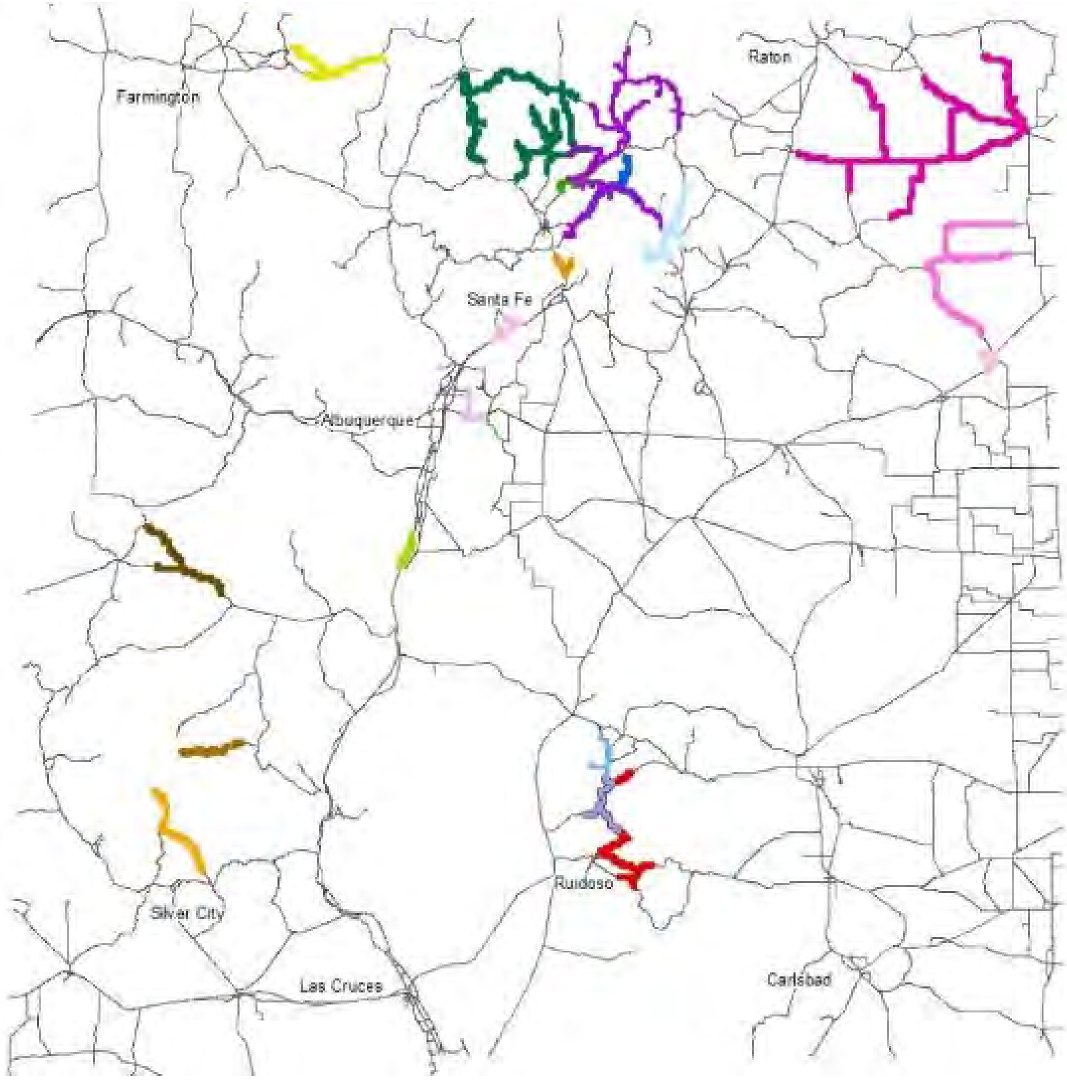

Figure 5-10. The top three habitat linkages bisected by roads for all six species. Black bear = blues, Cougar = browns, Mule deer = yellow to red, Elk = greens, Pronghorn = pinks, Bighorn sheep = purples.

The connectivity models above were then run without respect to roads. The resulting maps were largely aspirational corridors. The combined six species map for this model is presented in Figure 5-11.

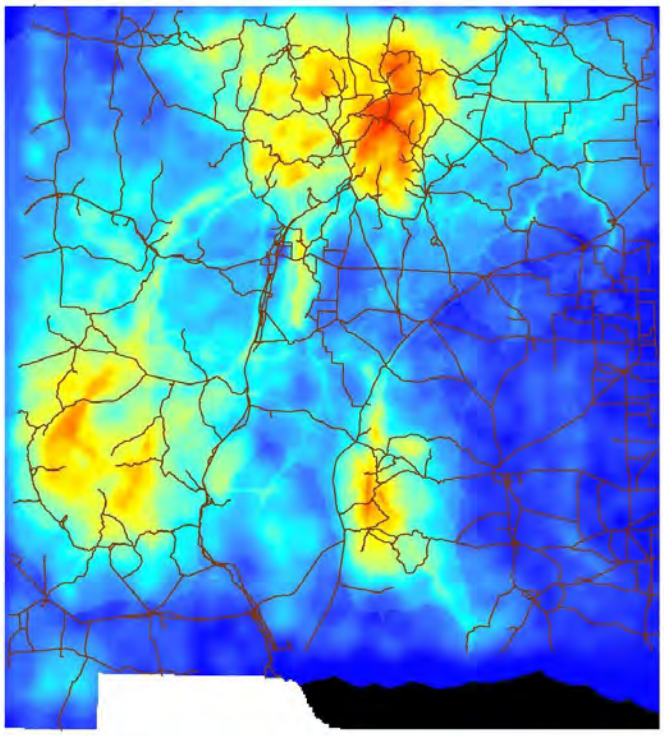

Figure 5-11. State-wide connectivity map for all six focal species of concern without reference to roads. Hotter colors indicate potential areas of larger habitat patches and higher connectivity for wildlife.

The linkage modeling team performed an analysis of GPS locational data for collared mule deer, elk, and pronghorn in northern New Mexico. NMDGF placed GPS collars on elk and pronghorn in northern New Mexico in the area of the Rio Grande Del Norte National Monument, near US 285 in 2019. The locations where those animals' movements were recorded were delivered to the research team in June 2020. The intent of the analysis was to find the locations where animals were crossing roads in northern New Mexico and to identify hotspots of wildlife activity. These data maps also helped the team calibrate the original models and test later models. GPS locational data were analyzed with a path density analysis. The six steps involved in this analysis mapped predicted density movement paths for each species across all individuals monitored. As an example, one of the resulting maps is presented in Figure 5-12.

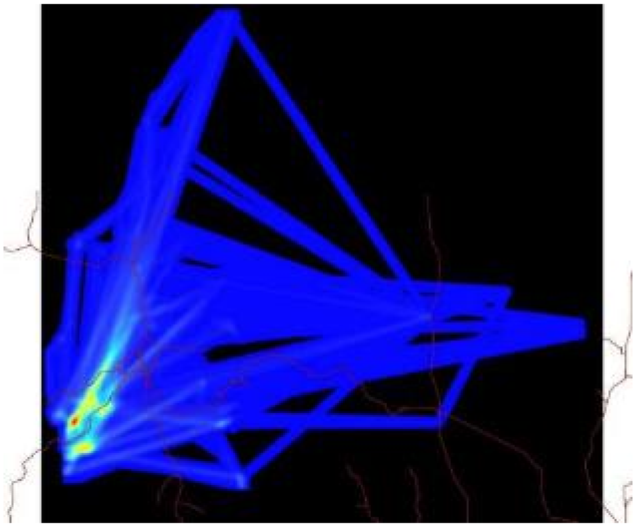

Figure 5-12. Path density map for mule deer GPS data from northern New Mexico.

There was a lower frequency of mule deer data compared to elk and pronghorn. The resulting predicted path density surface for mule deer in northern New Mexico displayed more long linear patterns than the other two species. The main concentrated area of high mule deer value is displayed in the southwestern corner of the analysis landscape. This corresponds to the Rio Chama State Wildlife Area on the south side of Heron Lake, southwest of Chama, New Mexico (Figure 5-12).

The above modeling results were helpful to NMDGF in support of habitat linkages for wildlife south, west, north, and east of Chama, and along US 285 north of Tres Piedras, in the Rio Grande del Norte National Monument.

5.2.4 Wildlife Habitat Linkages and Road Networks

This final step improved upon the first set of results by adjusting several UNICOR model variables. The various iterations of this effort are referred to by date—October 5, October 24, October 28, and December 17, 2020. For the October 5, 2020 models, a distance threshold was placed in UNICOR modeling of factorial least cost paths, which limits dispersal distances in the virtual individual animals modeled. This helped ensure that the simulated corridors remain biologically realistic. In this analysis, a standardized set of parameters of grain and focal kernel smoothing of predicted paths was used to allow for comparisons among the different species. Bighorn sheep subspecies were modeled separately. Mule deer movement predictions were collapsed down into one annual model rather than four seasons. Areas of predicted mule deer mortality were reduced to 250 m (820 feet) pixels along highways to refine potential areas where the models predicted mule deer mortality hotspots. Traffic volume data were then incorporated into the model maps.

For the October 24, 2020 models, predictions were made as to where high numbers of WVCs occur on New Mexico roads for each focal species. These models were then verified with known wildlife-vehicle crash data and the WVC hotspot modeling results.

In the October 28, 2020 modeling, machine learning was used to predict the top locations in New Mexico where each of the six focal species was predicted to have the greatest amount of wildlife-vehicle conflict.

The final December 17, 2020 model used telemetry data to further test and refine the October models.

5.2.4.1 Methods

For the October 5, 2020 model iteration, the prior developed models and maps were input to the UNICOR model with the above changed parameters and a map of the NMDOT roads and their traffic volumes. This analysis weighted wildlife movement and traffic volume as equally important. This was done by taking the spatial product of pixel values of traffic volume and predicted corridor strength along the full road network. This intersection of least cost path network and traffic volume produced a GIS raster layer with values that were the product of traffic volume and predicted connectivity for every pixel in the full highway road network. A sampling mask of 250 m (820 feet) pixels was created to all values of weighted connectivity along New Mexico roads. The top 500 pixels for each species were retained for the next map in the process. These pixels were ranked and mapped for each species.

Maps of the factorial least-cost path priority road crossing locations were then created for each species.

For the October 24 and October 28, 2020 modeling iterations, detailed maps were produced with the top predicted areas where each focal species was expected to be involved in WVCs. Random machine learning calibration was used to validate and calibrate connectivity surfaces and determine if they were able to effectively predict the locations of high-density wildlife-vehicle crashes. First, for each of the six focal species, a model selection using the machine learning algorithm "Random Forest" based on Model Improvement Ratio (Evans and Cushman, 2009) was run, predicting road mortality in that species as a function of all connectivity surfaces, traffic volume, and x and y coordinates. In the second step, the variables selected in the first step were pooled for each species' mortality data, which produced a multispecies predictor for each of the six species. This model included variables found to predict each of the six focal species of concern, which may include connectivity surfaces for that species as well as other species. The third step consisted of producing predicted road mortality surfaces and variance explained for each species model. These processes were slightly refined for the October 28, 2020 final model results.

The December 17, 2020 model refinement used NMDGF telemetry data for mule deer, elk, and pronghorn in northern New Mexico to help further calibrate and test the models. This necessitated a reduction in spatial extent to the footprint of the NMDGF northern New Mexico telemetry study and reduction of the analysis to calibration of connectivity for three species for which the telemetry data were available. Cost units were calculated for multiple model configurations for each species model using random forest machine learning calibration.

5.2.4.2 Results

The October 5, 2020 modeling resulted in the statewide factorial least cost path maps for each focal species with priority areas highlighted in red, which are presented in Figures 5-13 through 5-19.

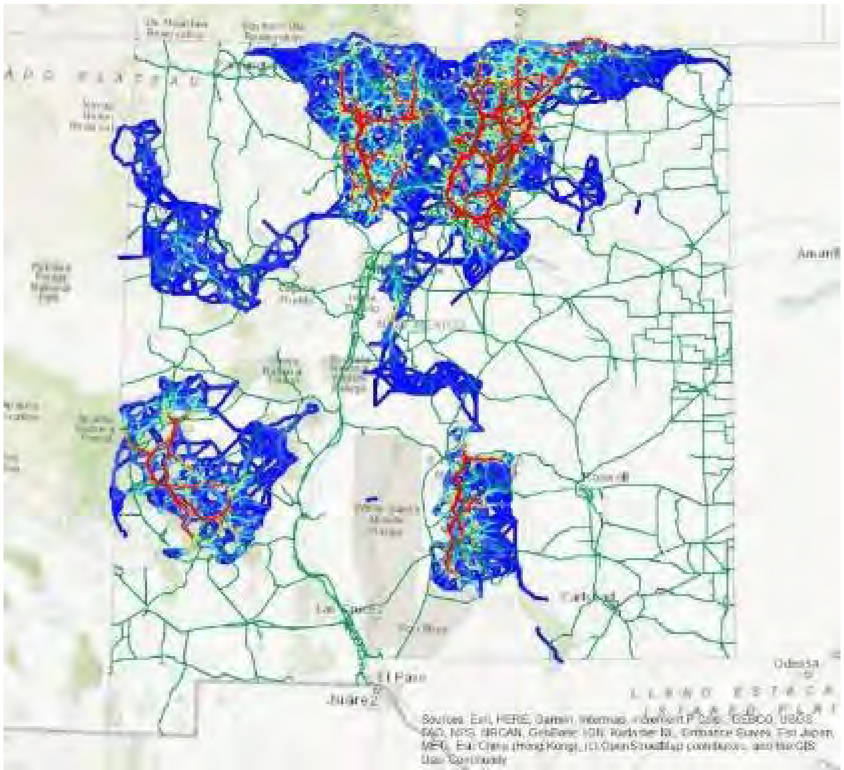

Figure 5-13. **Factorial least cost path density network for black bear across the full extent of New Mexico. The strength of the predicted corridor network is shown in a blue to red color map, with red areas predicted to have very strong least cost path linkages, blue areas predicted to have weak least cost path network linkages, and areas without paths predicted to not be optimal movement paths between any locations occupied by black bears.**

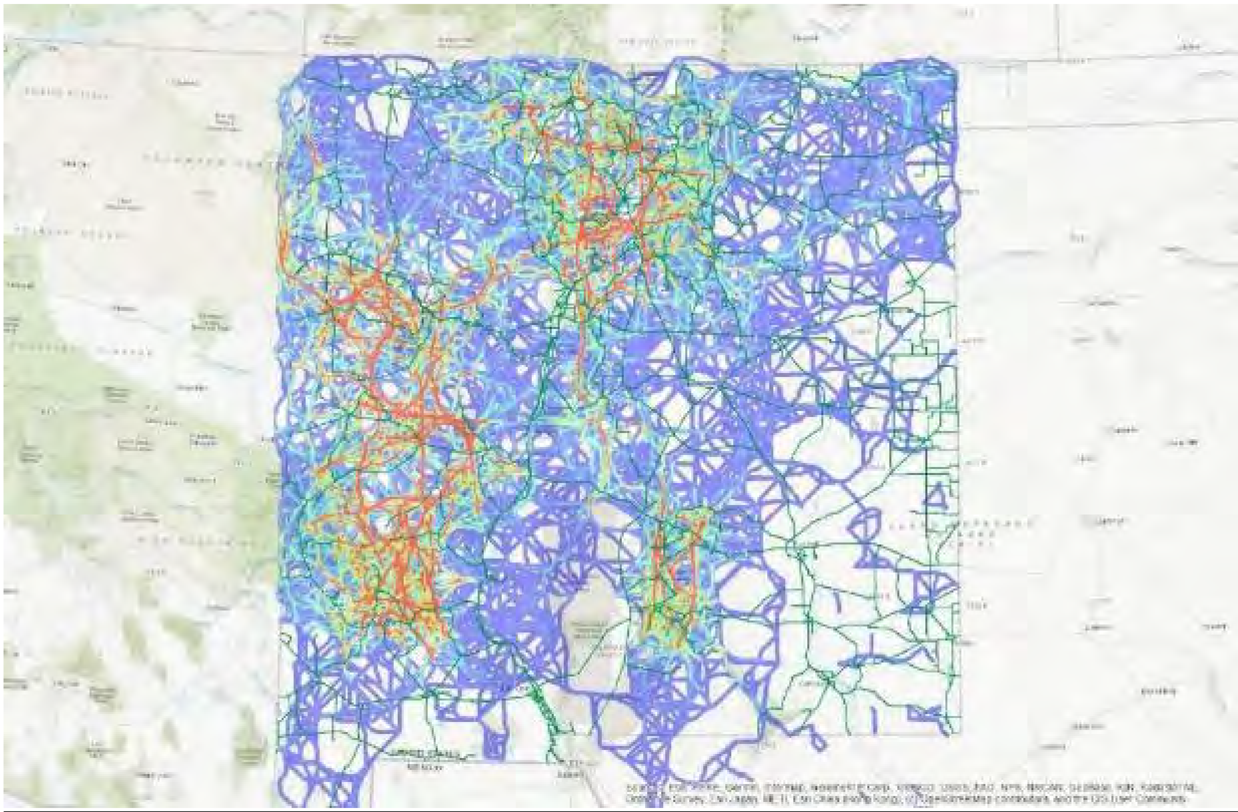

Figure 5-14. Factorial least cost path density network for cougar across the full extent of New Mexico. The strength of the predicted corridor network is shown in a blue to red color map, with red areas predicted to have very strong least cost path linkages, blue areas predicted to have weak least cost path network linkages, and areas without paths predicted to not be optimal movement paths between any locations occupied by cougars.

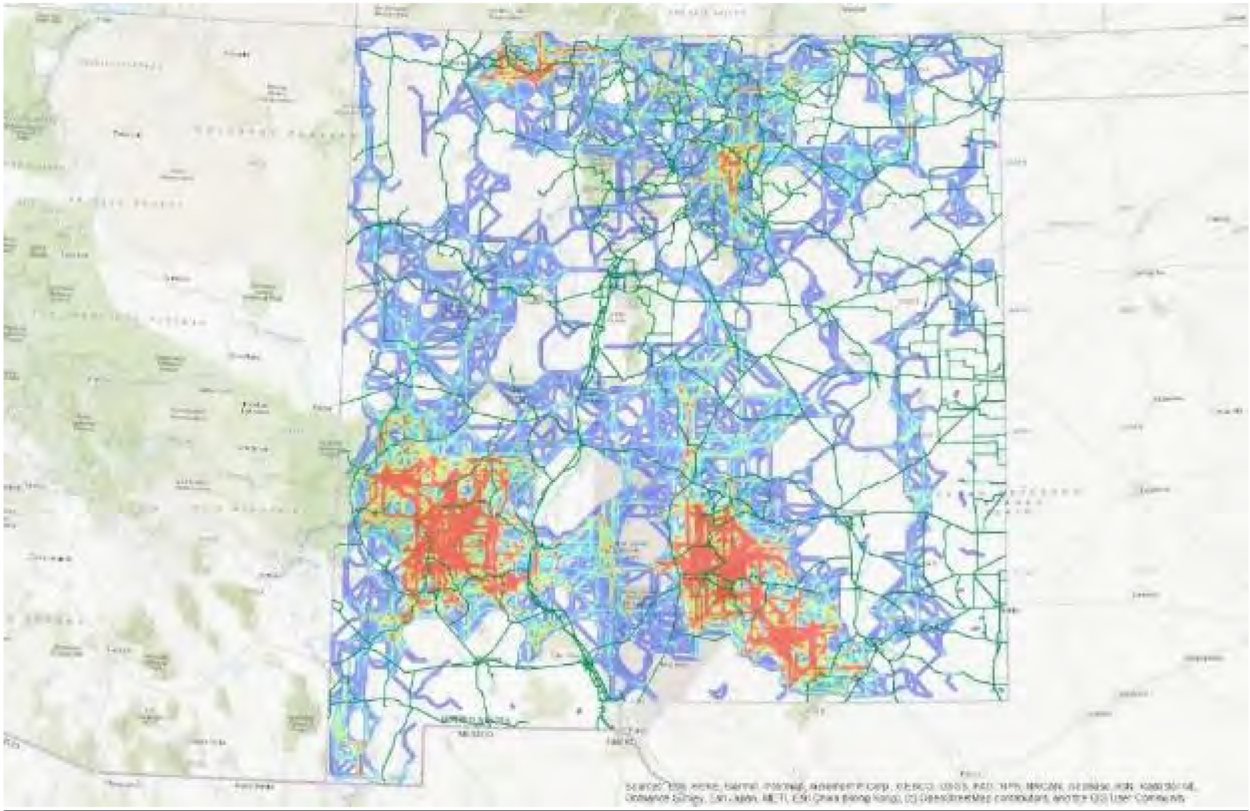

Figure 5-15. Factorial least cost path density network for mule deer across the full extent of New Mexico. The strength of the predicted corridor network is shown in a blue to red color map, with red areas predicted to have very strong least cost path linkages, blue areas predicted to have weak least cost path network linkages, and areas without paths predicted to not be optimal movement paths between any locations occupied by mule deer.

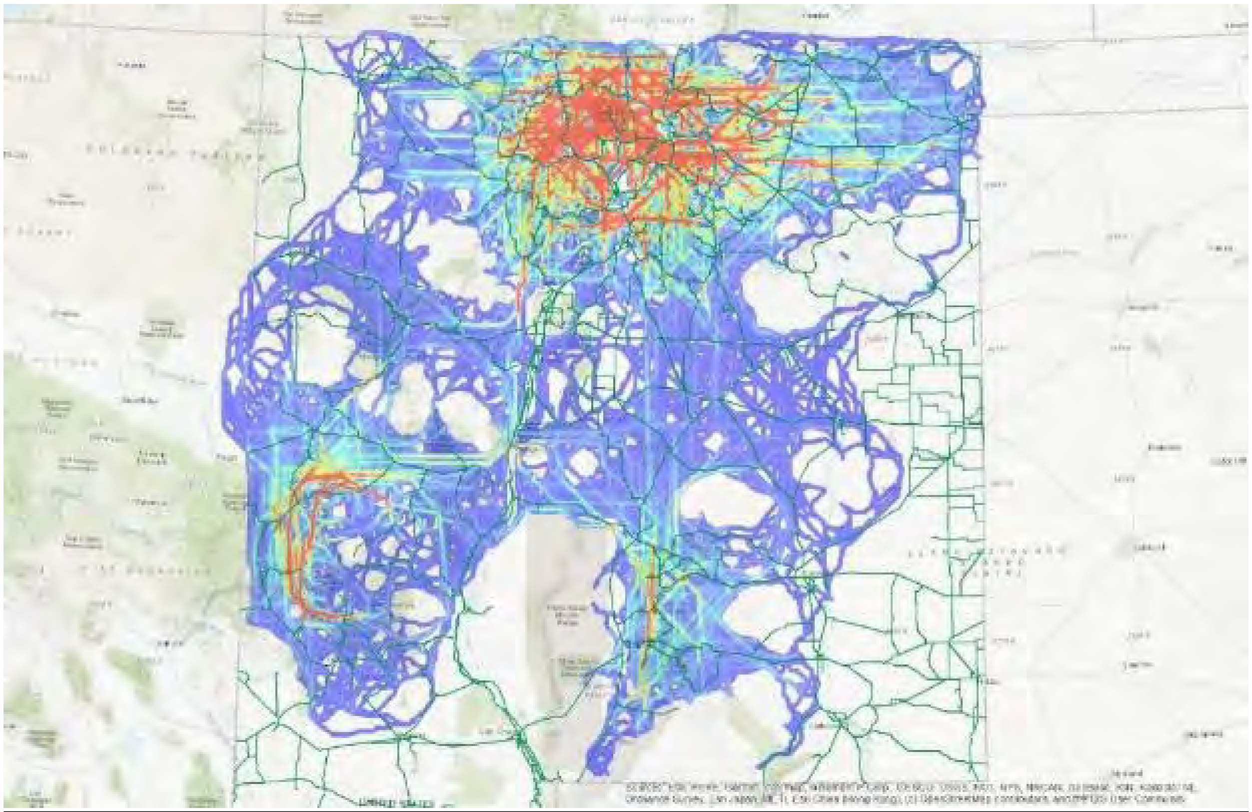

Figure 5-16. Factorial least cost path density network for elk across the full extent of New Mexico. The strength of the predicted corridor network is shown in a blue to red color map, with red areas predicted to have very strong least cost path linkages, blue areas predicted to have weak least cost path network linkages, and areas without paths predicted to not be optimal movement paths between any locations occupied by elk.

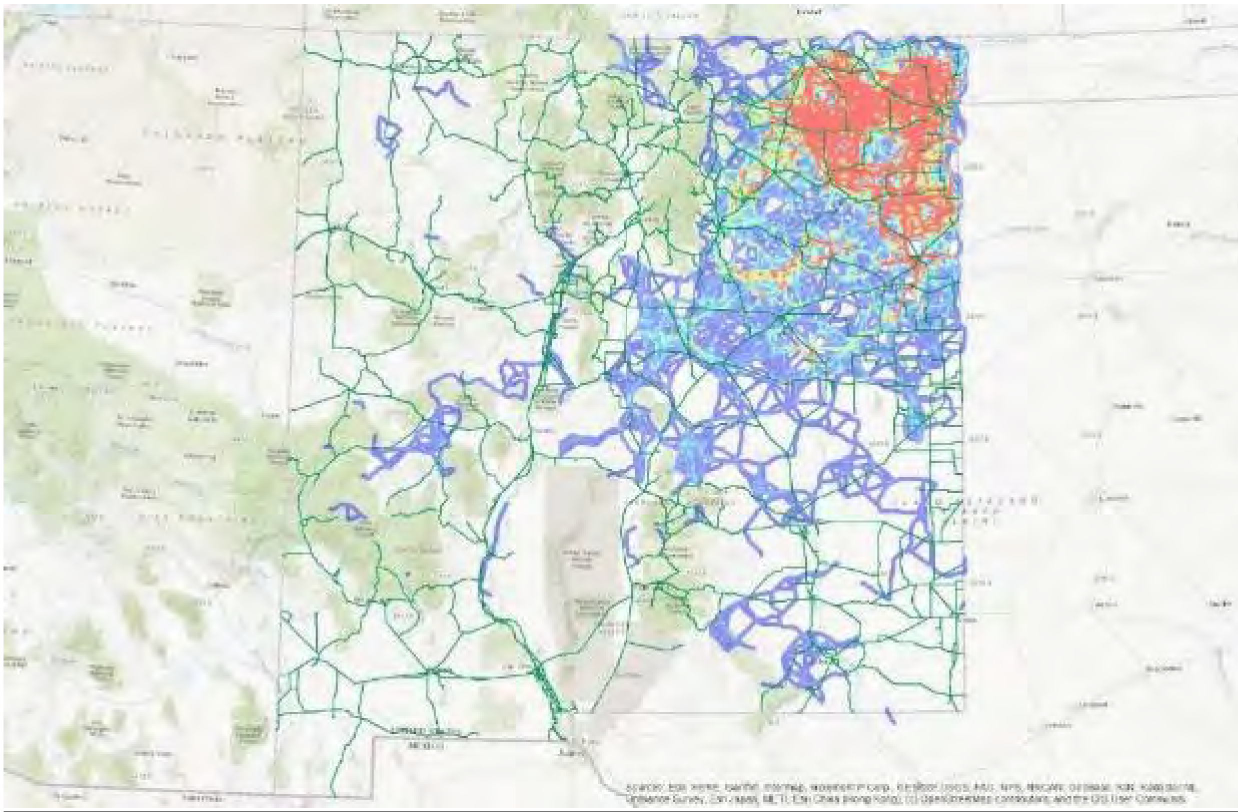

Figure 5-17. Factorial least cost path density network for pronghorn across the full extent of New Mexico. The strength of the predicted corridor network is shown in a blue to red color map, with red areas predicted to have very strong least cost path linkages, blue areas predicted to have weak least cost path network linkages, and areas without paths predicted to not be optimal movement paths between any locations occupied by pronghorn.

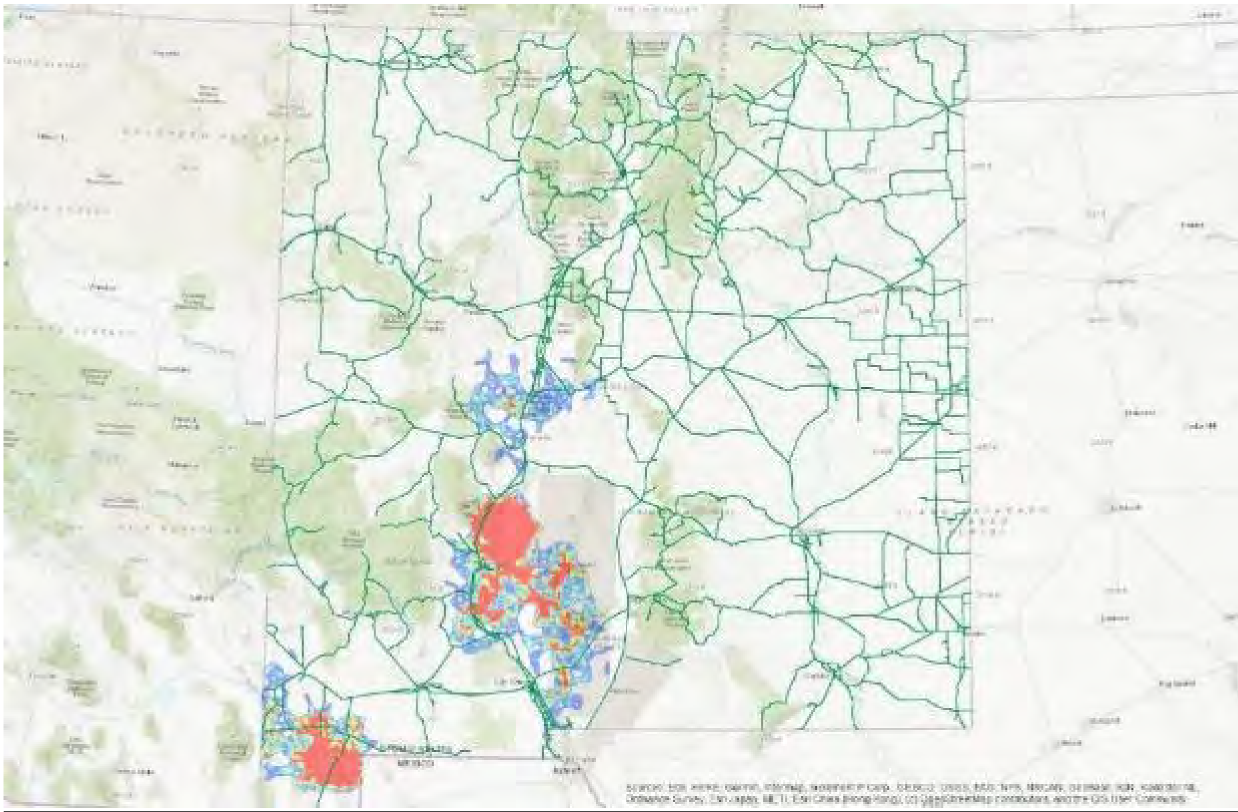

Figure 5-18. Factorial least cost path density network for desert bighorn sheep across the full extent of New Mexico. The strength of the predicted corridor network is shown in a blue to red color map, with red areas predicted to have very strong least cost path linkages, blue areas predicted to have weak least cost path network linkages, and areas without paths predicted to not be optimal movement paths between any locations occupied by desert bighorn sheep.

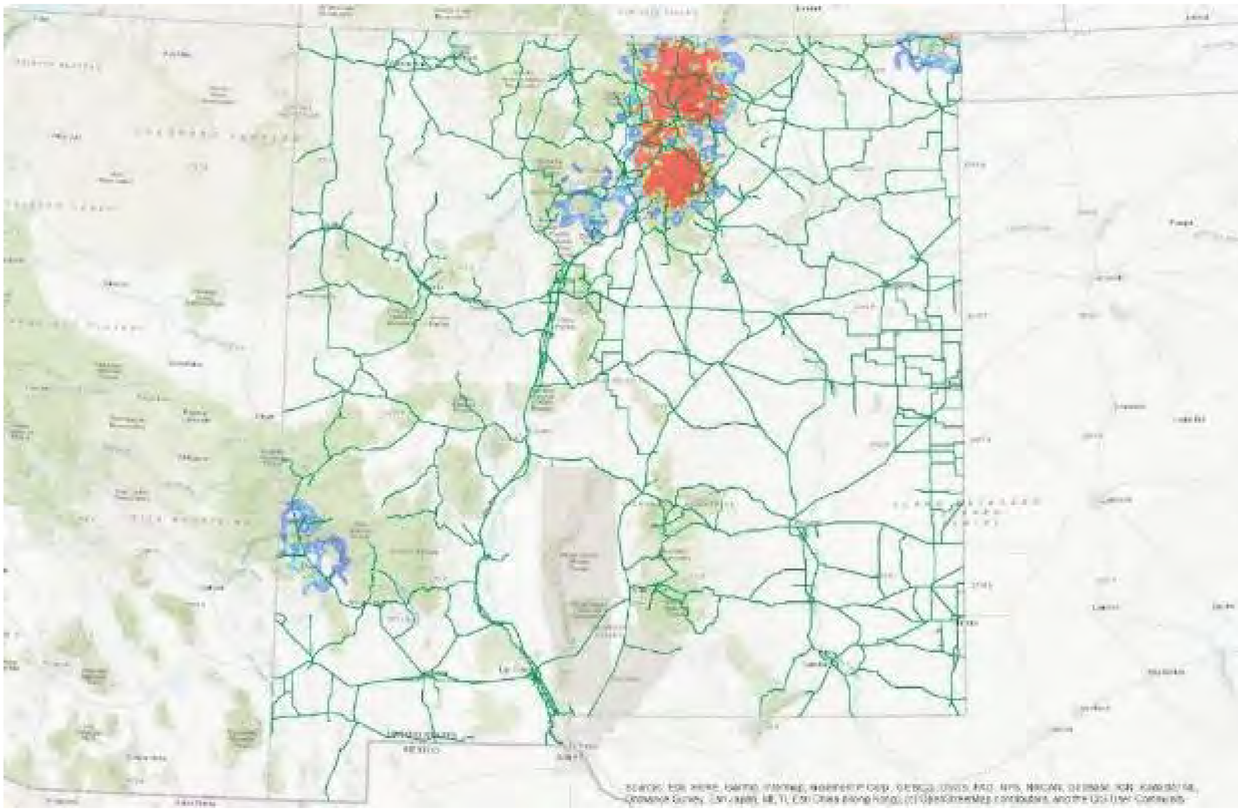

Figure 5-19. Factorial least cost path density network for Rocky Mountain bighorn sheep across the full extent of New Mexico. The strength of the predicted corridor network is shown in a blue to red color map, with red areas predicted to have very strong least cost path linkages, blue areas predicted to have weak least cost path network linkages, and areas without paths predicted to not be optimal movement paths between any locations occupied by Rocky Mountain bighorn sheep.

The October 24 and October 28, 2020 model iterations were also detailed with many maps of where the least cost factorial models predicted each of the six focal species would be involved in vehicle conflict. These details helped NMDGF biologists select wildlife corridors most important to the agency. Figure 5-20 is a compilation of the roads the model predicted would be the top areas of wildlife-vehicle conflict for each of the six focal species.

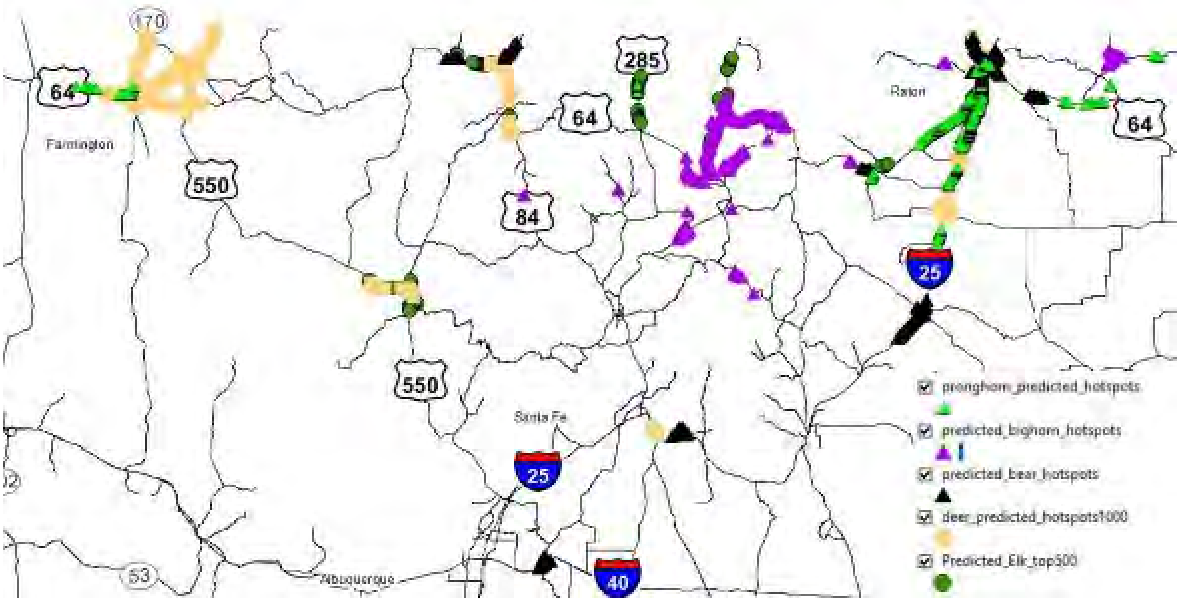

Figure 5-20. Top wildlife corridors across New Mexico roads for each of the six focal species based on connectivity modeling results from October 28, 2020 models.

The December 17, 2020 model calibration used mule deer, elk, and pronghorn telemetry data to further refine the model maps. Figures 5-21 and 5-22 display the top two overall single best predictor layers for multi-species habitat patches and connectivity based on verification with NMDGF northern New Mexico telemetry movement data for mule deer, elk, and pronghorn using random forest machine learning calibration.

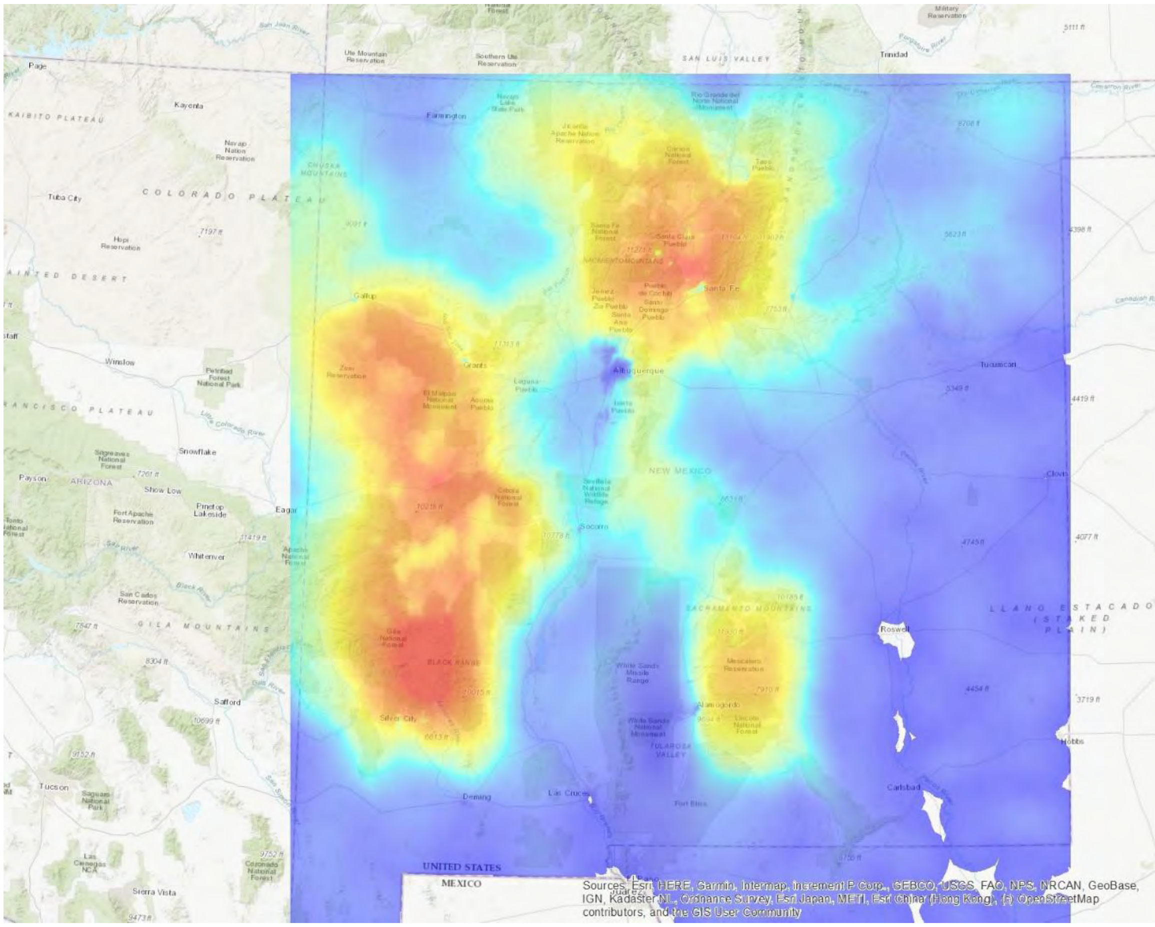

Figure 5-21. The 400,000 cost unit cougar resistant kernel model, which was the best overall single predictor layer for multi-species connectivity based on predicted risk of telemetry movement data using random forest machine learning calibration. Hotter colors denote habitat patches and top predicted wildlife corridors.

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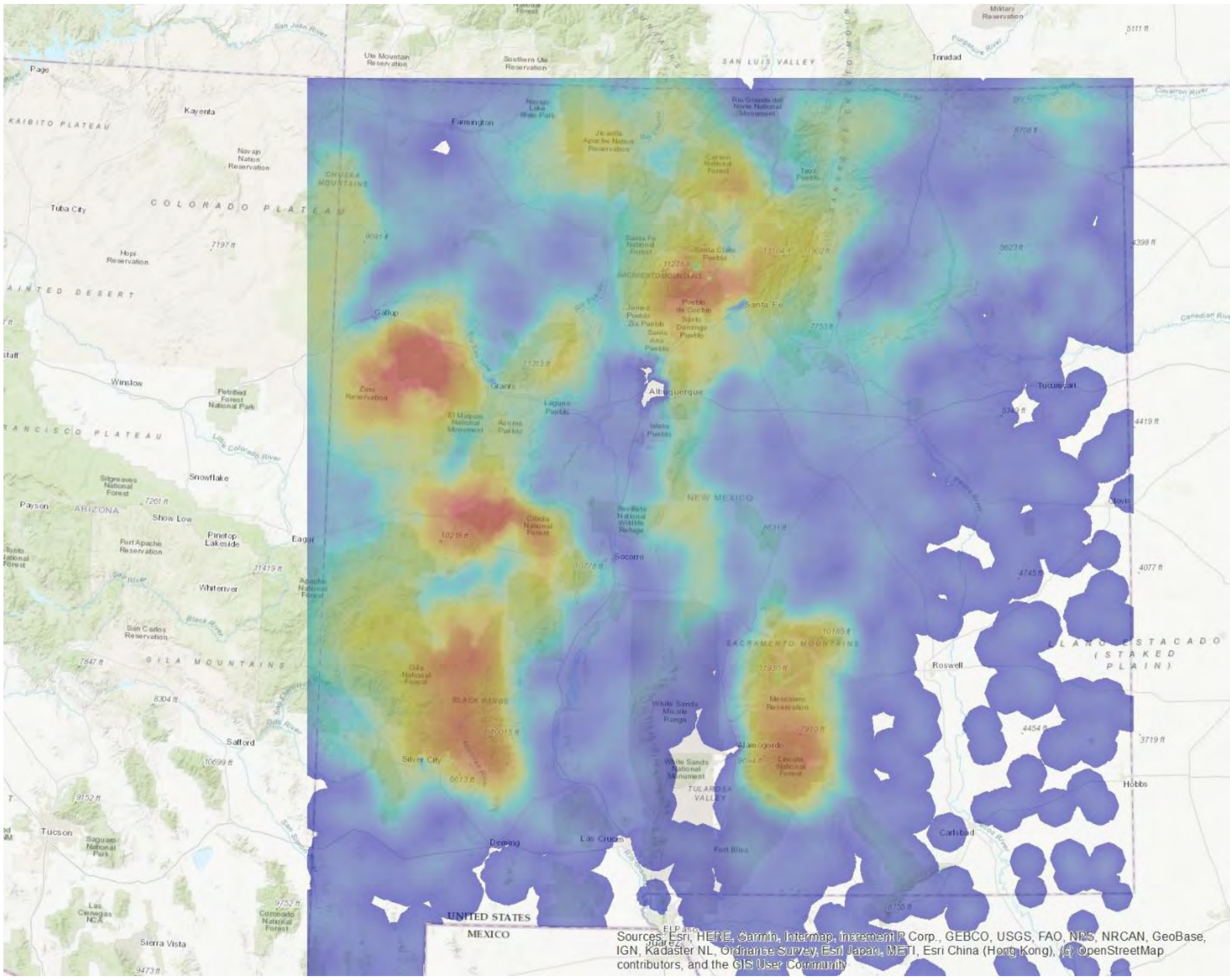

Figure 5-22. The 200,000 cost unit cougar resistant kernel model, which was the second best overall single predictor layer for multi-species connectivity based on predicted telemetry movement using random forest machine learning calibration. Hotter colors denote habitat patches and top predicted wildlife corridors.

5.2.5 Discussion of Models

The second set of iterations of connectivity maps proved to be a great improvement on the first set. It gave fairly accurate predictions of where NMDGF had GPS data collared animals belonging to the six focal species. However, the GPS collar data had very limited coverage across the state, and the models were only as accurate as the data placed into them. For example, the maps are lacking in the identification of pronghorn in areas in the state where there are known but uncollared populations, such as southern New Mexico. GPS movement data were provided for the unusual herd of pronghorn in northern New Mexico that migrates

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across mountain ranges, but models based on these atypical movements should not be extrapolated across the state. Most notably, the mule deer model, while accurate in what it does predict, failed to predict the areas where hundreds to thousands of mule deer have been recorded in WVCs across the state.

Overall, the modeling results in some specific areas were helpful to NMDGF when analyzing areas in northern New Mexico where the agency had ample data to substantiate those results. A step in the factorial least cost path models was zooming in to the model results for the top areas where each species was predicted to have conflict across the roads. The October 5, October 24, and October 28, 2020 modeling iterations generated hundreds of figures predicting top areas of wildlife movement across roads and associated mortality. For example, in the October 5, 2020 modeling, a top predicted black bear wildlife-vehicle conflict area was Glorieta Pass (Figure 5-23). NMDGF used this map to help support its recommendation of this area as a top wildlife corridor for the Action Plan, although it was ultimately prioritized as the number 5 hotspot instead. In the NMDGF recommendations (Section 5.3), dozens of these maps are referenced to help support the agency's recommendations.

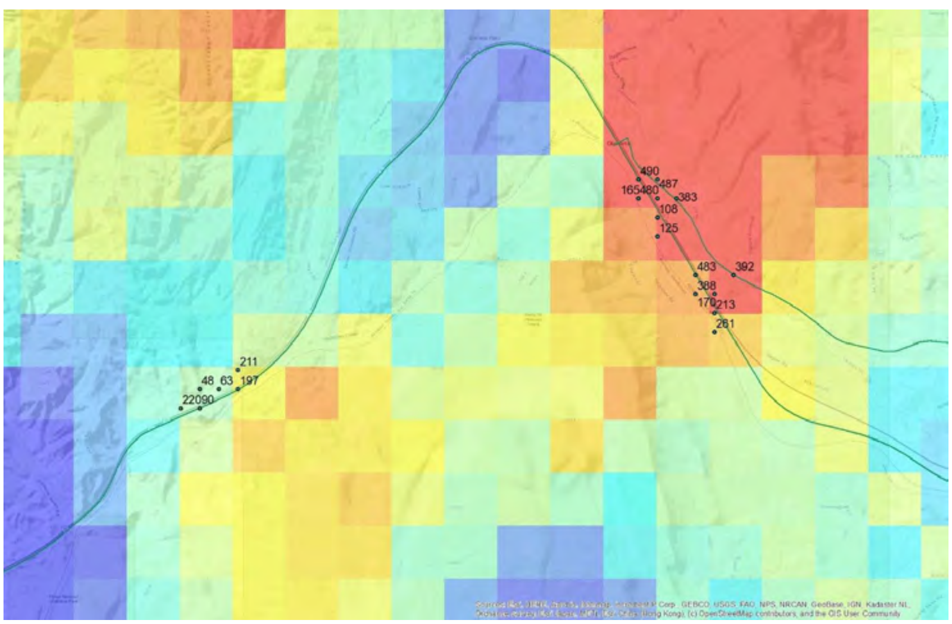


Figure 5-23. Black bear priority road-crossing location on I-25 at Glorieta Pass, as predicted by the October 5, 2020 model results. Top priority areas are in red pixels.

The map shown in Figure 5-23 summarizes the value of the habitat connectivity modeling to New Mexico. The WVC hotspot maps and the wildlife-vehicle crash data were used to substantiate this map.

Earlier iterations of models without respect to traffic volume and without telemetry data and crash data calibrations looked very similar to maps produced in the final model. For comparison, Figure 5-11 from early model iterations of state connectivity for all six focal species was highly similar to Figure 5-21 for all six focal species once additional data and model iterations were completed in the process.

With these examples in mind, the habitat linkage modeling was aspirational and informative, but needed additional verification and research endeavors to help inform the selection of wildlife corridors.

5.3 NMDGF Selection of Wildlife Corridors

NMDGF used unpublished big game GPS collar movement data, the results of the habitat linkage modeling, other sources of large game animal movement data, expert opinion of NMDGF Wildlife Management Division biologists, and previous connectivity reports to identify the top 10 priority areas representing habitat linkages and wildlife corridors intersecting high-traffic-volume roads across New Mexico. Prior to the development of this top 10 linkages list, NMDGF also recommended a linkage in the northern Taos Mountains that extended from Questa to Red River. Therefore, 11 linkages were recommended in total. Selection of all prioritized linkages and corridors was based on data and model results that indicated the importance of habitat connectivity across these highways for the six focal large mammal species.

5.3.1 Methods

The top priority habitat linkages were selected based on the following sources:

- Unpublished NMDGF large ungulate GPS radio collar movement data
- One or more focal large mammal species' least cost path and resistant kernel modeling results developed by the research team and reported in this chapter
- The NMDGF S.O. Action Plan identifying New Mexico's priority landscapes for big game winter range and migratory movements (NMDGF, 2020)

- Input from NMDGF Wildlife Management Division big game biologists regarding seasonal migratory movements of wildlife with respect to roads and vehicle traffic
- Large ungulate GPS and radio collar data from other New Mexico studies (e.g., Tator, 2016 and 2020)
- NMDGF "Share with Wildlife" cougar corridor modeling (Menke, 2008)
- Dr. J. Cain of the U.S. Geological Survey (USGS) New Mexico Cooperative Fish and Wildlife Research Unit, New Mexico State University GPS collar data for elk and mule deer (USGS, in press)
- Large game animal-vehicle collision accident report data
- The Wildlands Network's report, New Mexico Highlands Wildlands Network Vision (Forman et al., 2008)

Team member Mark Watson of NMDGF led the effort to finalize the ranking of wildlife habitat linkages.

The NMDGF S.O. Action Plan (NMDGF, 2020) was an important document that helped direct the selection of priority wildlife linkages for this draft Action Plan. In the S.O. Action Plan, NMDGF identified high priority landscapes for big game movement based on important known or presumed migration movements that were lacking actual GPS collar movement data. Five priority landscapes were selected: (1) Northwestern Landscape, (2) Northcentral Landscape, (3) Northern Sangre de Cristo Landscape, (4) I-25 Corridor from Las Vegas North to the Colorado Border, and (5) Southeastern Plains. Funding obtained by NMDGF after the development of the S.O. Action Plan is currently being used to deploy GPS collars on mule deer, elk, and pronghorn to assess seasonal migratory movements, important breeding and wintering ranges, and stopover areas within these high priority landscapes.

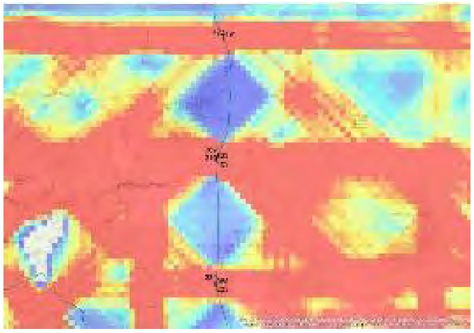
5.3.2 Results

The top 10 wildlife corridors selected by NMDGF are presented in the following subsections, together with the most pertinent maps from the habitat linkage modeling. A 2019 New Mexico State Game Commission fair chase regulation prohibits the distribution of wildlife locality data collected by NMDGF, so no wild ungulate telemetry maps are included in the Action Plan.

5.3.2.1 U.S. Highway 285 North of Tres Piedras

This wildlife corridor is supported by Action Plan models and NMDGF unpublished GPS radio collar data for elk and pronghorn. It is also within the S.O. Action Plan high priority Northcentral Landscape. The Taos Plateau east of US 285 is important winter range for elk and pronghorn, which move across US 285 to higher elevation calving/fawning range west of US 285. This corridor is also supported by Presidential Proclamation 8946 declaring establishment of the Rio Grande del Norte National Monument, which recognized the importance of the national monument (both sides of US 285) to big game migration and habitat connectivity. Wildlife-transportation conflict mitigation offers partner opportunities with the Bureau of Land Management (BLM) Taos Field Office, which manages the national monument, and the Carson National Forest, which manages some of the calving and fawning habitat in the Tusas/South San Juan Mountains.

The habitat linkage modeling conducted for the development of this Action Plan supported prioritization of this linkage, as mapped in three habitat linkage model iterations in October 2020 (Figure 5-24).



a (Elk)

b (Elk)

c (Elk)

d (Elk)

e (Elk)

f (Elk)

g (Elk)

h (Pronghorn)

Figure 5-24. Habitat linkage modeling results in support of where elk and pronghorn are predicted to cross US 285 north of Tres Piedras.

5.3.2.2 U.S. Highways 64/84 South of Tierra Amarilla to Chama

This corridor/linkage was supported by this Action Plan's mule deer and elk models, NMDGF unpublished GPS radio collar data for mule deer, and other GPS collar movement data for mule deer and elk. This area is also supported by the S.O. Action Plan high priority Northcentral Landscape. Mule deer occupy winter range near and around Heron and El Vado Reservoirs, and cross US 64/84 south of Chama to higher elevation fawning habitat in the Tusas/South San Juan Mountains. Wildlife-transportation conflict mitigation efforts offer partner opportunities with NMDGF, which owns the Rio Chama Wildlife Management Area just east of El Vado Reservoir, the Carson National Forest, which manages some of the calving and fawning habitat in the Tusas/South San Juan Mountains, and the Jicarilla Apache Tribe, which owns Tribal land on both sides of US 64/84 south of Chama. See Figure 5-25 for greater modeling details on where these species were expected to cross US 64 and US 84.

a (Elk)

b (Elk)

c (Mule Deer)

d (Mule Deer)

e (Elk)

Figure 5-25. Linkage modeling predicted locations where mule deer and elk are in conflict with vehicles on US 64 and US 84, south of Tierra Amarilla to Chama.

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5.3.2.3 U.S. Highways 64/84 West of Chama to US 64/84 Junction

This corridor's importance for wildlife was supported by this Action Plan's habitat linkage models for mule deer and elk, unpublished NMDGF GPS radio collar data for mule deer, published Jicarilla Apache Tribe elk GPS radio collar data (Tator, 2016), and mule deer data (Tator, 2020). This corridor is also supported within the S.O. Action Plan high priority Northcentral Landscape. Mule deer occupy winter range near and around Heron and El Vado Reservoirs, and cross US 64/84 west of Chama to reach higher elevation fawning habitat in the southern San Juan Mountains. Actions in this corridor offer partner opportunities with the Jicarilla Apache Tribe, which owns Tribal lands north of the reservoirs, NMDGF, which owns the Humphries and Sargent Wildlife Management Areas north and south of US 64/84 west of Chama, and possibly private landowners along the linkage. Figure 5-26 shows where the linkage modeling predicted mule deer and elk are and will be involved in wildlife-vehicle conflict.

a (Elk)

b (Elk)

c (Mule Deer)

d (Elk)

e (Elk)

Figure 5-26. Linkage modeling predicted locations where mule deer and elk are in conflict with vehicles on US 64 and US 84, Chama.

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5.3.2.4 US 84 from US 64/84 Junction West of Chama North to Colorado Border

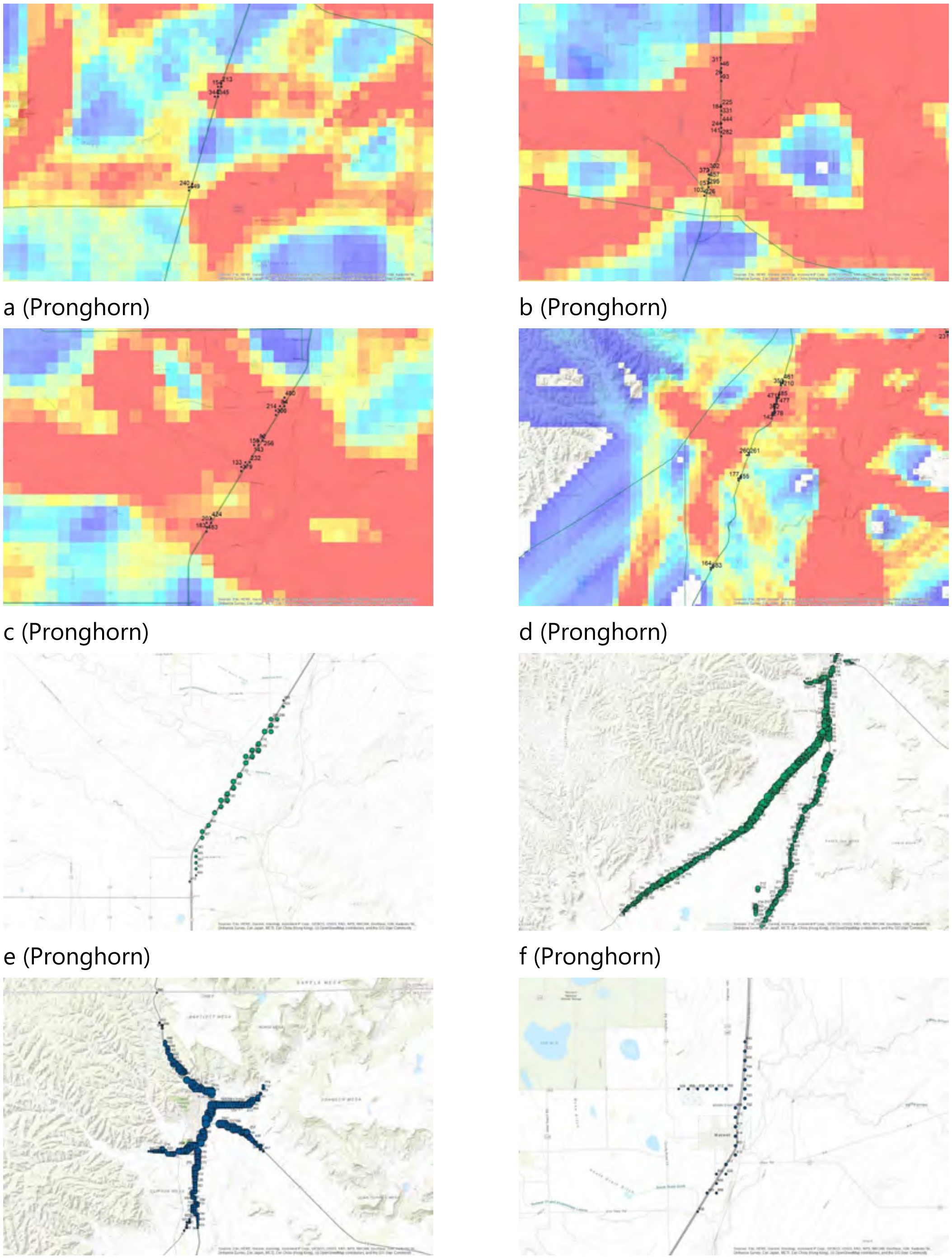
This corridor is supported by this Action Plan's habitat linkage models largely for elk, published Jicarilla Apache Tribe elk GPS radio collar data (Tator, 2016) mule deer GPS collar data (Tator, 2020), and the S.O. Action Plan high priority Northcentral Landscape. This corridor offers the same partner opportunities as above Chama corridors. Figure 5-27 shows pertinent linkage modeling results in support of this corridor, as does Figure 5-26.

Figure 5-27. Linkage modeling predicted locations where elk are in conflict with vehicles on US 64 and US 84, Chama.

The three wildlife linkages in these areas around Chama were combined into a single Chama linkage.

5.3.2.5 I-25 South of Raton to Maxwell Primarily for Pronghorn

The corridor is supported by the Action Plan's models for pronghorn, mule deer, and elk (Figure 5-28). This linkage is also supported by the S.O. Action Plan as part of the I-25 Las Vegas to Colorado priority landscape for pronghorn habitat connectivity. Partner opportunities may be largely limited to private landowners although both Maxwell National Wildlife Refuge (NWR) and the U.S. Bureau of Reclamation (USBR) both also have abutting lands.



a (Pronghorn)
b (Pronghorn)
c (Pronghorn)
d (Pronghorn)
e (Pronghorn)
f (Pronghorn)
g (Mule Deer)
h (Mule Deer)

Figure 5-28. Linkage modeling predicted areas where mule deer and pronghorn are predicted to come in conflict with roads and vehicles south of Raton.

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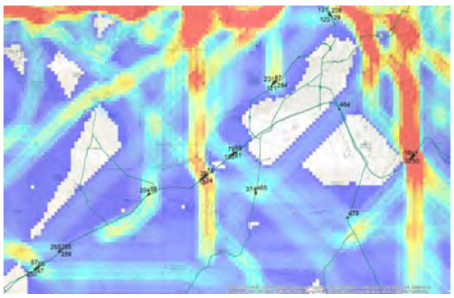
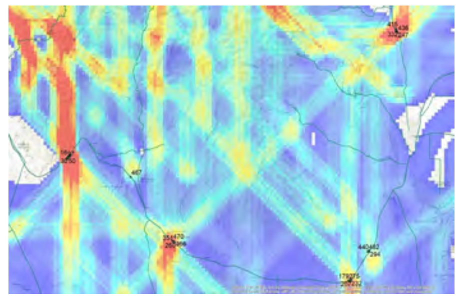
5.3.2.6 I-25 Glorieta Pass to Cañoncito

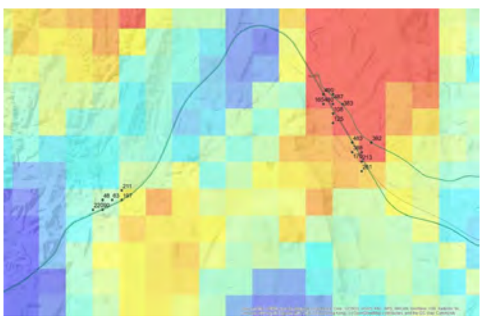
The selection of this corridor is supported the Action Plan habitat linkage models for elk, black bear, and cougar (Figure 5-29). Santa Fe National Forest submitted a supporting letter and could be a future partner, and the National Park Service Pecos National Monument could also become another mitigation partner. Note that this area is also a mule deer collision hotspot (Chapter 4), perhaps indicating the presence of an "urbanized" deer herd that routinely crosses I-25 to get food and water at the Glorieta camp, with those types of herd behavior/movements not represented by the resistance layer for mule deer.



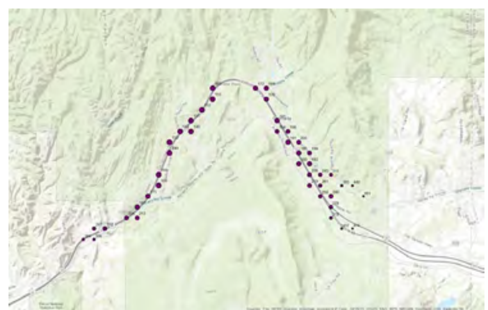
a (Elk)



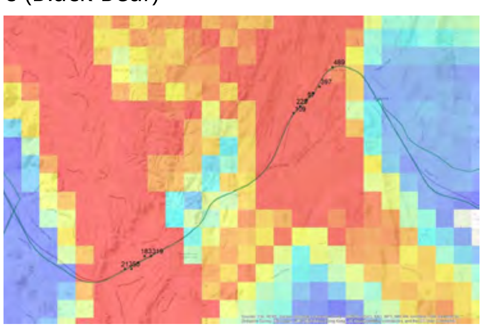
b (Elk)



c (Black Bear)



d (Black Bear)



e (Cougar)

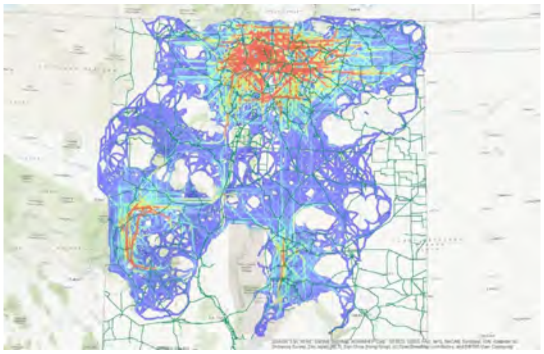
Figure 5-29. Linkage modeling predicted areas where elk, black bear, and cougar are predicted to come in conflict with I-25 at Glorieta.

5.3.2.7 I-10 Steins/Peloncillo Mountains at New Mexico-Arizona Border

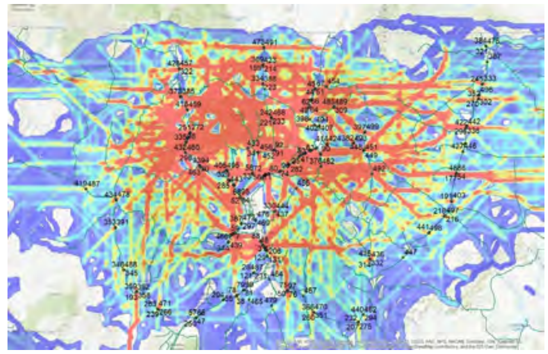
This wildlife corridor is supported by NMDGF Wildlife Management Division staff expert opinion and NMDGF and AZGFD desert bighorn GPS collar data. I-10 is a known major barrier to habitat connectivity for desert bighorn sheep populations on both the north and south sides of this major interstate. There is at least one known desert bighorn sheep roadkill mortality (NMDGF unpublished data). Partner opportunities include AZGFD, New Mexico State Lands Office, BLM, Wild Sheep Foundation, Malpais Borderlands Group, and Wildlands Network major donors. This area was not indicated as a priority area in the Action Plan habitat linkage modeling. However, other entities, as described later in the chapter, did have data on the potential of connectivity for wildlife in the Peloncillo Mountains with implementation of future wildlife crossing structures.

5.3.2.8 New Mexico Highway 4 Jemez Mountains

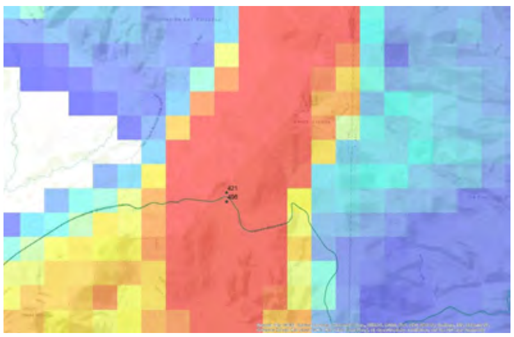
This corridor was supported by Action Plan habitat linkage models for elk, black bear, and cougar (Figure 5-30). Dr. J. Cain of the USGS New Mexico Cooperative Fish and Wildlife Research Unit, New Mexico State University also provided GPS collar data for elk and mule deer (USGS, unpublished data) which supported protecting wildlife linkages in this area. Partnership opportunities are possible with the Jemez Pueblo, Santa Fe National Forest, Valles Caldera National Preserve, and Bandelier National Monument.



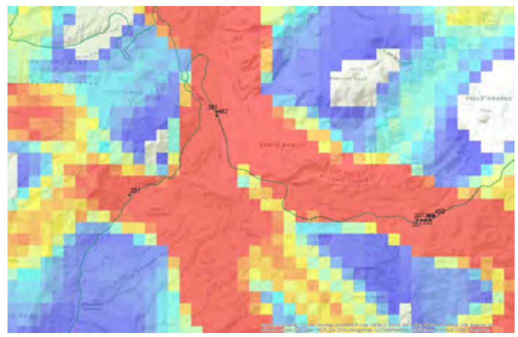
a (Elk)



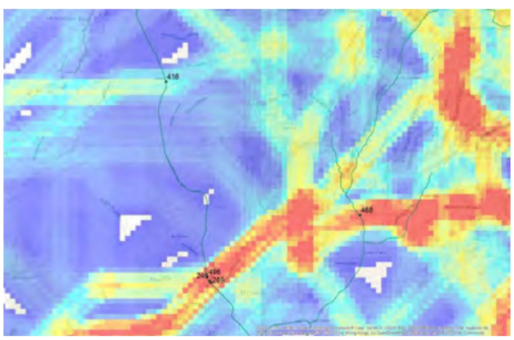
b (Elk)



c (Black Bear)



d (Black Bear)

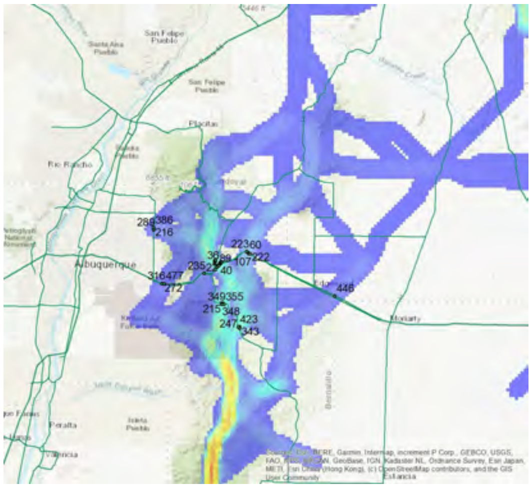


e (Cougar)

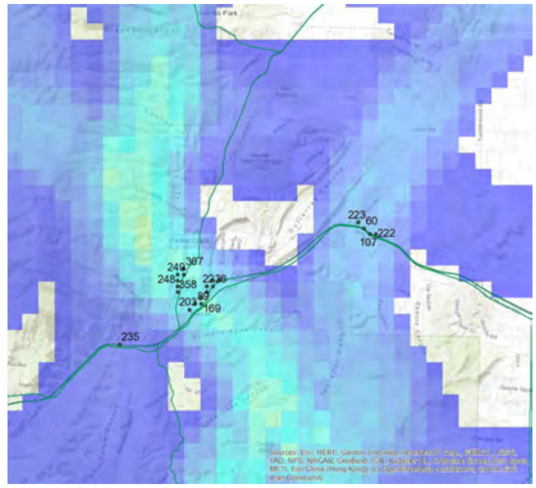
Figure 5-30. Linkage modeling predicted areas where elk, black bear, and cougar are predicted to come in conflict with NM 4 in the Jemez Mountains.

5.3.2.9 I-40 and NM 333 in Tijeras Canyon

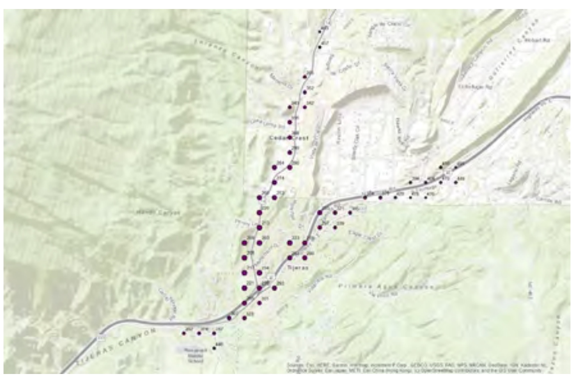
The identification of this corridor is supported by this Action Plan's habitat linkage models for black bear and cougar (Figure 5-31). Dr. T. Perry (Furman University) also provided cougar GPS collar data that indicated this area was important to cougar movements. The Menke (2008) cougar corridor model, NMDOT Research Branch camera monitoring data for mule deer and cougar, and New Mexico Highlands Wildlands Network Vision (Foreman et al., 2003) all identified this area as a high wildlife corridor priority for New Mexico. Potential partner opportunities include Cibola National Forest, Albuquerque and Bernalillo County Open Space programs, Sandia Bear Watch, and other local conservation groups.



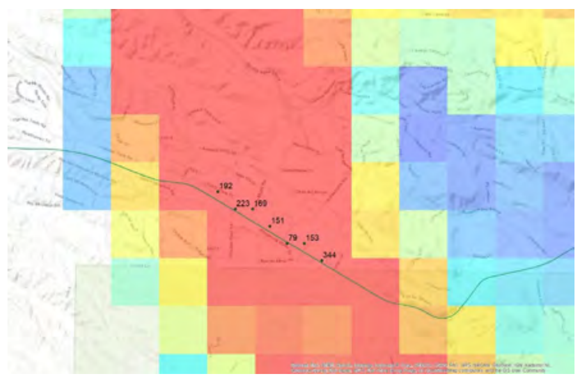
a (Black Bear)



b (Black Bear)



c (Black Bear)



d (Cougar)

Figure 5-31. Linkage modeling predicted areas where black bear and cougar are predicted to come in conflict with I-40 and NM 333 and traffic in Tijeras Canyon.

5.3.2.10 U.S. Highway 70, San Augustin Pass

This corridor was supported by this Action Plan’s habitat linkage model for desert bighorn (Figure 5-32). There are also unpublished NMDGF bighorn GPS radio collar data that support this corridor, as does the cougar corridor model (Menke, 2008) and New Mexico Highlands Wildlands Network Vision (Foreman et al., 2003). Partner opportunities include the BLM, which manages the Organ Mountains–Desert Peaks National Monument, New Mexico State Lands

Office, U.S. Army's White Sands Missile Range, and U.S. Fish and Wildlife Service's San Andres National Wildlife Refuge.

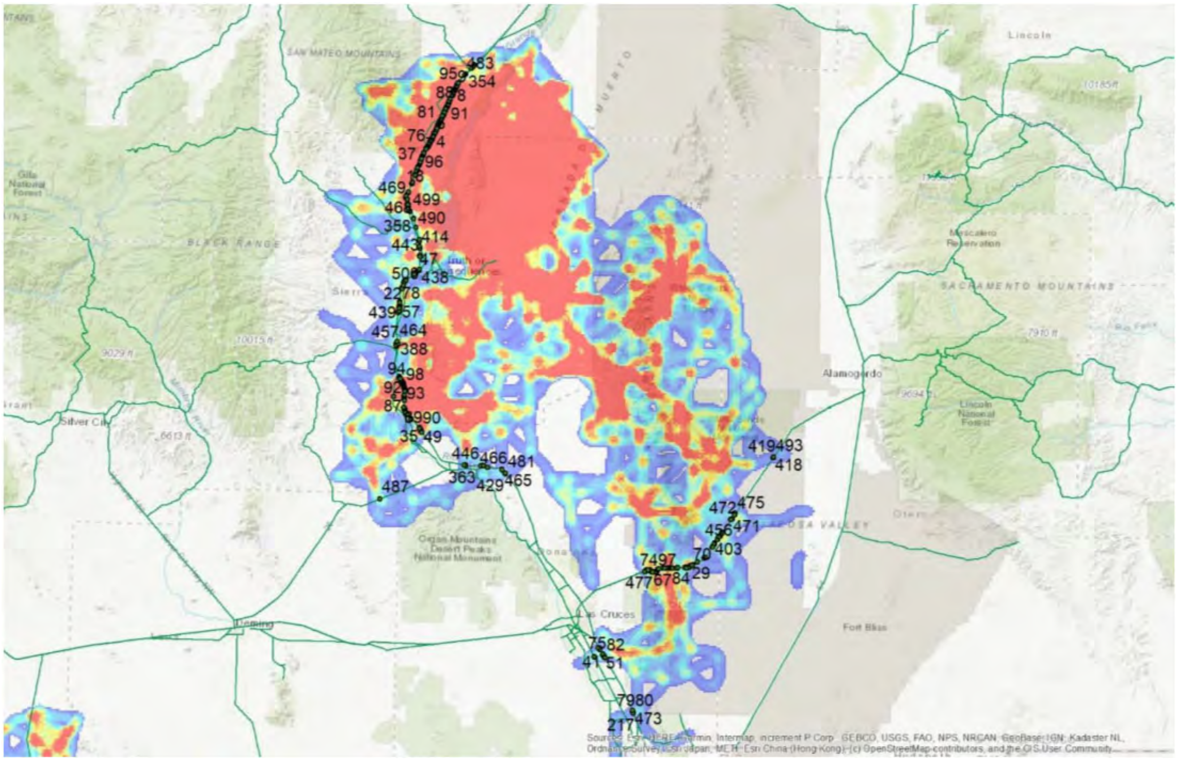


Figure 5-32. **Linkage modeling predicted area where desert bighorn sheep are predicted to come in conflict with US 70 at San Augustin Pass.**

The following linkage was proposed by NMDGF early in the Action Plan process and was already a priority project when the top 10 linkages above were formulated. It is the eleventh linkage proposed by NMDGF.

5.3.2.11 New Mexico Highway 38 Questa to Red River

This corridor/linkage in the northern Taos Mountains was supported by unpublished NMDGF GPS radio collar data for Rocky Mountain bighorn sheep and accident report data that document multiple bighorn mortalities from WVC and one human fatality. This linkage was also identified by NMDGF bighorn biologists as the most important Rocky Mountain bighorn sheep movement corridor for metapopulation habitat connectivity in the state. This linkage is also included in the NMDGF S.O. Action Plan Northcentral New Mexico priority area. Wildlife-

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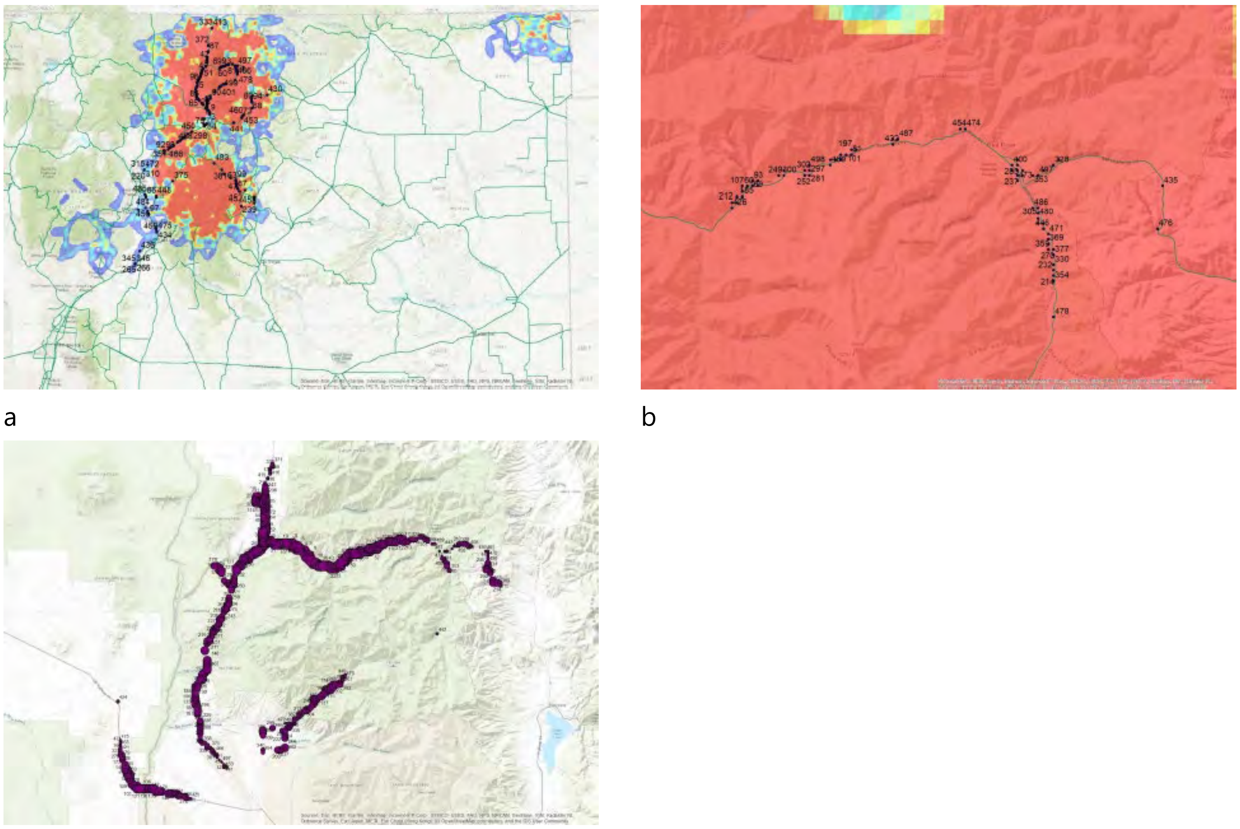
transportation conflict mitigation will also benefit elk, mule deer, black bears, and cougars. Partner opportunities exist with the Carson National Forest and the Questa Mine.

The habitat linkage modeling conducted for the development of this Action Plan supported prioritization of this corridor (Figure 5-33).



a

b

c

Figure 5-33. Linkage modeling predicted area where Rocky Mountain bighorn sheep are predicted to come in conflict with NM 38.

These 11 corridor priorities were then discussed among the researchers and agency panel members and several actions ensued. First, all three corridors near Chama were combined into one Chama corridor. Second, additional data, models, maps, public, Tribal, and agency input were considered and the final five project corridors were selected. The following section describes those other inputs.

5.4 Other Sources Used to Select Wildlife Corridors

This is not the first mapping of wildlife corridors in New Mexico, and all efforts were made to gather information from previous wildlife corridor mapping efforts, GPS and radio collar data from animals of the six focal large mammal species, reports, data and maps from Tribal and non-profit entities, and citizens concerned with New Mexico wildlife corridors. These pieces of information were brought together for the top 10 linkages prioritized by NMDGF, and for additional potential linkages and corridors others prioritized.

5.4.1 Tribal Input on Potential Wildlife Linkages and Corridors

Native Tribes in New Mexico manage wildlife on their lands. The larger Tribes have natural resource agencies and some have wildlife ecologists concerned with large wild mammals. All New Mexico Tribes were contacted (see Chapter 3 for details) to ask for any data, maps, reports, or information they wanted to share with the Action Plan team to help identify top areas for mitigation in wildlife-vehicle conflict areas. Several Tribes provided pertinent information. The Tribal lands in New Mexico are presented in Figure 5-34.

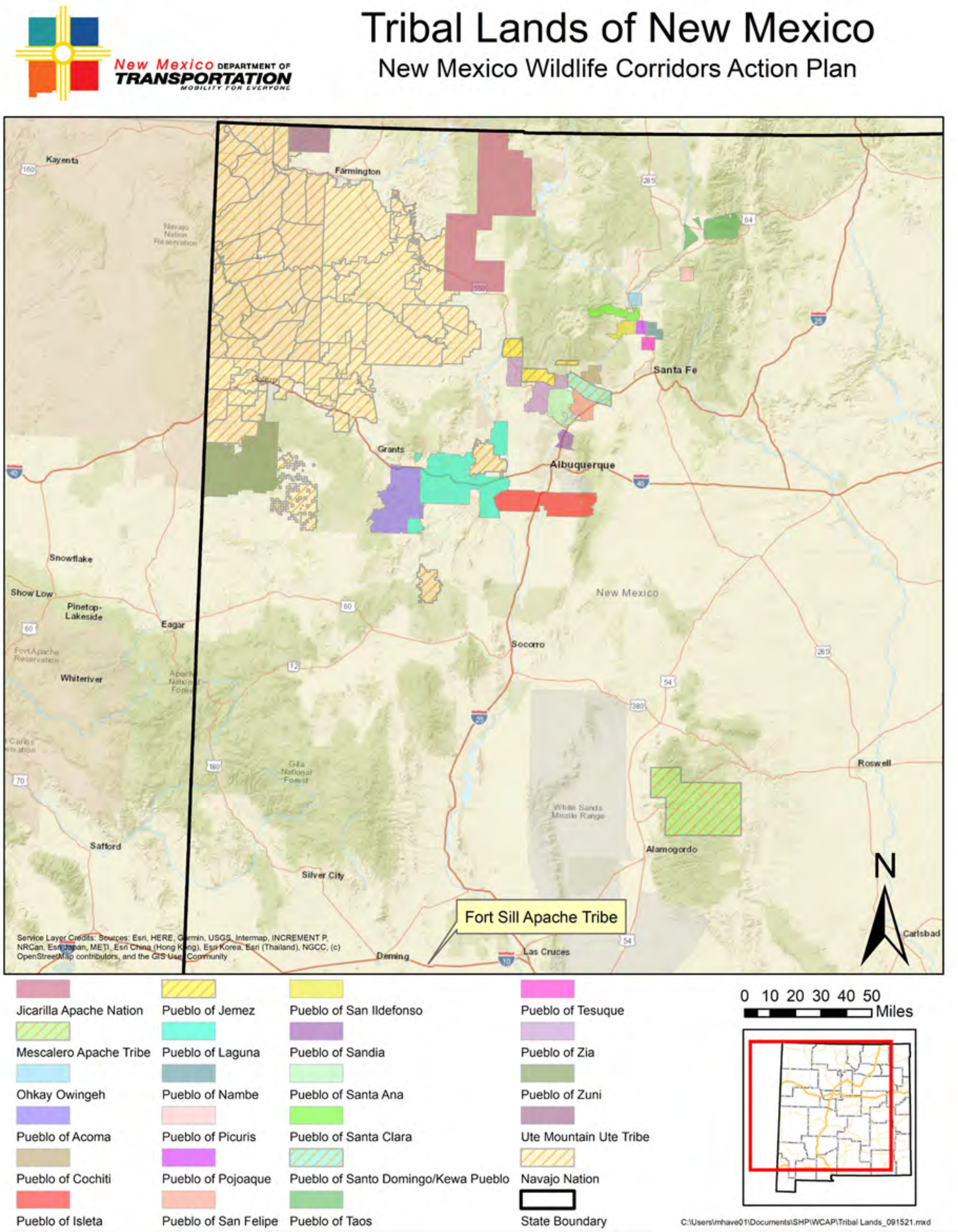


Figure 5-34. Tribal lands in New Mexico.

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5.4.1.1 *Jicarilla Apache Nation*

The Jicarilla Apache Nation in northern New Mexico has a robust wildlife management program. Ongoing studies by the Jicarilla Apache Nation Department of Game and Fish, starting from 1983, have revealed mule deer and elk movements across US 64 and US 84 in numerous spots in a linkage near Chama (Tator, 2016 and 2020; Watts, 2014). Elk have consistently been radio and GPS tracked crossing US 64/US 84 at the Humphries State Wildlife Management Area (WMA) (MP 148 to 151) and have overwintered on the south and west side of US 64 from Humphries WMA, south to Tierra Amarilla. The 2011 Rosa Mule Deer Study (Sawyer et al., 2011) tracked deer west of the area, and also demonstrated mule deer crossing US 84 just south of the Colorado border (Watts, 2014). According to NMDGF, elk and mule deer winter near El Vado and Heron Reservoirs on the south and west sides of this linkage (NMDGF, unpublished data). This information and these studies show that elk and mule deer have distinct migratory patterns for accessing summer and winter ranges (Figure 5-35). There are year-round residents in this landscape as well. The Jicarilla Apache Nation's big game biologist worked closely with the Wildlife Corridors Action Plan team in identifying the specific locations for wildlife mitigation across roads in this area.

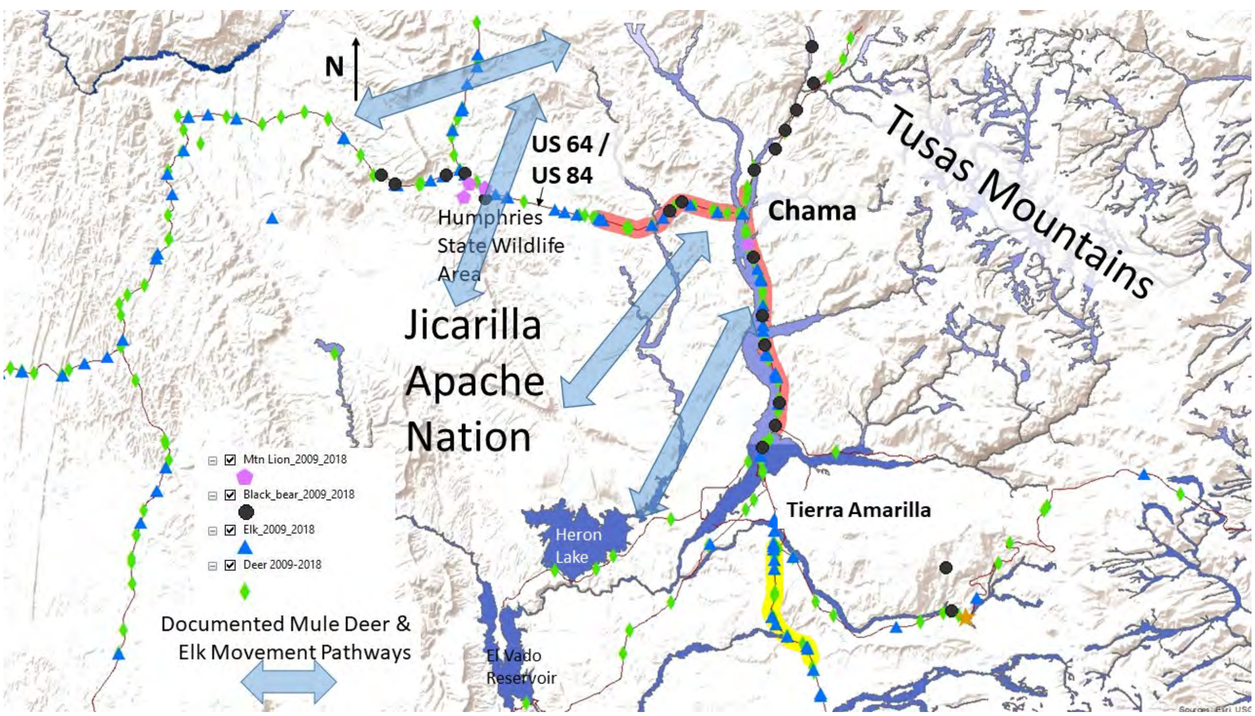

Figure 5-35. Mule deer and elk documented movement corridors near Chama.

5.4.1.2 Mescalero Apache Tribe

The Mescalero Apache Reservation lies in south-central New Mexico in the Sacramento Mountains and on the east side of the US 70 Bent hotspot. The Tribal government shared wildlife-vehicle crash data with the Action Plan development team. They also provided information on potential management actions, including placing water guzzlers for elk outside of the US 70 area to try to coax animals away from the highway. There were no identified linkages in the Tribe's area, so the information was largely used in the identification of WVC hotspots and potential project solutions. The Tribe gave their full support for this Action Plan.

5.4.1.3 Pueblo of Santa Ana

The wildlife movement data collected from GPS collars placed by the Department of Natural Resources at the Pueblo of Santa Ana were extremely helpful in demonstrating where mule deer, elk, pronghorn, black bear, and cougar move across the landscape north, northeast, west, and northwest of Bernalillo (Figure 5-36). The Tribal wildlife ecologist who conducted the wildlife studies and collected the crash and carcass data was instrumental in helping to identify this area and locate potential wildlife mitigation opportunities along I-25 and US 550 in this area.

5.4.1.4 San Felipe Pueblo

San Felipe Pueblo shared a wildlife corridors map of where they identified important connections for wildlife movement across their and adjacent lands north of Bernalillo. A member of their natural resources department helped locate wildlife mitigation sites in the Sandia-Jemez Mountains Bernalillo linkage.

5.4.1.5 Tesuque Pueblo

The environmental biologist from the Tesuque Pueblo's Department of Environment and Natural Resources shared both mule deer GPS locational data and carcass data locations with the research team. These mule deer locations and crashes were in the WVC hotspot number 13 (US 285/US 84 north of Santa Fe). This area is important to wildlife movement, but the area did not make the top 10 corridors for wildlife.

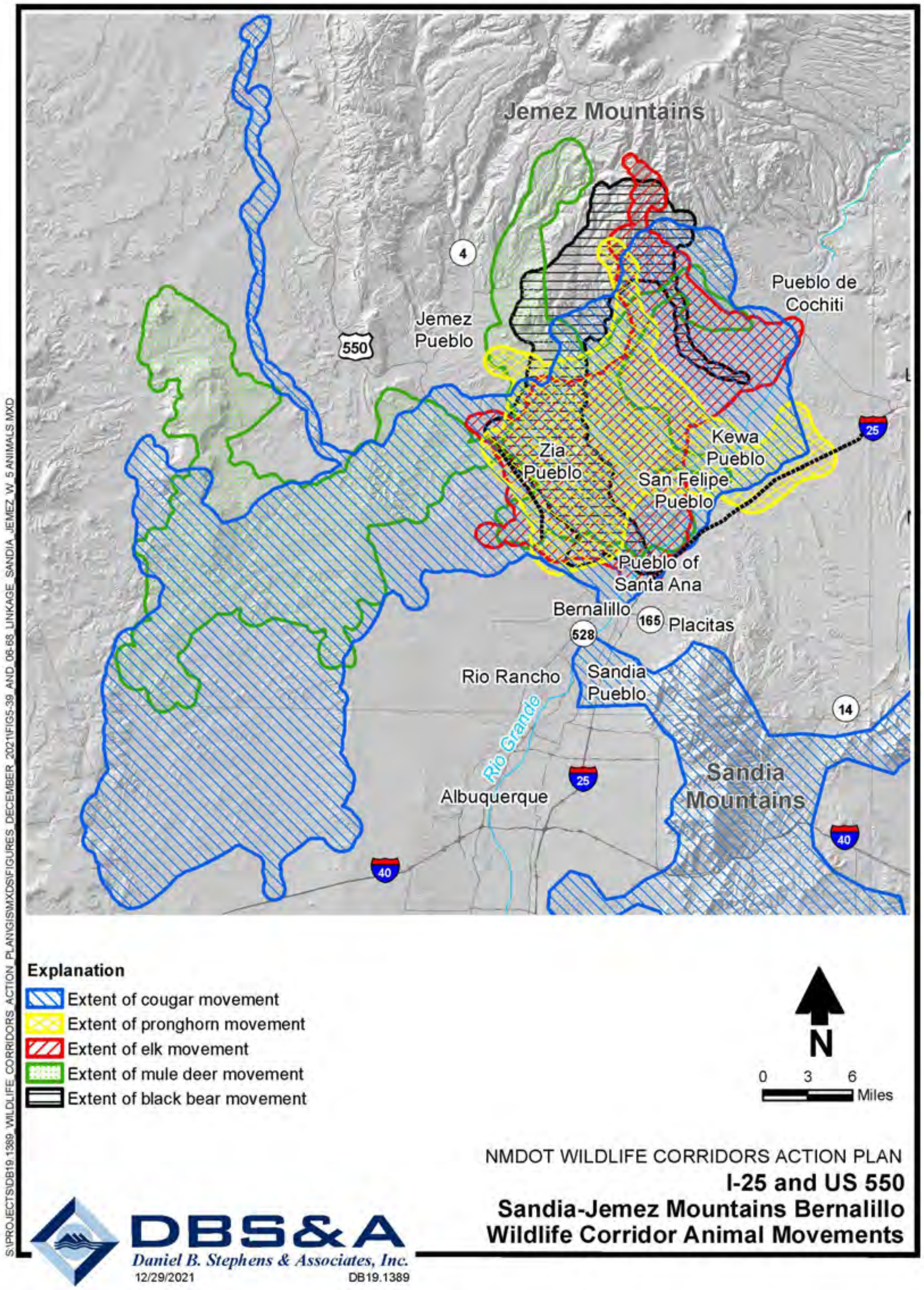

Figure 5-36. General wildlife movements in I-25 and US 550 Sandia-Jemez Mountains Bernalillo wildlife corridor. Based on data received from the Pueblo of Santa Ana's Range and Wildlife Division and Travis Perry's GPS collared cougars.

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5.4.1.6 Navajo Nation

The Navajo Nation's big game biologist worked with the research team to identify top WVC hotspots on Navajo Nation land in New Mexico, Arizona, and Utah. There are three top WVC hotspots on Navajo Land in New Mexico that they are concerned with, and that are recorded in the Action Plan for future actions:

- NM 134/Tribal Road 32 in the Chuska Mountains, from Crystal in the west to Sheep Springs in the east. Navajo Nation biologists have collared mule deer that demonstrated movements across this road and Tribal Road 12 to the southwest.
- Tribal Route 12 runs south to north along the Arizona-New Mexico border, north from Window Rock in Arizona near the border from Fort Defiance north to the Navajo Nation. The collared mule deer regularly move across this road.
- NM 264 Window Rock in the west to Yah-ta-hey in the east. This area is at the south end of the Chuska Mountains. It is a high traffic volume area. Mule deer are migrating through there in the spring and fall. The Navajo Nation recommends variable message boards, at a minimum during April and during the end of October into early December. There is a master's degree student who followed the GPS collared deer in the area, and they will have a Brownian Bridge movement map later in 2021 showing exactly where collared deer crossed.

The Navajo Nation traffic engineers shared animal crash data for 2015-2019. There were 371 recorded crashes. Of those crashes, 138 involved human injuries, and there were 2 fatal crashes, both in 2018. Annual animal crashes ranged from 51 in 2019 to 90 in 2016. These crash data were not included in the hotspot modeling. This was because the crashes involved wildlife, horses, cows, and burros. There was not a field for animal species in the crash data collected; therefore the wildlife crashes could not be filtered from overall animal crashes. A review of the crashes found that the following roads on Navajo Nation within New Mexico had the most animal crashes, listed in order of highest number of crashes to lower number of crashes: Tribal Road 12, US 160, NM 264, and US 491.

5.4.2 Research Models, Maps, Data, and Input from Agencies, Non-Profits, and the Public

The research team worked with NMDGF to reference pertinent reports and maps from past efforts to identify wildlife connectivity in New Mexico.

5.4.2.1 *Menke Cougar Connectivity Model*

In 2008, as a NMDGF-funded Share with Wildlife Program research project, K. Menke published the results of modeling cougar corridors in New Mexico using least cost path modeling. The results supported the prioritization of linkages in the Peloncillo Mountains bisected by I-10, US 70 at San Augustin Pass between the Organ and San Andres Mountains, I-40 through Tijeras Canyon between the Sandia and Manzano Mountains, a Jemez Mountains-Sandia Mountains linkage (across I-25), a Sangre de Cristo Mountains-Sandia Mountains linkage, and the San Juan Mountains-Taos Mountains corridor (Menke, 2008).

5.4.2.2 *Watts Study of the San Juan and Chama Watersheds*

The Chama Peak Alliance funded a study by Watts (2014) to compile GPS collar data and maps on mule deer and elk movements in the San Juan and Chama watersheds. The maps of where the collared animals used the landscape were helpful in identifying the wildlife linkage based in the Chama area of New Mexico.

5.4.2.3 *Wildlife Doorways of the Upper Rio Grande*

The Wildlife Doorways of the Upper Rio Grande was both a publication (Muldavin and McCullough, 2016) and series of workshops to collect all available spatial data on the occurrence and movement of wildlife in northern New Mexico and southern Colorado, in the region of the Upper Rio Grande. The resulting maps helped support the Action Plan team's choices in prioritizing wildlife corridors in the northern landscapes of New Mexico.

5.4.2.4 *Past Legislated Maps of Wildlife-Vehicle Conflict*

For House Memorial 1-Senate Memorial 11, NMDOT Environmental Bureau staff conducted a state-wide hotspot analysis using a 10-year data set of large game animal-vehicle collision accident report data (Figure 5-37). Approximately 10,000 collisions were reported from 2002 to 2011, with an increasing trend. Approximately 75 percent of the collisions were with deer and approximately 20 percent were with elk. The hotspots in this map coincided with many of the top 10 hotspots in the Action Plan, and the linkages from Albuquerque north to Colorado.

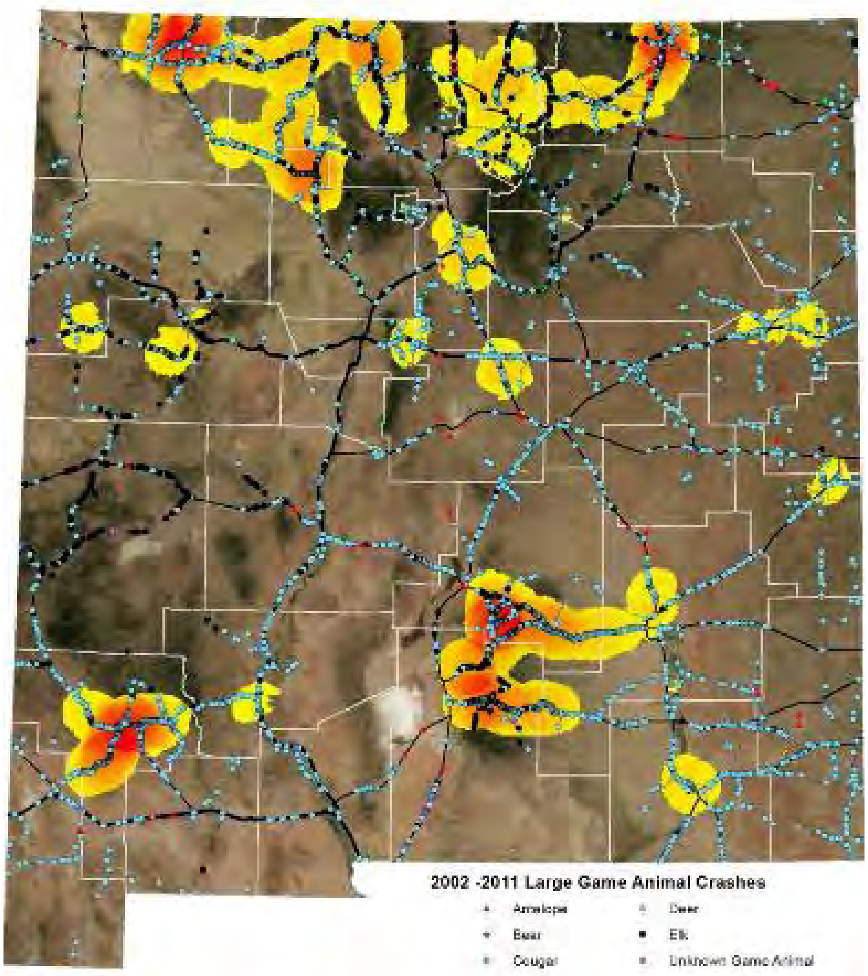

Figure 5-37. NMDOT hotspot map showing WVCs involving large wild animals, 2002-2011.

A separate memorial directed NMDOT and NMDGF to conduct a workshop of concerned agencies and parties. The 2013 workshop involved approximately 50 NMDOT and NMDGF personnel, state police, and academic personnel. The workshop identified and prioritized 32 highway segments (Figure 5-38). These priority areas coincided with many of the 2021 NMDGF proposed wildlife linkages; therefore, the mapping effort in 2013 helped support the wildlife corridor selection in 2021.

5.4.2.5 Non-Profit, Research Data, Public and Public Lands Commissioner, and the Sandia-Jemez-Bernalillo and Crest of Montezuma Linkage

The public comments that were received during the Action Plan's initial public outreach efforts in winter and spring 2020 demonstrated a groundswell of support for a linkage known as the Crest of Montezuma. This linkage is located at the northern end of the Sandia Mountains and is mapped to include wildlife movement northwest and northeast of Placitas. The Commissioner of New Mexico Public Lands, S. Garcia Richard, wrote a letter in support of this corridor and reviewed the past efforts to protect the lands in the Crest of Montezuma. Multiple legislative and agency efforts have been conducted in the past to protect critical public land. In May 2021, two leaders of the non-profit Pathways: Wildlife Corridors of New Mexico, P. Callen and M. Johnson, brought multiple forms of data and maps (Figure 5-39) to the Action Plan team to demonstrate the importance of the Crest of Montezuma to wildlife movements in and out of the Sandia Mountains. These data included photographs from multiple camera trap locations that demonstrated wildlife present in the Placitas area of the Sandia Mountains, tracking data, and suggested actions at points along I-25 where wildlife could move beneath the highway. he meeting with Mr. Callen and Mr. Johnson helped the Action Plan team form a better understanding of the significance of the data regarding the Crest of Montezuma and larger region.

With input from NMDOT, it was determined that focus on the Crest of Montezuma linkage should largely be on wildlife movements across I-25. Potential wildlife movements to the northeast are not bisected by major highways, and are therefore not a concern of the Wildlife Corridors Action Plan at this time, but of course warrant further actions to protect wildlife movement.

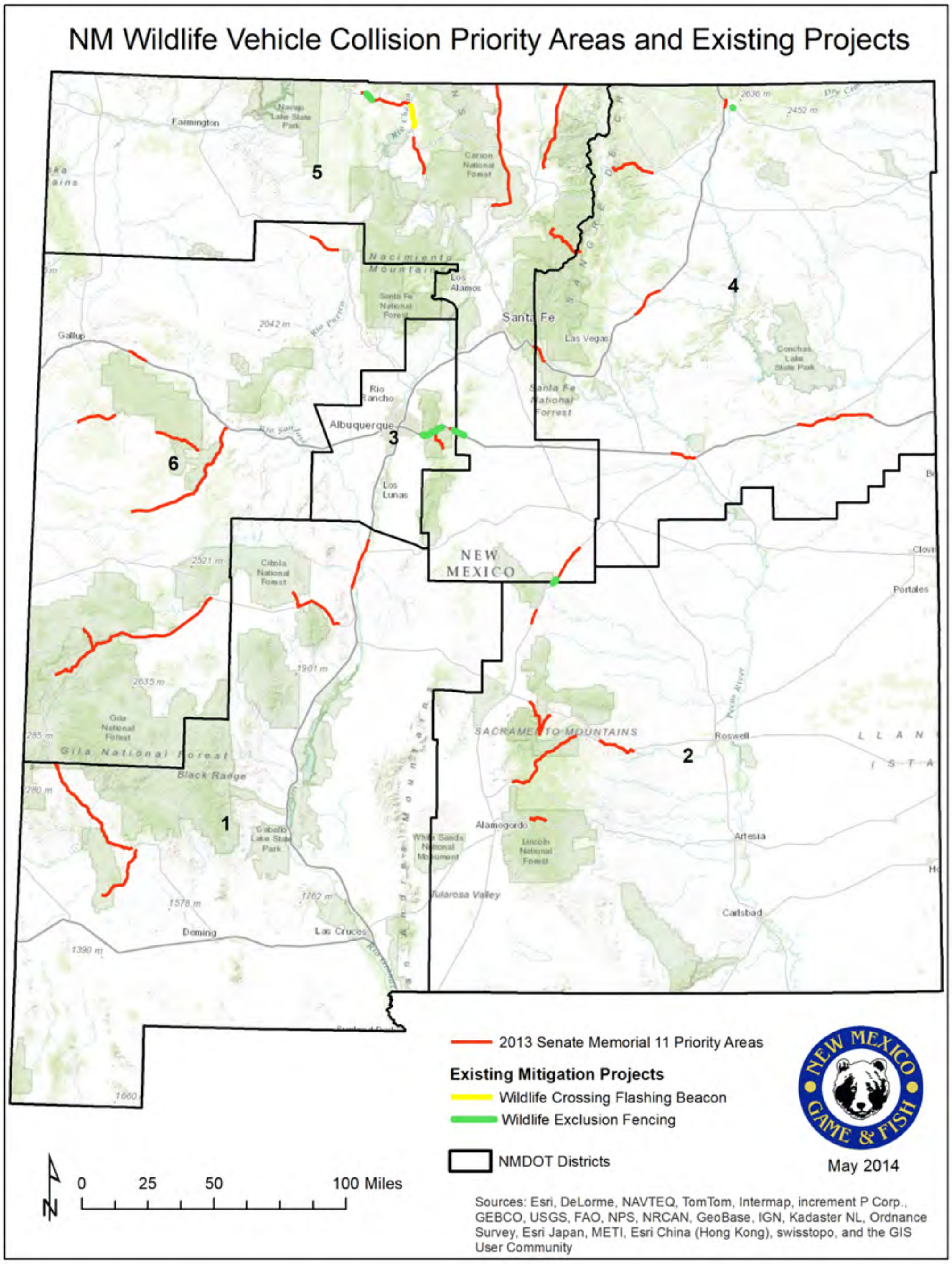

Figure 5-38. New Mexico WVC priority road segments as collectively agreed upon by the 2013 workshop participants. Numerals refer to NMDOT districts.

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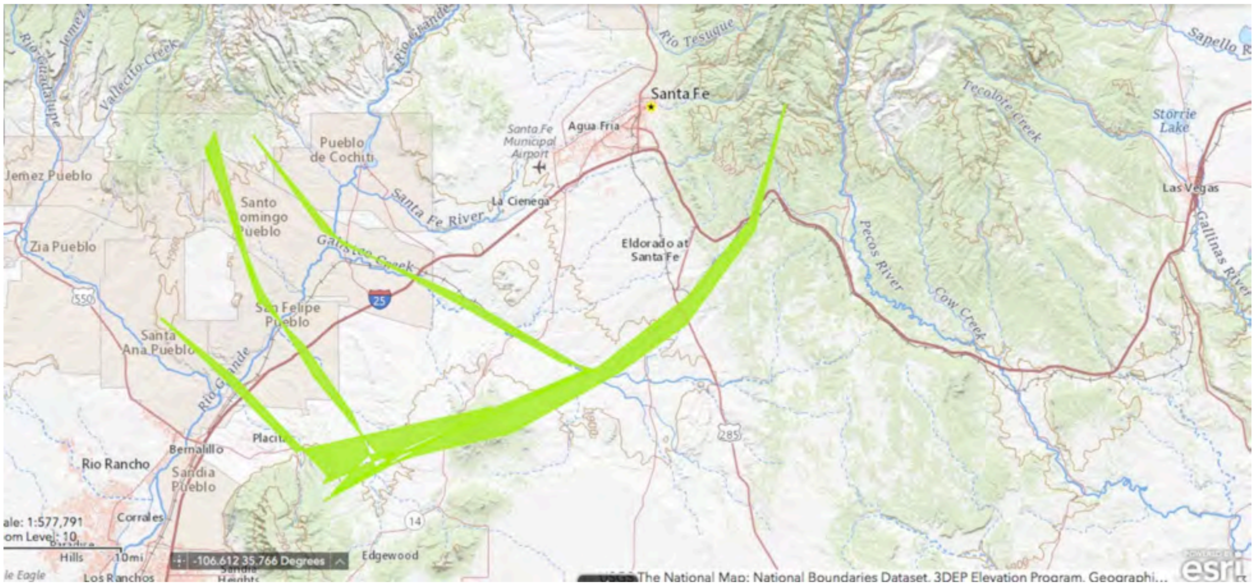

Figure 5-39. Crest of Montezuma potential linkage from the northern end of the Sandia Mountains west to Jemez Mountains and northeast to the Sangre de Cristo Mountains, with reference to Tribal lands. Figure courtesy of Peter Callan.

Cougar movement data collected by T. Perry of Furman University provided additional information as to where these animals were moving north of Albuquerque (Figure 5-40).

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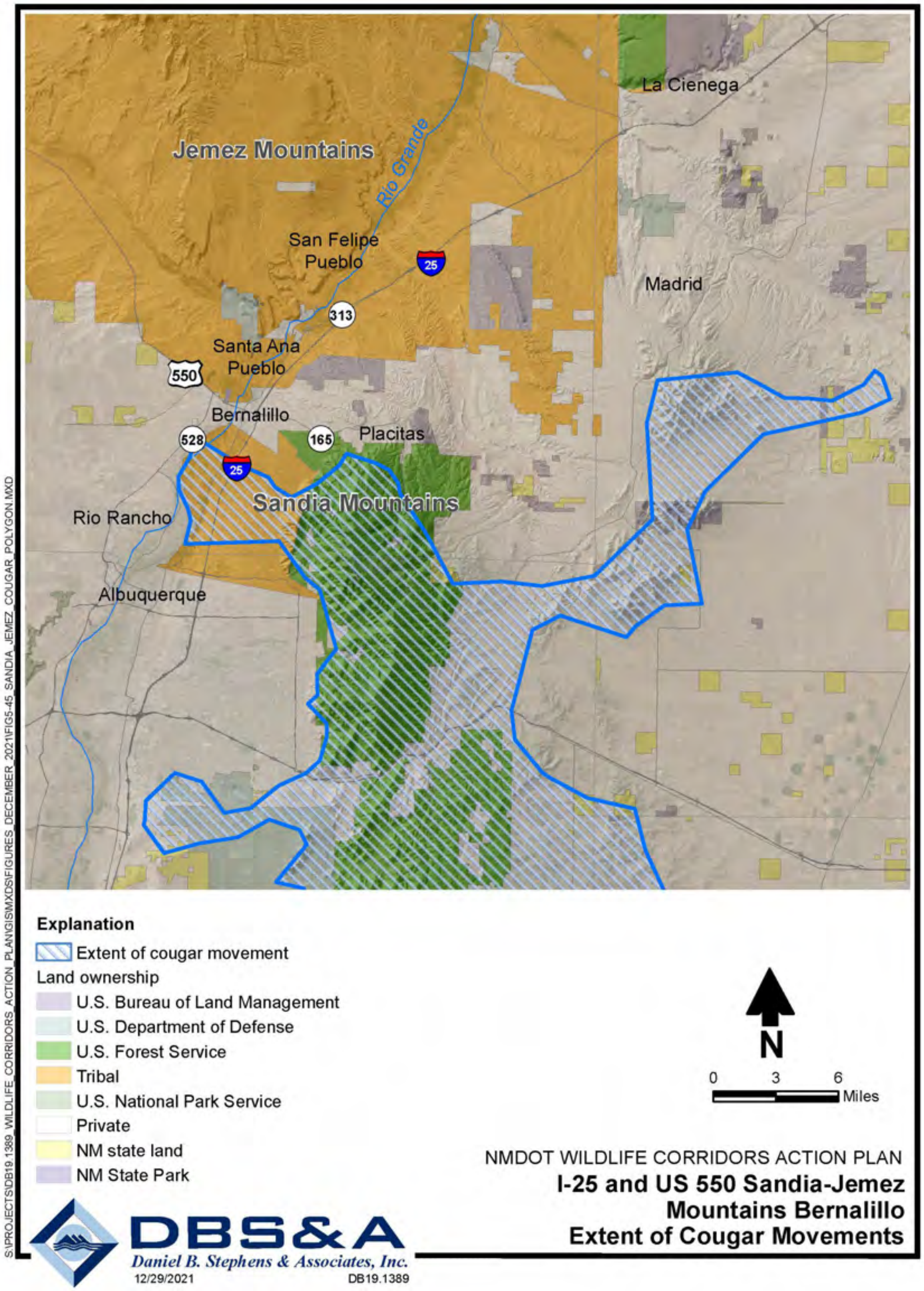

Figure 5-40. Polygon around GPS data of cougar movements as monitored by T. Perry, Kirtland Air Force Base. (Data from Dr. T. Perry, Kirtland Air Force Base).

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5.4.2.6 Peloncillo Mountains Linkage Supported by Non-Profit, Models, and Wildlife Agency Data

Personnel of the non-profit Wildlands Network brought the Peloncillo Mountains linkage to the attention of the research team and panel through the public outreach process. The Peloncillo Mountains along I-10 have been monitored with camera traps in a Wildlands Network study conducted by M. Traphagen (Traphagen, 2021). The photographs shared with the Action Plan team helped solidify the importance of this linkage, and helped to determine where existing structures may be retrofitted to help guide wildlife under the highway.

Mexican gray wolf and jaguar were not included as species of concern in the Action Plan, but data on Mexican gray wolf movement, established wolf packs in New Mexico (Mexican Wolf Interagency Team, 2021), jaguar photographs in the Peloncillo Mountains, models of jaguar reintroduction (Sanderson et al., 2020), and other data were all also congruent with this wildlife corridor being selected among the top five for New Mexico wildlife and interstate and international wildlife movement.

The AZGFD shared desert bighorn sheep GPS collar data and maps of these animal movements in the Peloncillo Mountains north of I-10. As of the date of this draft plan, these animals had not been recorded crossing I-10. NMDGF also has collared desert bighorn sheep in the Peloncillo Mountains, and the data and maps shared with the research team demonstrated that GPS collared members of this population also did not move from the south to north across I-10 during the monitoring period. The combined data (Figure 5-41) helped to solidify the need for dedicated wildlife crossing structure(s) that would allow desert bighorn to cross I-10, and to raise the level of importance of the Peloncillo Mountains I-10 Steins linkage. The letter from the New Mexico State Land Commissioner that supported wildlife corridor protection and projects helped to assure the team that a section of state land in the Peloncillo Mountains bisected by I-10 could provide a location for a wildlife overpass or other mitigation structure.

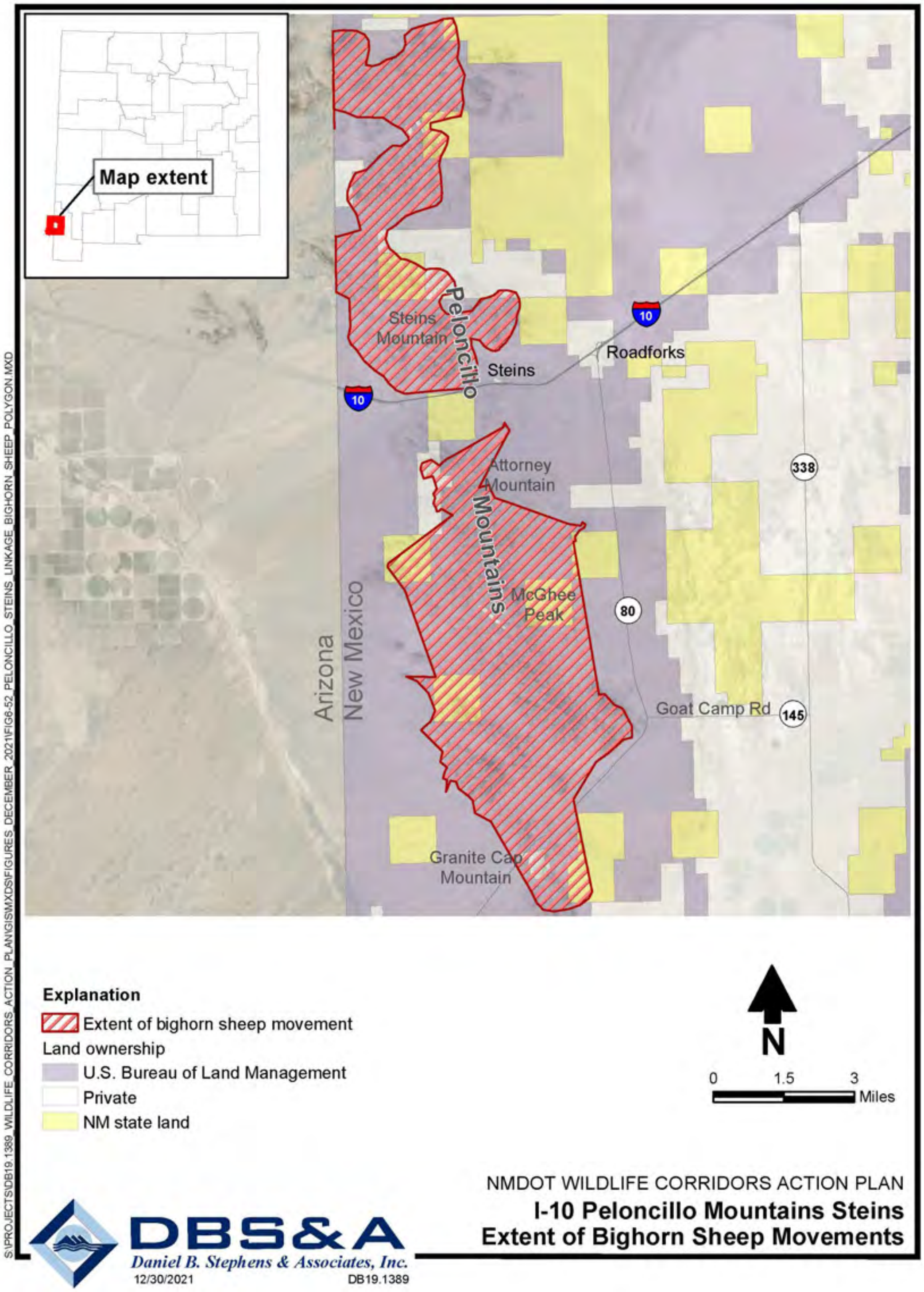

Figure 5-41. AZGFD GPS-collared desert bighorn sheep movements north of I-10 and NMDGF GPS-collared desert bighorn sheep movements south of I-10.

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5.4.2.7 U.S. Forest Service Support of the Cuba and Glorieta Linkages

The WVC hotspots of Cuba and Glorieta could have also been designated as wildlife linkages. The Forest Supervisor of the Santa Fe National Forest, J. Melonas, sent a letter to NMDOT in support of these two corridors/WVC hotspots being included as locations for WVC projects in the Action Plan. Glorieta was on the original list of NMDGF corridors of priority; however, because it was also a WVC hotspot, it was included in the top priority listing for WVC hotspots. Cuba was also included as a top WVC hotspot.

5.5 Selection of Top 10 Wildlife Corridors

The multiple inputs to the selection of wildlife corridors for New Mexico were discussed over numerous conference calls among the research team and agency partners. Issues of private land, district level NMDOT support, outside agency support, public support, and representation of linkages for each of the six focal large mammal species also factored into the decisions to prioritize the top 10 corridors. The top seven wildlife corridors were all recommended for wildlife mitigation projects. The Glorieta Pass area along I-25 was prioritized as a WVC hotspot, as it had enough WVC crashes to rank among the top 10 WVC hotspots. The team and panel members believed that the top six corridors were important; therefore, six corridor projects were developed rather than the five called for by the Wildlife Corridors Act. The following is a list of the top 10 wildlife corridors in New Mexico in order of priority:

1. US 64/84 South of Tierra Amarilla to Chama to US 64/84 Junction to Colorado Border
2. US 285 Del Norte National Monument North of Tres Piedras
3. Pronghorn Triangle I-25 South of Raton to Maxwell
4. Peloncillo Mountains I-10 Steins
5. Sandia-Jemez Mountains Bernalillo I-25 and US 550
6. Questa NM 338 to Red River
7. Glorieta Pass to Glorieta I-25
8. Jemez Mountains NM 4
9. Tijeras Canyon I-40 NM 333
10. San Augustin Pass US 70

Chapter 6 explains in greater detail the multiple factors that went into the ranking of these 10 wildlife corridors and the selection of the top 6 as recommended priority project areas. The 6 top-priority wildlife corridors are those in greatest need of urgent actions to protect key population movement for multiple species.

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Chapter 6. Project Recommendations

This chapter first details how the top 10 WVC hotspots and top 10 wildlife corridors identified in earlier Action Plan chapters were further analyzed to select those representing the highest priorities in terms of mitigation needs. From the top 10 WVC hotspots, 5 were prioritized and selected as top-priority areas. Of the top 10 wildlife corridors, 6 were selected as top-priority areas (a sixth corridor was selected because it was too important in the view of the Action Plan development team to be left out). Detailed explanations are provided about the criteria used to prioritize the top 10 WVC hotspots and top 10 wildlife corridors. For the WVC hotspots, criteria were all quantified with a scoring system, and the scores were summed in a scorecard matrix. Wildlife corridor projects were selected with the input of datasets, modeling results, other research, and government agency, Tribal, and public support. Each of the 11 top-priority hotspots and corridors—referred to as priority projects or priority project areas—are presented in detail in this chapter, with lists of specific mitigation recommendations and benefit-cost analyses.

6.1 Wildlife Corridor Selection and Prioritization

Wildlife corridors in New Mexico were identified through a step-wise process of (1) modeling wildlife movements based on habitat suitability and resistance layers, (2) validation and calibration of modeling results based on wildlife GPS collar, radio collar, and crash report data collected in New Mexico, and (3) further validation using past modeling studies and input from government agencies, non-profit organizations, Tribes, and the general public. See Chapter 5 for more detail on this process.

The top 10 wildlife corridors were further examined with respect to the following:

- GPS locational data of wildlife movement
- Camera trap photographs
- Past modeling of potential wildlife corridors
- WVC hotspots modeled
- Expert opinion from NMDGF wildlife biologists
- Tribal, non-profit, public, and agency support for these corridors

- Feasibility of constructing wildlife crossing structures on public lands and areas with conservation easements

This process was not as quantitative as the prioritization of WVC hotspots. Rather, the selection of the top-priority wildlife corridors came about through numerous meetings of the Action Plan development team. Ultimately, a total of 6 top-priority corridors were selected to help represent different New Mexico ecosystems and to facilitate wildlife movement for all six focal species, especially those not featuring as predominantly in the WVC hotspots. The seventh-ranked I-25 Glorieta Pass wildlife corridor is also identified as a top WVC hotspot. It is treated as a hotspot in the Action Plan (and is thus selected as a recommended project). The following are the 6 top-priority wildlife corridors for the Action Plan:

1. US 64/84 South of Tierra Amarilla to Chama to US 64/84 Junction to Colorado Border
2. US 285 Rio Grande Del Norte National Monument North of Tres Piedras
3. I-25 South US 64 NM 505 and NM 445 South of Raton to Maxwell Pronghorn Triangle
4. I-10 Peloncillo Mountains - Steins
5. I-25 and US 550 Sandia-Jemez Mountains - Bernalillo
6. NM 38 Questa to Red River

These top-priority wildlife corridors are analyzed in detail later in this chapter.

6.2 WVC Hotspot Prioritization

As described in Chapter 4, the hotspot analysis of wildlife-vehicle crash data was performed using the ESRI ArcGIS 10.6.1 OHSA tool and the Getis-Ord GI* statistic. After initial testing, five model variables were set at optimal values for the final WVC hotspot map: road segment length, buffer segment width, analysis buffer search distance, range of years of crash data, and confidence intervals. The selected values of all the variables are presented in Table 6-1.

Table 6-1. Optimized Hotspot Analysis (OHSA) model variable values used for final master WVC hotspot map.

Segment Length	Buffer Width	OHSA Analysis Buffer/ Analysis Distance	Crash Data Year Range	Confidence Intervals
1 mile (5,280 feet)	200 meters (656.168 feet)	1 mile (1,609 meters)	10 years (2009–2018)	95 and 99 percent

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The initial WVC hotspot ranking was based solely on the number of reported wildlife-vehicle crashes per mile per year. This was a first step and not the final ranking for priority projects for the Action Plan. It was largely a transportation safety prioritization of areas with crashes involving just deer (mule and white-tailed) and elk. Mitigating the top WVC hotspots across the state is key to reducing WVCs overall, and enhancing the safety of the traveling public. The top 10 WVC hotspots are ranked in Table 6-2.

Table 6-1. Top 10 wildlife-vehicle collision hotspots.

Hotspot Rank	Hotspot	Average Number of Crashes per Mile per Year from 2009-2018
1	US 70 Bent – Sacramento Mountains	1.76
2	US 180 NM 90 Silver City	1.71
3	US 285 North Carlsbad – Pecos River	1.65
4	NM 516 and US 550 Farmington to Aztec to CO	1.34
5	US 550 North of Cuba	1.21
6	US 70 NM 48 Ruidoso – Sacramento Mountains	1.09
7	US 82 West of Cloudcroft	1.80
8	I-25 North Raton to Colorado Border and South of Raton	1.06
9	US 82 East of Cloudcroft	1.03
10	I-25 Glorieta Pass	0.95

6.2.1 Transportation Factors Used to Prioritize WVC Hotspots

Several transportation-related factors were quantified and used to help prioritize mitigation, based in part on the level of danger to motorists and wildlife. Each WVC hotspot was given a score for each factor. The scores were summed, and the totals were used to help re-rank the top 10 hotspots.

For each of the 10 WVC hotspots, the number of severe injuries per mile due to wildlife-vehicle crashes was determined from 10 years of NMDOT crash data. The number of severe crashes per mile per 10 years of data was multiplied by 10 to obtain scores ranging from 0 to 5.88 points per WVC hotspot.

Average annual daily traffic (AADT) represents another important factor for determining both road permeability and the risk of crashes in a WVC hotspot. High-volume traffic can form a complete barrier to wildlife movement all day and into the night once AADT reaches above 15,000 vehicles per day. At 10,000 vehicles per day, the road still acts as a barrier, but some level of nocturnal movement across it may remain possible. At traffic volumes between 2,000 and 10,000 vehicles per day, wildlife will try to cross roads as they perceive less of a risk in doing so. However, they will incur greater mortality in some areas due to the continued flow of traffic (Charry and Jones, 2009; Ng et al., 2004; Seiler, 2005). AADT was determined for each WVC hotspot. Each hotspot was assigned points based on the following AADT classification criteria:

- AADT >0 and <2,000: 0 points
- AADT= 2,001 to 7,500: 3 points
- AADT = 7,501 to 15,000: 5 points
- AADT >15,000: 7 points

These classifications are based on the effect traffic volume has on the ability of wildlife, specifically large ungulates, to cross roads safely. Values for the WVC hotspots ranged from 0 to 7. Higher scores were given to those highways associated with high traffic volumes.

The percentage of all crashes that were wildlife related was calculated for each WVC hotspot. This percentage was then divided by 10 to obtain a score more in line with the scores derived for severe injuries and AADT. The values ranged from 0 to 6.94.

The total scores each WVC hotspot received for these additional transportation factors ranged from 6.83 to 16.27.

6.2.2 Ecological Factors Used to Prioritize WVC Hotspots

The WVC hotspots were also evaluated based on the number of species of concern with the potential to occur locally.

In addition to the 6 focal species, an additional 13 native species of concern were considered when prioritizing project areas. The selection process for identifying species of concern, together with detailed descriptions of their distribution and habitat, is provided in Chapter 2.

When calculating final scores to rank top-priority WVC hotspot projects, the Action Plan development team summed the number of focal species and other species of concern that could potentially occur within each project area. These sums were factored into the overall score used to rank the top-priority WVC hotspot projects. The scores for each hotspot for this criterion ranged from 3 to 9.

6.2.3 Feasibility Factors

Two feasibility factors were analyzed for each WVC hotspot: (1) the amount of public land adjacent to the road segment and (2) public support for road mitigation projects within the WVC hotspot.

6.2.3.1 Surrounding Land Use and Ownership

To account for public land within any given WVC hotspot, the total mileage of public land on both sides of the road was calculated for each location and added to the other scores. This calculation gave some preference to WVC hotspots with a greater availability of public lands on both sides of the roadway, thus ensuring the long-term effectiveness of wildlife crossing structures. Values for this criterion ranged from 0 to 7.7 points, representing the number of miles of public land along the road within the WVC hotspot.

6.2.3.2 Local Community Support for Proposed WVC Hotspot and Wildlife Corridor Infrastructure

The Action Plan development team, in partnership with NMDOT and NMDGF, reached out to multiple agencies, Tribes, non-profit organizations, researchers, and other entities to gather their input on potential wildlife corridors and areas deemed important for consideration in the Action Plan. These efforts are detailed in Chapter 3. Input was received in the form of comments, letters, reports, data, and other information, and helped determine the level of support for mitigation within each of the WVC hotspots. Scores for each WVC hotspot under this criterion ranged from 0 to 4.

These scores will be revisited after concluding the public involvement process for the draft Action Plan.

6.2.4 Matrix of Factors Used to Prioritize Top WVC Hotspots

The criteria described above were brought together in a scorecard matrix. Table 6-3 summarizes this information. The scorecard reports the range of possible scores under each criterion.

Table 6-3. Factors used to re-rank the top 10 WVC hotspots and identify the five top-priority areas.

Factor	Potential Range of Points	Total Resulting Range of Points in Factor Area for Top 10 WVC Hotspots
Transportation Factors		
Number of severe injury WVCs per mile per 10 years of data x 10	0–5.88	
Percentage of all crashes in WVC hotspot that were wildlife related	1.88–6.94	
Average annual daily traffic (AADT) 0 < 2,000 AADT; 3 = 2,001–7,500; 5 = 7,501–15,000; 7 > 15,000	0–7	
Range of total transportation scores for the top 10 hotspots		6.83–16.27
Ecological Factors – Species of Concern Potential Presence (yes = 1)		
Black bear crashes recorded in WVC hotspot	0–1	
Cougar crashes recorded in WVC hotspot	0–1	
Pronghorn crashes recorded in WVC hotspot	0–1	
Bighorn crashes recorded in WVC hotspot	0–1	
Badger	0–1	
White-nosed coati	0–1	
Red fox	0–1	
Swift fox	0–1	
Kit fox	0–1	
Hog-nosed skunk	0–1	
Collard peccary	0–1	
Jackrabbit, white-tailed	0–1	
Jackrabbit, white-sided	0–1	
Gila monster	0–1	
Mexican garter snake	0–1	
Ornate box turtle	0–1	
Western Massauga rattlesnake	0–1	
Range of total scores for species of concern of the top 10 WVC hotspots		3–9

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Table 6-3 (cont.)

Factor	Potential Range of Points	Total Resulting Range of Points in Factor Area for Top 10 WVC Hotspots
Feasibility Factors		
Number of miles of public land on both sides of the WVC hotspot: range of scores on top 10 WVC hotspots	0–7.7	0–7.7
Agency/tribal/NGO/public support for the WVC hotspot: 1 point for each agency or tribal letter or comment in support of the WVC hotspot, plus 1 point if 1–3 citizen letters or comments were received, or 2 points if 4 or more citizen letters or comments were received. Range of scores of top 10 WVC hotspots.	0–4	0–4
Total	1.88–48.52	Actual range of points: 14.03–29.29

6.3 Field Visits to Top WVC Hotspots and Wildlife Corridors

The top 10 WVC hotspots and 6 top-priority wildlife corridors were visited by teams of field ecologists to document existing conditions and make recommendations for mitigation along the highways. The teams represented NMDOT, NMDGF, AZGFD, Tribal natural resource professionals, and DBS&A researchers, and they documented environmental conditions and existing infrastructure using the ESRI application, ArcGIS Survey123 (ESRI, 2021) with a custom-made template created by AZGFD. Field documentation included locations of existing culverts, bridges, and the potential locations of future wildlife underpasses, overpasses, animal-activated detection systems, variable message board signs, fence-end locations, private and public land ownership, land use, sources of water, potential food resources, and visible signs of wildlife use of the area. Existing culverts and bridges were measured and described in the field notes. The team decided which locations were most important for wildlife movement based on crash data, wildlife signs (e.g., tracks, carcasses, and live animals), land ownership, land use, water features, modeling results, and knowledge of the area by local wildlife professionals. If there was an existing culvert or bridge where wildlife could move beneath the road, the team recommended (1) adapting the structures with retrofits and wildlife exclusion fences tied to those structures, (2) maintenance of the structures, such as clearing debris and illegal fences, or (3) completely replacing them with new and different infrastructure that could be used by the focal species of greatest concern locally.

When no structures existed in areas where wildlife was very likely to cross the road based on topography and other factors, the field reconnaissance team recommended completely new, standalone wildlife overpasses or wildlife underpass bridges and culverts. When practical, fence-end locations were proposed at suitable crossing structures or steep embankments to minimize the chance of animals moving around fence ends and entering the roadway. Wildlife attractant areas, such as orchards, were noted as elevating the risk of WVCs so that they could be addressed when planning a wildlife mitigation project at that location.

After the field reconnaissance, the entire Action Plan development team conducted multiple meetings to discuss findings of the surveys and identify the top-priority projects. WVC hotspots and corridors that provided insufficient crossing structure location options, contained excessive human development, or were likely to be cost-prohibitive were excluded from further analysis. The entire team identified the 5 top-priority projects out of the top 10 WVC hotspots, and also came to an agreement on 6 top-priority wildlife corridors. Within each of these project areas, the team collectively identified the locations of priority wildlife overpasses and underpasses and other mitigation. These recommendations were represented in maps for each project area. The maps showed locations of the priority overpasses, underpasses, and fences, which were depicted on one side or the other of the road in the maps, but represent both sides of the road being fenced in all locations.

The recommended structures were tailored to best suit species behavior and habitat requirements as learned from previous research, especially in neighboring states. The field reconnaissance represented an attempt to maximize the successful use of crossing structures by the target species within a given project area. Significant research has been conducted over the last 20 years examining wildlife crossing structures and wildlife use, or lack thereof (Cramer, 2014; Cramer and Hamlin, 2017, 2019a, 2019b, and 2021; Dodd et al.; 2007; Gagnon et al., 2015 and 2017; Kintsch et al., 2021). Table 2-2 (Chapter 2) summarizes general guidelines and recommendations for species-specific crossing structure dimensions based on a thorough examination of the existing published literature, while Appendix D provides definitions and descriptions of all wildlife mitigation types recommended in the Action Plan. In addition to structure dimensions, spacing between crossing locations plays a key role in successful use by target species (Bissonette and Adair, 2008; Dodd et al., 2007; Cramer and Hamlin, 2019a). Research has documented the importance of the appropriate design and placement of crossing structures within wildlife habitat and movement areas. Design and placement are key for facilitating movement across roadways and mitigating the impacts of habitat fragmentation and collision mortality (Cramer, 2014; Cramer and Hamlin, 2017, 2019a, 2019b, and 2021; Dodd et al., 2007; Gagnon et al., 2015 and 2017; Kintsch et al., 2021). The Action Plan development team took these factors into account when designing conceptual projects for each of the 11 top-priority WVC hotspot/ wildlife corridor locations identified later in this chapter.

Of the top 10 WVC hotspot locations, 3 were eliminated from the 5 top-priority locations for potential projects, due to the urbanized nature of the area and lack of feasible solutions based on private land along the hotspot. These included the US 550 and NM 516 Farmington to Aztec to Colorado WVC hotspot, and the US 82 East and West of Cloudcroft WVC hotspots.

6.4 Benefit-Cost Analyses of Wildlife Mitigation Infrastructure

The benefit-cost analysis for each WVC hotspot or wildlife corridor was conducted as a two-step process: (1) estimating the costs of the proposed infrastructure, and then (2) estimating the potential benefit derived from 75 years of mitigation in terms of reducing the number of animal-vehicle crashes. The Action Plan development team chose to use all animal crashes (rather than just crashes caused by collision with wildlife) to estimate the monetary value associated with a reduced number of crashes as a result of the recommended mitigation. This was done for several reasons:

- The mitigation would help to reduce all animal-vehicle crashes, not just those with the six focal species.
- The crash database included many entries establishing that an animal was involved in the crash, but not specifying the species, and therefore leaving the possibility that the animal was domesticated.

It was also understood that if wildlife exclusion fencing is placed in a location, it could help restrict the livestock and domestic animals such as cows, horses, and dogs from getting on the road and becoming involved in crashes; therefore, these data were brought into the benefit analyses.

6.4.1 Estimating Costs

There are several types of benefit-cost analyses. However, they all share the same basic premise, which is to use a benefit-cost ratio with the benefit in the numerator and the cost in the denominator. The cost is associated with the construction and maintenance of the proposed mitigation infrastructure. The estimated monetary benefit is derived from the reduction in the number of crashes over the lifetime of the mitigation.

The unique approach here is based on the Colorado DOT's new method of including the economic value of elk and mule deer not killed in crashes as a result of the mitigation among the benefits (Kintsch et al., 2019).

The costs of the mitigation recommendations were estimated for each top-priority WVC hotspot or wildlife corridor. This value was the denominator of the benefit-cost equation.

The Action Plan team's two civil engineers developed cost estimates for recommended wildlife crossing structures and additional infrastructure based on NMDOT 2020 average unit bid prices (Table 6-4), and wildlife crossing structure dimensions that are proven to work for mule deer and elk in neighboring states (Kintsch et al., 2019). Estimates were generalized based on structure type to compare project costs without requiring further site-specific analysis, which should occur once actual project-specific planning begins. For each top-priority project location, realistic conceptual plans were taken into consideration, but were designed in a manner that the team thought would represent a "gold standard" for a crossing project at that location. Future project planning will have to account for site-specific geology, hydrology, and other abiotic factors, which could alter the design of the conceptual projects presented in this chapter.

Table 6-4. Wildlife mitigation cost estimates based on NMDOT 2020 costs and Colorado DOT costs (Kintsch et al., 2019).

Structure Type	Cost Estimate	Structure Type	Cost Estimate
14-foot x 14-foot concrete box culvert (CBC) (2-lane)	$1,430,000	14-foot x 14-foot CBC (4-lane)	$2,280,000
2-lane pipe arch underpass	$1,840,000	4-lane pipe arch underpass	$3,230,000
2-lane underpass bridge	$1,070,000	4-lane underpass bridge	$2,520,000
2-lane overpass	$4,460,000	4-lane overpass with median	$7,280,000
4-lane overpass without median	$7,430,000	Double cattle guard general	$60,000
Fence per mile	$100,000	Escape ramp	$14,000

6.4.2 Estimating Benefits

The benefits of proposed mitigation were estimated based on (1) the current monetary value associated with the average number of animal-vehicle crashes of different crash severities, and (2) how much those were expected to be reduced over the lifetime of the mitigation. The process of estimating benefits occurred in several steps.

In Step 1, the first part of the benefits was estimated from NMDOT crash data. The monetary values associated with animal-vehicle crashes were taken from NMDOT 2019 cost estimates and Federal Highway Administration (FHWA) cost estimates as reported by Harmon et al. (2018) (Table 6-5).

Table 6-5. NMDOT 2019 crash cost values and Federal Highway Administration 2018 cost values.

Crash Type	NMDOT-Estimated Crash Costs to Society	FHWA-Estimated Crash Costs to Society based on Harmon et al. (2018)
Property damage only (PDO)	$7,400	$ 11,900
Possible injury (Type C)	$44,900	$125,600
Minor injury (Type B)	$79,000	$198,500
Incapacitating/serious injury (Type A)	$216,000	$655,000
Fatality	$4,008,900	$11,295,400

To avoid overestimation of crash costs, only the higher crash value injury was taken for vehicles with more than one passenger injured. This ensures that the number of crashes per type equals the number of reported WVCs. Total numbers for each wildlife-vehicle crash severity type was summed for the 10 years of crash data, and divided by 10 for an annual average. The new numbers were then multiplied, first by the NMDOT crash cost values under each of the different severity categories, then by the FHWA crash cost values to get different total crash costs based on the NMDOT and FHWA estimates.

The estimated costs were then divided by the number of miles within the WVC hotspot or wildlife corridor to estimate a crash cost per mile per year. This result was then multiplied by the number of miles mitigated to obtain a total average cost of animal-vehicle crashes for the area to be mitigated.

In Step 2, the lifespan of all mitigation infrastructure was assumed to be 75 years. This lifespan is typical for bridges and culverts. Shorter lifespan estimates exist for these structures and for fencing, but due to the complex nature of the project descriptions, the Action Plan development team used the full 75 years as the expected lifespan of all infrastructure.

In Step 3, the mitigation was as a general rule estimated to reduce all future WVCs by 90 percent, as reported by Huijser et al. (2009) and in research in Colorado (Kintsch et al., 2021), Alberta (Clevenger and Barrueto, 2014), and Wyoming (Sawyer et al., 2012). The overall value of crash reductions over 75 years of mitigation was multiplied by 0.9 to represent this 90 percent reduction in crashes.

When the length of the wildlife exclusion fence was 3 miles or shorter, the 90 percent estimated reduction was deemed an inaccurate estimation of crash reduction. The development team determined a rough estimate of 30 percent reduction based on data from three previous studies (Table 6-6). The crash reduction in an area with fences and structures for wildlife to move beneath the road would be expected to be over 30 percent. However, if the fence and wildlife mitigation are not present for an entire stretch of road that is either in a WVC hotspot or a designated wildlife corridor where wildlife are known to be present, the unfenced areas would not yield as great a reduction in the number of crashes, or could even result in an increase in crashes. Thus, the 30 percent was a very rough estimate for the entire partially fenced road based on the three studies.

In Step 4, the development team used the Colorado DOT estimates for the economic costs of mule deer and elk killed in WVCs (Kintsch et al., 2019), which equated to $2,061 and $2,392, respectively. These values were multiplied by the average number of animals of each species killed annually, and then multiplied by 0.9 as expected based on the 90 percent reduction of crashes (or 30 percent, where appropriate). These reduced crash values and costs of deer and elk that could be expected to not be killed by WVCs were then added and inserted into the numerator in the benefit-cost ratio.

The benefit-cost equation was calculated to find the ratio of benefits to costs. The ratio was first calculated with NMDOT crash values, and then with FHWA values. If the ratio was 1 or greater, the mitigation was expected to pay for itself over the 75 year time frame. If it was less than 1, the mitigation was not expected to pay for itself over 75 years. These calculated ratios had no bearing on the ranking of the WVC hotspots or wildlife corridors.

Table 6-6. Percentage crash reductions in wildlife mitigation studies with 3.5 miles of fence or less.

Study	Miles of Fence	Mitigation Area Crash Reduction	Crash Reduction in 2 Controls with No Exclusion Fence or Mitigation	Overall Whole Road Segment, Mitigation + Controls, Crash Change
US 160 in Colorado (Cramer and Hamlin, 2021)	0.77	55%	Decrease 24% and 27%	Decrease 35%
US 191 Monticello in Utah (Cramer and Hamlin, 2019a)	3.5	55%	Increase 70% and 155%	Decrease 1%
US 189 Deer Creek SP 1st section in Utah (Cramer and Hamlin, 2019b)	1.1	69%	Decrease 55% and increase 113%	Increase 2%
US 189 Deer Creek SP 2nd section in Utah	3.4	74%	Increase 200% and decrease 11%	Decrease 32%

6.5 Top-Priority WVC Hotspot and Wildlife Corridor Projects

The 5 top-priority WVC hotspots to receive recommendations for future mitigation projects are listed below in priority order:

1. US 550 North of Cuba
2. US 180 and NM 90 Silver City
3. US 70 and NM 48 Ruidoso
4. I-25 Glorieta Pass
5. US 70 Bent Sacramento Mountains

The 6 top-priority wildlife corridors selected as projects are listed below in priority order, based on the level of concurrence with NMDGF-identified wildlife corridors and the level of public support:

1. US 64/US 84 Chama from South of Tierra Amarilla to Chama to US 64/84 Junction to Colorado
2. US 285 Rio Grande Del Norte National Monument North of Tres Piedras
3. I-25, US 64, NM 505, and NM 445 South of Raton to Maxwell (Pronghorn Triangle)

4. I-10 Peloncillo Mountains-Steins
5. I-25 and US 550 Sandia-Jemez Mountains Bernalillo
6. NM 38 Questa to Red River

Figure 6-1 provides a map showing the locations of the 5 top-priority WVC hotspots and the 6 top-priority wildlife corridors.

Project recommendations for WVC hotspots and wildlife corridors will be finalized based on public input on the draft Action Plan, engineering constraints, and future funding availability. The potential exists to update the Action Plan and priority project list on an annual basis, as needed. Updating the Action Plan may come about in light of new data or funding opportunities.

The following subsections present the 11 top-priority wildlife mitigation projects, with details on the exact nature and placement of the mitigation features recommended.

Note that the recommendations for these projects are subject to change in future planning studies. The Action Plan team is not presenting these recommendations as the final and only opportunities for enhancing wildlife movement below and above the roads. Rather, these are the top recommendations based on a one-day field reconnaissance of each project area, existing road conditions, 2021 costs, and the current state of the science and practice of transportation ecology. Many of the existing culverts and bridges are described in the project-specific subsections. Details are provided on the limitations they present for allowing wildlife to cross the roads, and the type of new infrastructure needed to increase road permeability.

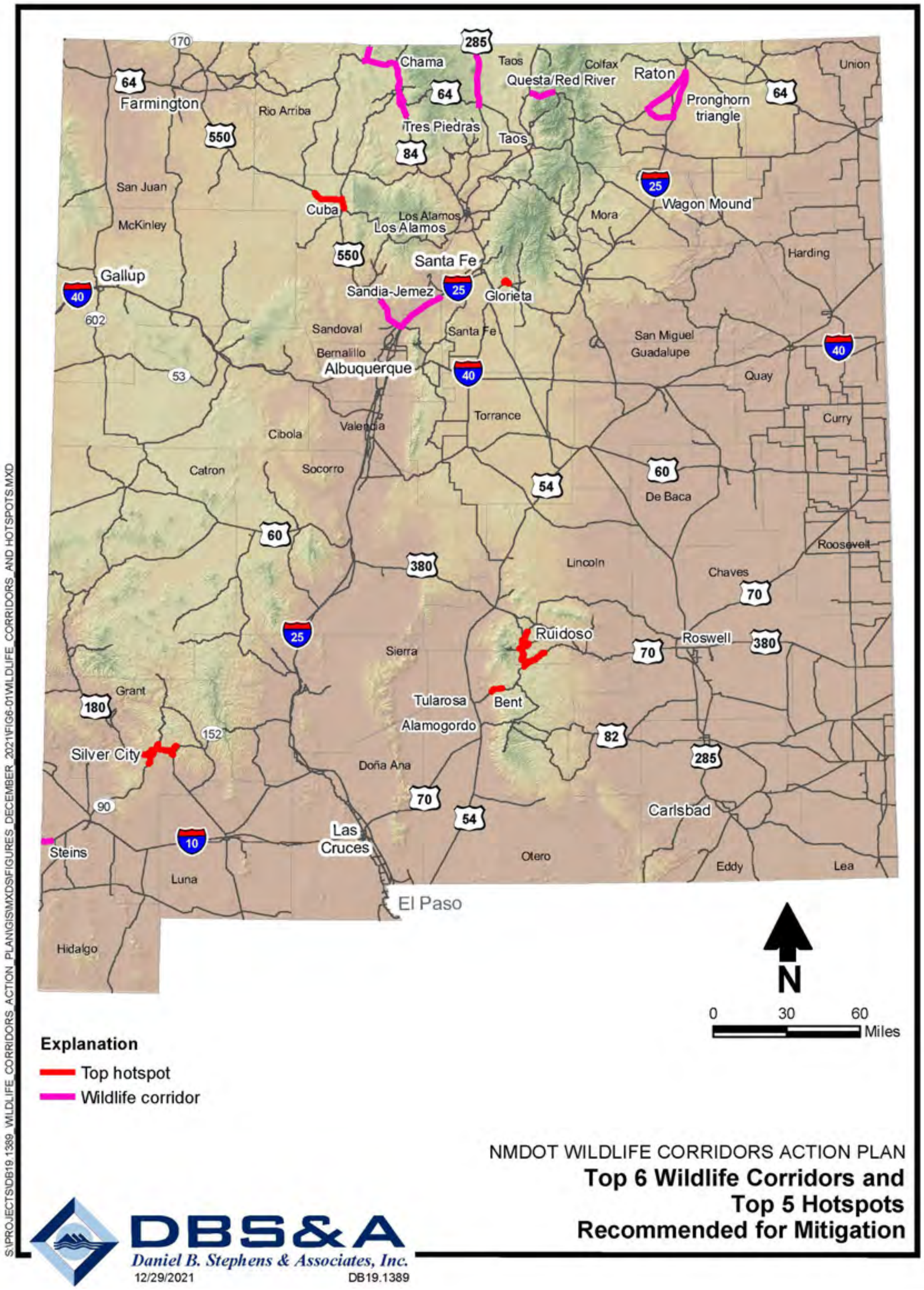

Figure 6-1. The 5 top-priority WVC hotspots and 6 top-priority wildlife corridors.

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6.5.1 US 550 North of Cuba WVC Hotspot Recommendations for Wildlife Mitigation Projects

- *NM 90 MP 0–1*
- *17-mile hotspot, 14 miles of mitigation*
- *Sandoval County*
- *NMDOT District 6*

6.5.1.1 Project Area Overview

The US 550 North of Cuba WVC hotspot is located on US 550 from milepost (MP) 64 to MP 80. It also includes NM 96 from MP 0 to MP 1. The area is bordered to the east by the San Pedro Parks Wilderness of the Santa Fe National Forest and on the north/northwest by Jicarilla Apache Nation Tribal lands. The Bureau of Land Management (BLM) manages the majority of the land along US 550, with a portion of the Santa Fe National Forest along the southeast side. US 550 is an important four-lane highway that links the Albuquerque-Rio Rancho metropolitan center to both the Farmington area in northwestern New Mexico and Durango in southwestern Colorado. Mule deer (Figure 6-2) and elk herds in this area are thought to include year-round residents and migratory animals, likely with higher concentrations in the winter.

Figure 6-2. Mule deer move beneath the US 550 Rio Puerco Bridge south of Cuba (photo credit: NMDOT).

The hotspot had the fifth highest number of WVCs per mile per year. It is the second highest priority WVC hotspot in northern New Mexico. Elk are the wild ungulate species most often involved in reported crashes, with 120 elk-vehicle crashes reported in this hotspot in 10 years. The crashes with the six species of interest are placed on a map of US 550 in Figure 6-3.

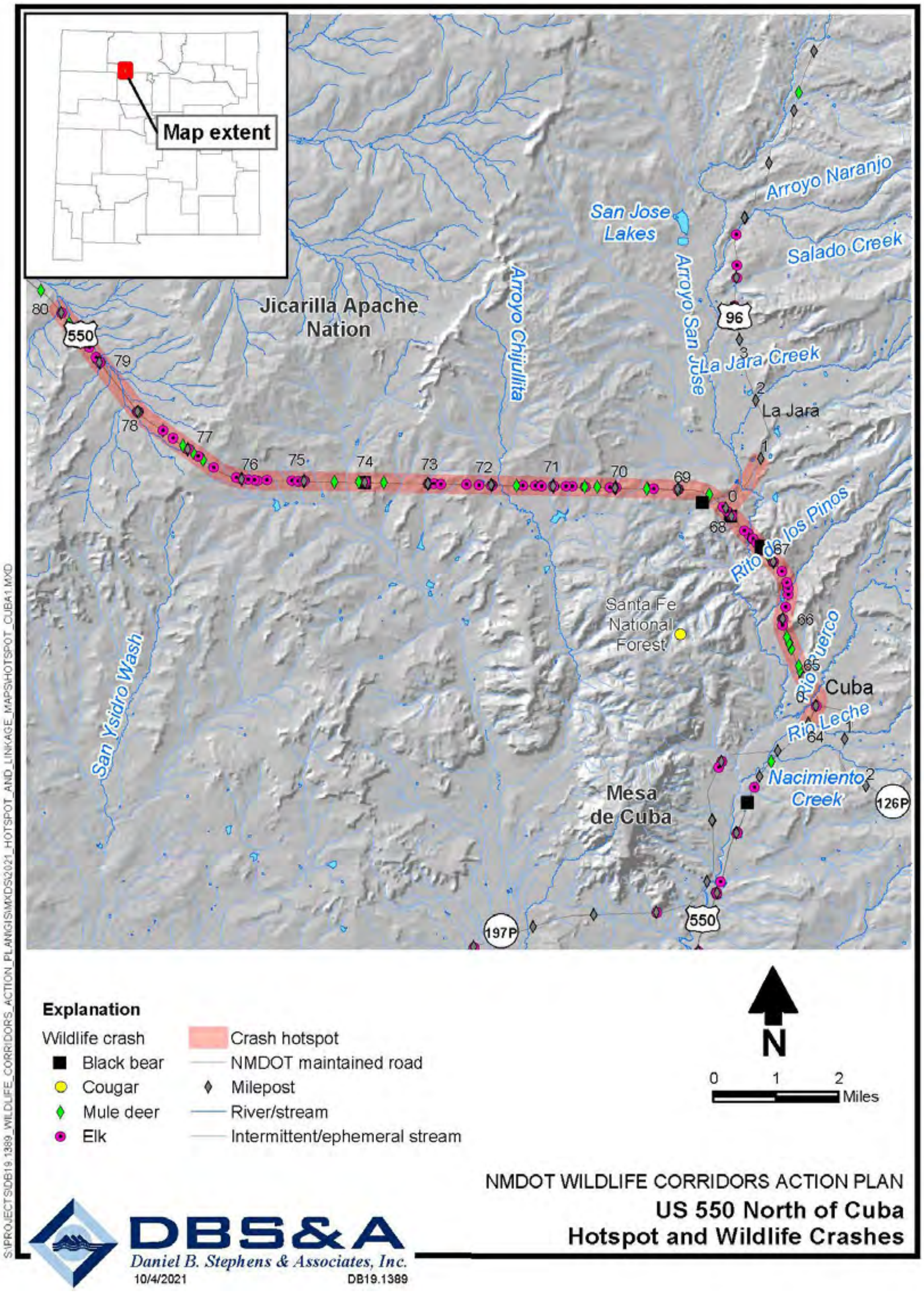

Figure 6-3. Wildlife-vehicle crashes in the US 550 North of Cuba hotspot.

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6.5.1.2 Transportation – Safety Statistics

The crash data reported in the following subsections include both animal-vehicle crashes and wildlife-vehicle crashes to better reflect the impact of collisions with all animals. Animal-vehicle crashes include wild and domestic animals and livestock. Using all animal statistics to evaluate the situation helps the reader to differentiate where there are strictly wildlife problem areas, and where these domesticated animals may also be involved. The recommended wildlife mitigation that includes wildlife exclusion fences would be expected to reduce all these crashes, not just those with wildlife. Therefore, the total animal crashes are reported and then used in the benefit-cost analyses of the value of the recommended infrastructure. The reported wildlife crashes are those strictly with the six focal species: mule deer, elk, pronghorn, bighorn, black bear, and cougar.

6.5.1.2.1 Wildlife-Vehicle Crashes per Mile per Year

According to NMDOT data, there were 208 reported crashes involving the six focal species from 2009 through 2018: 82 with mule deer, 120 with elk, 5 with black bears, and 1 with cougar (Table 6-7).

There were two areas of concentrated WVC in the hotspots: 77 WVCs recorded along US 550 from MP 66 to MP 69 and 53 WVCs recorded along US 550 from MP 74 to MP 77. Wildlife crashes in these two segments accounted for 63 percent of all types of crashes recorded for the hotspot.

Table 6-7. US 550 North of Cuba WVC hotspot, NMDOT data for crashes with all animals and with just the six focal wildlife species, 2009-2018.

Length (miles)	Total Crashes with All Animals	Total Crashes with Focal Species	Wildlife Crashes per mile per year	Crashes Involving the Six Focal Species					
				Deer	Elk	Black Bear	Cougar	Pronghorn	Bighorn Sheep
17	223	208	1.21	82	120	5	1	0	0

6.5.1.2.2 Seasonality of Wildlife-Vehicle Crashes

The months with the greatest number of reported wildlife-vehicle crashes in this WVC hotspot were October through December (Figure 6-4).

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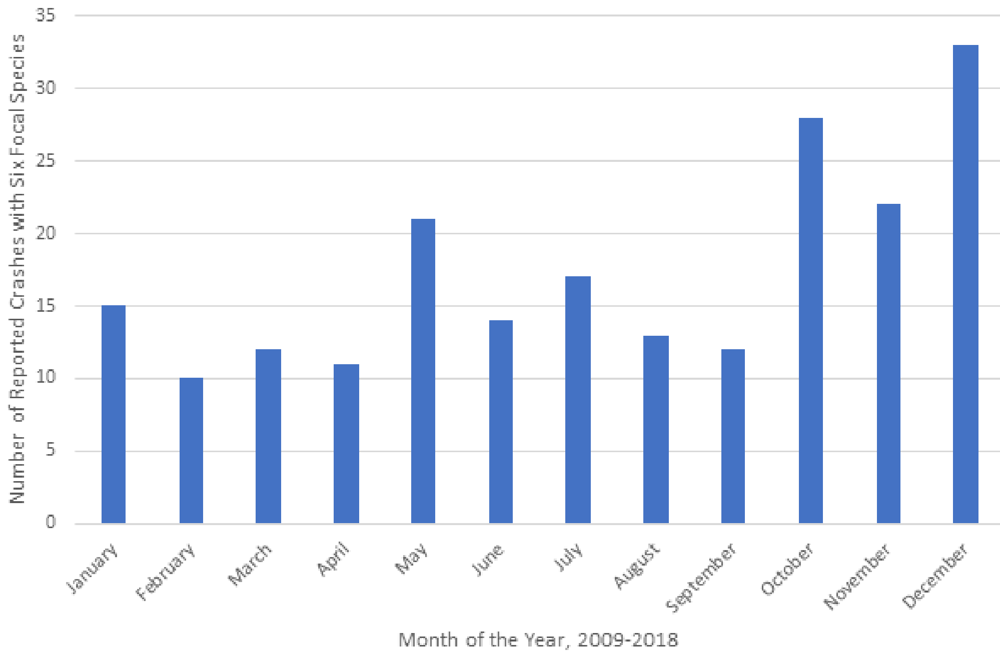

Figure 6-4. Wildlife-vehicle crashes by month in the US 550 North of Cuba hotspot.

6.5.1.2.3 WVC Species Percentages

Of the WVCs in this hotspot, 39 percent involved deer, 58 percent involved elk, 2 percent involved black bear, and less than 1 percent involved cougar.

6.5.1.2.4 Wildlife-Vehicle Crashes as Percentage of All Crashes

Of the 359 crashes in the hotspot, 58 percent were the results of collisions with wildlife.

6.5.1.2.5 Average Annual Daily Traffic (AADT)

AADT is important in estimating if large wild animals such as the six focal species have opportunities to cross the roads under scrutiny. Traffic volumes can form a complete barrier to wildlife movement all day and into the night once AADT reaches well above 20,000 vehicles per day. At 10,000 vehicles per day there is still a barrier, with some opportunity for nocturnal movements across roads. Wildlife can find limited opportunities to cross roads with AADT between 2,000 and 10,000 vehicles per day. However, at AADT of 2,000 and 10,000 per day, wildlife will try to cross roads, and will have greater mortality in some areas because of the lower perceived risk by wild animals but the continued presence of vehicles (Charry and Jones, 2009; Ng et al., 2004; Seiler, 2005).

AADT in the hotspot is 5,112 vehicles per day.

6.5.1.2.6 Number of Lanes

US 550 is a four-lane road. NM 96 is a two-lane road.

6.5.1.2.7 STIP Possibility

- STIP Control Number 6100847, Bridge over Rito Leche, Bridge Rehab. US 550 MP 63.7–64.4. District 6, 2020 start. Total Programmed = $1,915,616

6.5.1.3 Ecological and Feasibility Considerations

6.5.1.3.1 Species of Concern

A total of 6 species of concern have the potential to occur in the general area of the US 550 North of Cuba hotspot: black bear, cougar, mule deer, elk, American badger, and red fox.

6.5.1.3.2 Data

While NMDOT provided crash records and NMDGF black bear and cougar mortality data for the hotspot, important, additional information was also received from the Jicarilla Apache Nation. Jicarilla Apache Nation GPS collar data from mule deer and elk demonstrate that both species seasonally gather and primarily remain on the north side of US 550 near MP 76 to MP 77 (Tator, 2016). Reports from Jicarilla Apache Nation research on local mule deer and elk movements (Tator, 2016 and 2020; Sawyer et al., 2011) helped to identify the Cuba 550 North of Cuba hotspot as more than just one of the top hotspots; it is also an important wildlife corridor that deserves recognition in the Action Plan..

6.5.1.3.3 Public Land

The hotspot represents 7.7 miles of road with some public land on one or both sides, mainly BLM-managed, the rest administered by the U.S. Forest Service (USFS) (Santa Fe National Forest).

6.5.1.3.4 Support

Letters expressing support for the US 550 North of Cuba hotspot to be recommended as a mitigation project in the Action Plan were received from the NMDGF, Jicarilla Apache Nation, and USFS, and from a member of the public. The level of documented support received for this hotspot was unmatched by any other hotspot in New Mexico.

The Jicarilla Apache Nation not only submitted documentation that supported the need for mitigation actions in this hotspot, but also participated in the field reconnaissance of the hotspot examining potential wildlife overpass and underpass locations and fence ends.

James Melonas, Forest Supervisor of the Santa Fe National Forest, wrote a letter in support of mitigation actions in the US 550 North of Cuba hotspot. Mr. Melonas specifically mentioned the National Forest lands north of Cuba on both sides of US 550, and the challenges of placing viable wildlife crossing structures. The Santa Fe National Forest expressed its interest in continuing its partnerships with NMDGF and NMDOT.

One citizen wrote a letter of support for this area to be mitigated.

6.5.1.4 Recommendations Overview

The US 550 North of Cuba hotspot is of prime importance for wildlife-transportation mitigation in New Mexico. Public land is present along one or both sides of US 550. There are public land and wildlife agencies, a Tribe, and public citizens all in support of mitigation options that help mule deer, elk, black bear and other species of animals over and beneath US 550 to avoid vehicle collisions and maintain wildlife connectivity. The prescribed recommendations for actions would help reduce both the impacts of the road and its associated traffic on wildlife, and the danger to motorists from wildlife attempting to cross the road. The project recommendations are based on ecological considerations rather than cost. Entire herds of elk cross the highway within the hotspot. These animals will not use a culvert or small span arch culvert in large numbers, based on research in the neighboring states of Arizona, Colorado, and Utah (Cramer, 2014; Gagnon et al., 2015 and 2017; Cramer and Hamlin, 2019a and 2021; Kintsch et al., 2021). Thus, single span bridges and overpasses are highly recommended for this hotspot, and they should be placed based on documented elk movements near or on the road to ensure successful use by elk herds. AZGFD monitors the MP 52.6 bridge south of Cuba, and elk readily use this structure (Gagnon and Loberger, 2021).

Ungulates need crossing structures located approximately every mile (Bissonette and Adair, 2008), although Dodd et al. (2007a) found that 2 miles between crossing structures was acceptable for elk in Arizona. Thus, replacement of some aging smaller culverts with span bridges and wildlife overpasses is necessary for successful passage of herds of mule deer and elk.

The costliest but also most effective recommendation is for four wildlife overpasses to be placed in this hotspot. In addition, four single span bridges would need to be built, along with the installation of 17 miles of wildlife exclusion fence. If these multiple crossing structures were placed so that mule deer, elk, and other wildlife find suitable, safe passage options within 2 miles or less of each other, road permeability would become possible for entire herds of ungulates, with significant reduction in the frequency of WVCs.

The preferred location for the number one recommended overpass in this WVC hotspot is located between MP 68.5 and MP 70, where National Forest or BLM lands are found on both sides of the road. There are multiple fill slopes between MP 72 and MP 74 where a second overpass could also work. US 550 bisects Tribal land for the northwestern 2 miles of this hotspot. The Jicarilla Apache Nation helped identify the need for placement of the west-northwest fence end near MP 80.3. Eight culverts were recommended by the reconnaissance field crew for replacement with structures large enough to accommodate elk herds.

The six species of concern that may be in the area could all benefit from the proposed project recommendations. The overpasses should be readily used by elk and mule deer based on research in Colorado and Arizona (Kintsch et al., 2021; AZGFD, 2021). Black bear and cougar should readily use all the culverts, especially those along arroyos, canyons, streams, and other natural corridors. The culverts would also accommodate smaller animals that are associated with drainages. Mule deer could readily use larger and short culverts. Elk would be expected to use areas under larger bridges and over overpasses. American badger and red fox will also benefit; both these carnivores have been recorded using overpass structures in Colorado (Kintsch et al., 2021) and underpass structures in New Mexico (Loberger et al., 2021), Colorado (Kintsch et al., 2021; Cramer and Hamlin, 2021), and Utah (Cramer and Hamlin, 2019). Smaller animals such as medium sized and small mammals, lizards, snakes, amphibians, and invertebrates would benefit from the placement of logs, tree stumps, large rocks and boulders, and native vegetation to the extent possible all along the structures. These animals will use the road-crossing structures much more readily with vegetation or rocks providing hiding cover and a more natural substrate for their movements.

There were no mitigation recommendations for NM 96 due to the low traffic volume and lack of wildlife-vehicle crashes.

Overall, the field team identified 16 potential wildlife mitigation opportunities (Appendix E, Table E-1), and two to three potential fence ends at each end of the hotspot. Only nine of the potential wildlife crossing structure options are prioritized and mapped in Figure 6-5.

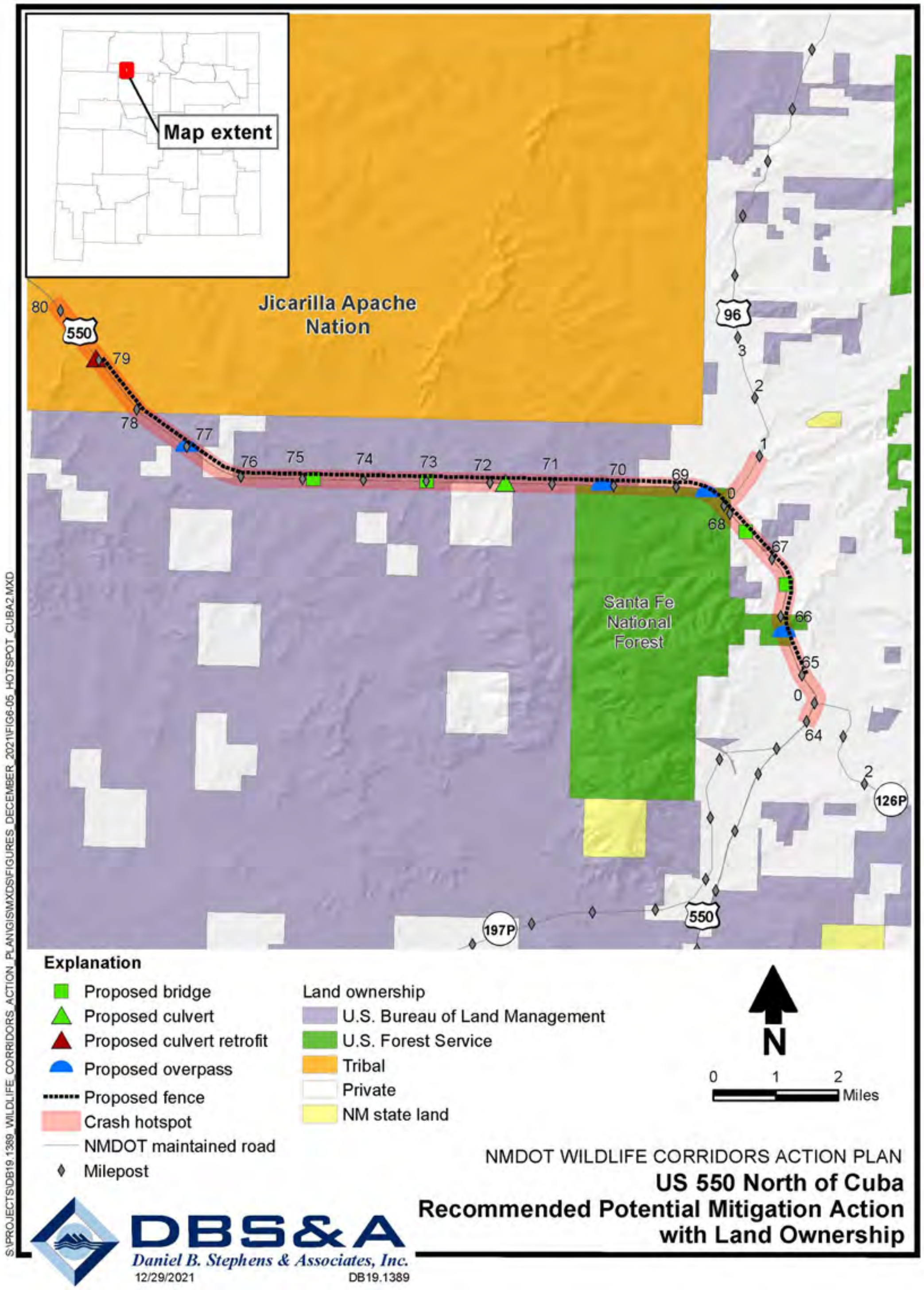

Figure 6-5. Land ownership and recommended project mitigation actions in the US 550 North of Cuba hotspot.

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The top priority recommendations for overpasses, bridges, culverts, and fences are presented in Figure 6-6.

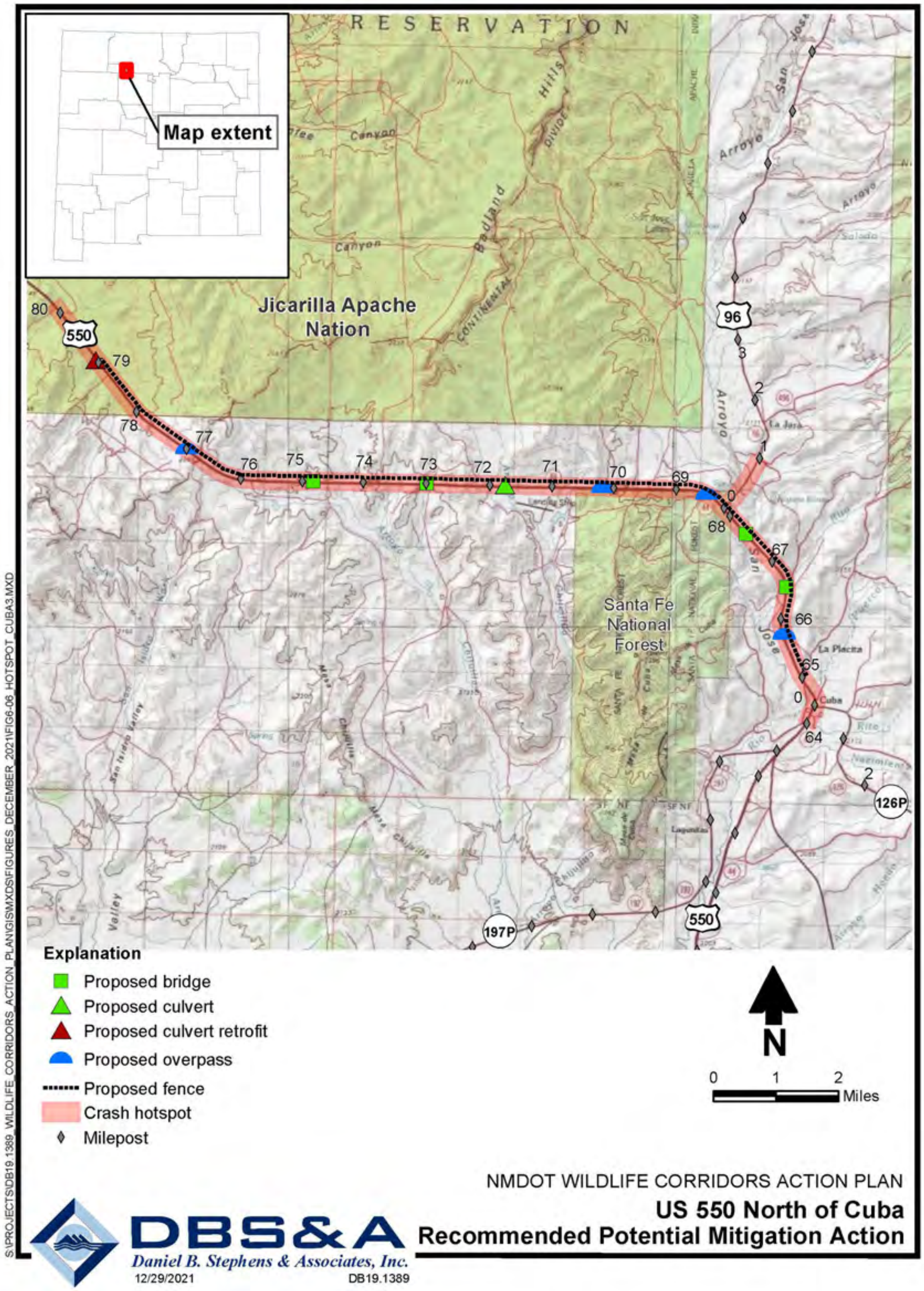

Figure 6-6. Top priority mitigation recommendations for the US 550 North of Cuba hotspot.

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6.5.1.5 *Specific Wildlife-Highway Mitigation Recommendations*

The recommendations give an overview estimate of what can be done for wildlife mitigation. Many of the existing culverts and bridges are presented in Table E-1 (Appendix E) to provide evidence of opportunities to replace them with more wildlife-friendly structures—for example, when the infrastructure is replaced or when there is a transportation project nearby. The Action Plan team is not presenting these recommendations as the final and only opportunities for enhancing wildlife movement below and above the roads. Rather, these are the top recommendations based on a one-day field reconnaissance of each project area, existing road conditions, 2021 costs, and the current state of the science and practice of transportation ecology.

6.5.1.5.1 *Cost-Effective Short-Term Solutions*

Variable message boards warning drivers should be an immediate priority in this WVC hotspot.

The message boards should be installed at each end of the hotspot to warn motorists about the danger of elk on the road, starting in early October and into January. The message board for northwest-bound road traffic should be placed at MP 64.5 and for southeast bound at MP 77.5. The boards should indicate the length of the road segment associated with the high danger of wildlife on the road (13 miles). The message boards only represent an interim measure until a more permanent solution is implemented by itself or in successive phases.

6.5.1.5.2 *Retrofitting of Existing Infrastructure*

If the fencing project in conjunction with wildlife crossing structure construction does not happen soon, we recommend that a 8-foot high wildlife exclusion fence be placed to culverts at the following locations:

- *MP 74.3:* Place wildlife exclusion fence to encourage mule deer use. Retrofit with additional vegetation and articulated concrete blocks at the end of the spillway to bring the outflow area up to the concrete spillway. Possibly work with private landowner at this site.
- MP 71.8: Place wildlife exclusion fence to box culvert to encourage mule deer use. Possibly work with private landowner at this site.

The lengths of the fences should be negotiated with NMDGF. Place wildlife paths in any riprap and short slopes under bridges.

Work with landowners to keep livestock fence away from structures so that wildlife can access them.

6.5.1.5.3 Intermediate Solutions - New Structures

Intermediate solutions would consist of installing new underpasses for wildlife. Because elk herds are not typically willing to use underpasses unless they are large bridges, underpasses may not represent a complete solution. Underpass culverts could be complete solutions at specific locations where mule deer are the only species that cross the road. Underpass choices for elk in this area are limited to only span bridges, which elk have used readily in Arizona (Dodd et al., 2007; Gagnon et al., 2011) and in an ongoing New Mexico study (Gagnon and Loberger, 2021) (Figure 6-7).

Figure 6-7. Elk photographed using US 550 Bridge at MP 52.6 south of Cuba (photo credit: AZGFD and NMDOT).

The span bridges would be placed at the following locations:

- *MP 74.8 Replace Culvert with Span Bridge:* There is ample fill. NMDOT has a 36-inch culvert at this location now. Water is potentially present. The bridge would need to be suitable for elk.
- *MP 73 Replace Culvert with Span Bridge:* Place a single span bridge. There is a valley at this location. The bridge must work for elk.
- *MP 71.8: Replace culvert with arch culvert.*
- *MP 67.5: Upgrade culvert to a span bridge.*

- *MP 66.5 Replace Culvert with Span Bridge:* Upgrade this underpass site for elk. If this does not occur, place the overpass at MP 65.8.

Where private land is adjacent to the location of a recommended mitigation action, government agencies will need to work with the property owners to ensure their support for protecting the land and wildlife, and to ensure the success of the road-crossing structures.

6.5.1.5.4 Solutions Based on Best Management Practices

Research has demonstrated that overpasses in areas where there is fill on one or both sides of the highway work best for herds of elk. This is the best management practice that has the highest probability of succeeding in allowing multiple types of elk to move above the highway. The Action Plan development team identified the four priority locations for building overpasses in this hotspot:

- *MP 70.2 Overpass (or Span Bridge):* This location is the top choice for location of an overpass. Protected land on both sides of the road (USFS on the south side, BLM land on the north side) and the presence of a north-south ridge that might be used by elk made this the top location for an overpass. A possible alternative would be to place a span bridge at MP 70, and place an overpass at MP 68.5.
- *MP 68.5 Overpass:* This is the second choice for an overpass location in this hotspot. It is located on USFS land at a curve where a secondary road comes in from the northeast. It appears to have the best potential for long-term persistence. To best meet elk and mule deer needs for wildlife crossing structure spacing, this project would need both this overpass and the first-choice overpass located at MP 70.2. As another option at this location, the research team recommends a type of single span bridge similar to what Arizona built for elk on SR 260. A USFS maintenance yard on the west side of the road represents a source of human disturbance.
- *MP 77.0 Continental Divide Overpass:* This third-choice overpass location for this hotspot is located entirely on BLM-managed land, and this location represents the only spot from MP 75.5 to the west end of the project area where a structure could be placed entirely on public land. It has only one side of slope, and would need fill on the other side. The Jicarilla Apache Nation has shown that collared elk concentrate on the north side of the highway. The site is not ideal, but no other option exists on the west end of the project, unless NMDOT were to partner with the Jicarilla Apache Nation and build structures on their land. Advantages presented by this location include some topography, a wide right-of-way, and

fair land ownership. This location is the one spot we have to work with for either an underpass or overpass, within the last few miles of the project. The parking area at the cell phone towers might need to be moved down the road. A kiosk could be added to the parking lot, informing the public about the project, similar to what has been done for the SH 93 bighorn sheep mitigation project in Arizona.

- *MP 65.8 Overpass:* This is the fourth-choice overpass location for this hotspot. It lies at the southeastern end of the road, with National Forest land on both sides. Human disturbance exists at this location in the form of a USFS maintenance yard on the west side.

6.5.1.6 Benefit-Cost Analysis

There are several types of benefit-cost analyses. However, they all share the same basic premise, which is to use a benefit-cost ratio with the benefit in the numerator and the cost in the denominator. The cost is associated with the construction and maintenance of the proposed mitigation infrastructure. The estimated monetary benefit is derived from the reduction in the number of crashes over the lifetime of the mitigation.

The unique approach here is based on the Colorado DOT's new method of including the economic value of elk and mule deer not killed in crashes as a result of the mitigation among the benefits (Kintsch et al., 2019).

6.5.1.6.1 Ballpark Estimates for Costs of Infrastructure

Table 6-8 presents the costs per unit for overpasses, bridges, and culverts placed on a four-lane highway as estimated by the Action Plan development team's engineers, based on NMDOT 2019 estimates. The prices of 8-foot wildlife exclusion fencing per mile for both sides of the highway, double cattle guards, also known as game guards, and escape ramps are all taken from Colorado DOT estimates in the West Slope Study (Kintsch et al., 2019).

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Table 6-8. US 550 North of Cuba hotspot project wildlife crossing structures and other mitigation rough cost estimates.

Infrastructure	Cost per unit	Cost for Infrastructure
MP 70.2 Overpass 4-lane	$7,280,000	$7,280,000
MP 68.5 Overpass 4-lane	$7,280,000	$7,280,000
MP 77 Overpass 4-lane	$7,280,000	$7,280,000
MP 65.8 Overpass 4-lane	$7,280,000	$7,280,000
MP 74.8 Span bridge 4-lane	$2,520,000	$2,520,000
MP 73 Span bridge 4-lane	$2,520,000	$2,520,000
MP 71.8 Arch culvert 4-lane	$3,230,000	$3,230,000
MP 67.5 Span bridge 4-lane	$2,520,000	$2,520,000
MP 65.8 Span bridge 4-lane	$2,520,000	$2,520,000
14 Miles of Fence	$100,000/mile	$1,400,000
Double Cattle guards, estimate 10 guards	$60,000	$600,000
Escape Ramps, 4 per mile 4 x 14 = 56	$14,000	$784,000
Total		$45,206,312

6.5.1.6.2 Animal-Vehicle Crash Costs

From 2009 to 2018, 223 vehicle crashes involving wildlife and domestic animals were recorded in this hotspot. The severity of these crashes varied. A total of 202 crashes resulted in property damage, with 9 Class C injury crashes, 11 Class B injury crashes, 1 Class A injury crash, and 0 fatal crashes also recorded.

The NMDOT 2019 and FHWA 2018 (Harmon et al., 2018) costs associated with each type of crash are presented in Table 6-5. Based on these costs, the total costs associated with animal crashes in this hotspot have been calculated (Table 6-9).

Table 6-9. Calculation of wildlife-vehicle crash costs in the US 550 North of Cuba hotspot using NMDOT and FHWA crash values.

Crash Type	NMDOT-Estimated Individual Crash Costs to Society	Total NMDOT Value of Crashes	FHWA-Estimated Individual Crash Costs to Society Based on Harmon et al. (2018)	Total FHWA Value of Crashes
202 property damage only	$7,400	$1,494,800	$ 11,900	$2,403,800
9 possible injury (Type C)	$44,900	$404,100	$125,600	$1,130,400
11 minor injury (Type B)	$79,000	$869,000	$198,500	$2,183,500
1 incapacitating/serious injury (Type A)	$216,000	$216,000	$655,000	$655,000
0 fatality	$4,008,900	$0	$11,295,400	$0
Total		$2,983,900		$6,372,700

The benefits portion of the ratio is estimated by examining the expected reduction in crash costs. These benefits are estimated by taking the crash costs, multiplying them by a 90 percent reduction in crashes expected from the mitigation, the projected 75-year life expectancy of the mitigation project, and the value of mule deer and elk saved by the mitigation over 75 years (Table 6-10).

Table 6-10. Estimated benefit value of mitigation, US 550 North of Cuba hotspot.

	NMDOT Crash Values	FHWA Crash Values
Total value of crash costs over 10 years	$2,983,900	$6,372,700
Crash cost per mile per year	$17,552	$ 37,486
Crash cost for 17 miles of project over 75 years of infrastructure (Cost/mile/year x 17 x 75)	$22,379,250	$47,795,250
Benefit value of mitigation based on a 90% reduction in crashes over a 75-year period	$20,141,325	$43,015,725
Wildlife Lost and Saved Values		Estimated Value of Elk and Mule Deer Saved over 75 years of Mitigation
If 54% of animal-vehicle crashes were with elk (120 out of 223 animal crashes) and 37% of vehicle-animal crashes involve deer (82 out of 223 animal crashes), and there have been 22.3 animal crashes per year, and there is a predicted 90% reduction of crashes, there would be 22.3 animal crashes on average prevented annually as a result of the mitigation. This would roughly equate to 10.8 elk and 7.4 mule deer saved each year. At a value of: $2,392 for each elk, and $2,061 for each mule deer, the value of animals saved each year x 75 years of mitigation= Elk ($2,392 x 10.8 x 75 years) + Mule deer ($2,061 x 7.4 x 75 years) = Elk - $1,937,520 + Deer - $1,143,855 = $3,081,375		$3,081,375

6.5.1.6.3 Benefit-Cost Ratio

- NMDOT values for crashes:
  Benefit/Cost Equation = $20,141,325+ $3,081,375/$45,206,312 = 0.51
- FHWA values for crashes
  Benefit/Cost Equation = $43,015,725+ $3,081,375/$45,206,312 = 1.02

If the MP 65.8 overpass were a single span bridge rather than an overpass, the project would cost approximately $4,760,000 less and the benefit/cost equations would then be as follow:

- NMDOT values for crashes:
  Benefit/Cost Equation = $20,141,325 + $3,081,375/$40,446,312 = 0.57

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- FHWA values for crashes
  Benefit/Cost Equation = $43,015,725 + $3,081,375/$40,446,312 = 1.14

If FHWA crash values are used, and four overpasses are installed, the mitigation would be expected to just pay for itself over 75 years, with a benefit/cost ratio of 1.02. If the FHWA crash values are used, and only three overpasses are built (with the MP 65.8 overpass replaced by a span bridge), the mitigation would be expected to pay for itself over 75 years, with a benefit/ cost ration of 1.14. However, all iterations of a benefit-cost equation with NMDOT values do not return a value near 1. The NMDOT-derived benefit-cost analysis indicates that the project would not pay for itself in saved crashes over time. If the full list of mitigation measures equaled approximately $23.22 million, the project would be expected to possibly pay for itself over the same time period based on NMDOT crash costs.

6.5.2 US 180 NM 90 Silver City WVC Hotspot Recommendations for Wildlife Mitigation Projects

- *US 180 MP 108–123, NM 90 MP 36–42, NM 15 MP 0–3, NM 152 MP 0–3*
- *27-mile hotspot, 11.7 miles of mitigation*
- *Grant County*
- *NMDOT District 1*

6.5.2.1 *Project Area Overview*

The Silver City WVC hotspot is approximately 27 miles long, extending from just west of Silver City, eastward along US 180 through the town of Silver City and through Santa Clara, and southward along US 180 into Bayard. Mule deer, javelina, and elk all occur in this area (Figure 6-8).

Figure 6-8. Mule deer, javelina, and elk all occur in this hotspot area, and would benefit from wildlife crossing structures (photo credits: P. Cramer [mule deer], AZGFD [javelina], and NMDGF [elk]).

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Three smaller "fingers" of the hotspot extend from US 180, the largest of which includes a 6-mile portion of NM 90 from Silver City to Tyrone. It is the second highest priority WVC hotspot in the state, based on the number of crashes per mile. The hotspot is located at the southern foot of the Pinos Altos Range of the Mogollon Mountains, approximately 3 miles east of the Continental Divide. The hotspot occurs within the transition zone between the Arizona/New Mexico Mountains and the Chihuahuan Desert where woodlands, scrublands, and desert grasslands converge.

Most of this hotspot is bordered by private lands, but small portions of New Mexico State Land Office (SLO), U.S. Department of Defense (DOD), and USFS lands are also present. This hotspot is located 2 miles north of the 20th ranked hotspot (NM 90 South of Tyrone) and less than 3 miles west of the 31st ranked hotspot (NM 152 East of Santa Clara).

Silver City is the largest town in the hotspot. While the stretch of US 180 between Silver City and Bayard has significant development bordering the highway, Silver City itself has seen an 11 percent human population decline from 2010 to 2019 (World Population Review, 2021). Approximately 65 to 70 percent of Silver City's economy comes from tourism related to ecotourism (including Gila National Forest), cultural and historical attractions (including Gila Cliff Dwellings National Monument), and the arts (Silver City Press Daily, 2021). The recorded wildlife crashes for this hotspot are plotted on Figure 6-9. Deer are the most highly reported animal to be involved in wildlife crashes in this area.

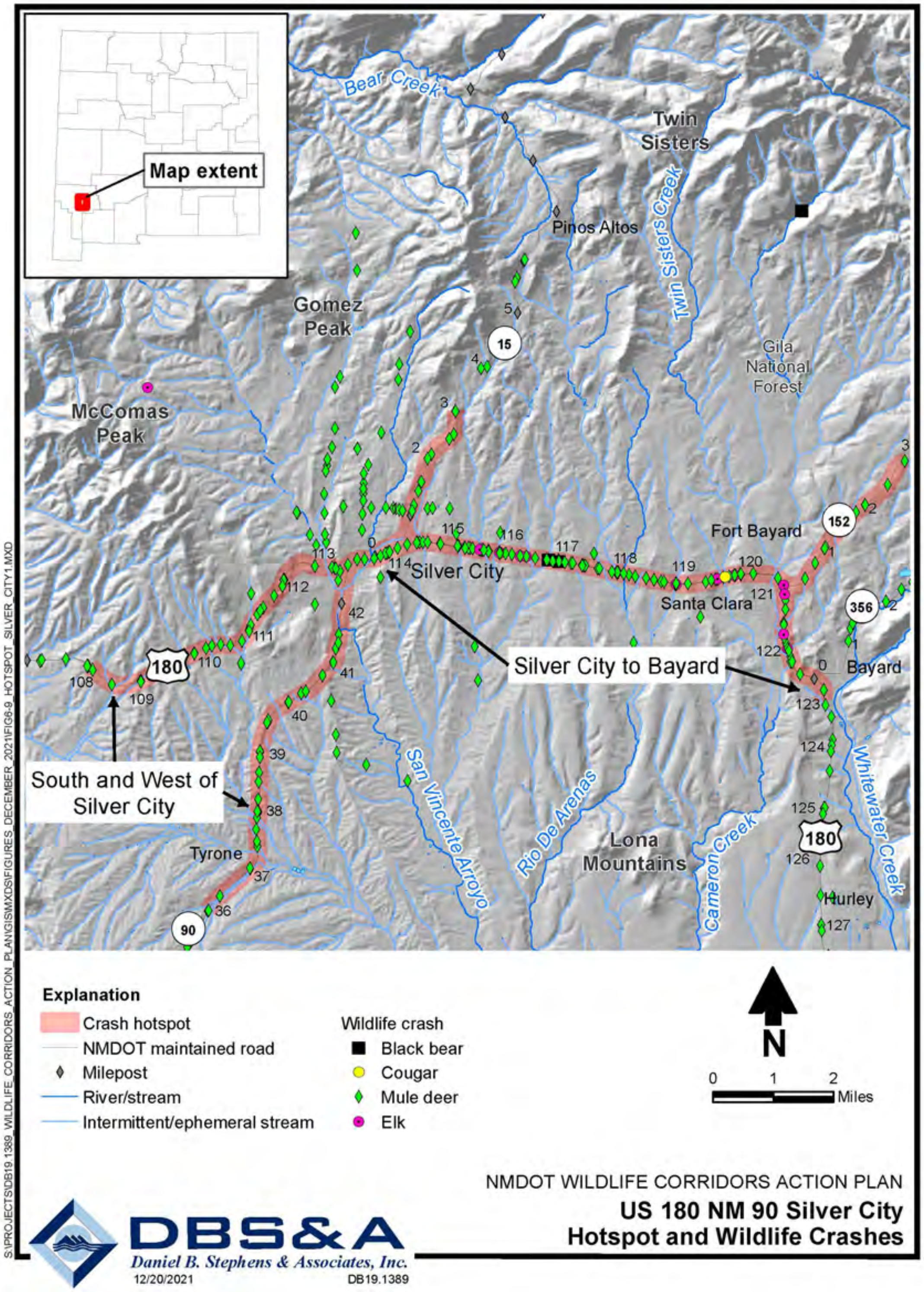

Figure 6-9. Wildlife-vehicle crashes in and around the US 180 NM 90 Silver City hotspot.

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6.5.2.2 *Transportation – Safety Statistics*

The crash data reported in the following subsections include both animal-vehicle crashes and wildlife-vehicle crashes to better reflect the impact of collisions with all animals. Animal-vehicle crashes include wild and domestic animals and livestock. Using all animal statistics to evaluate the situation helps the reader to differentiate where there are strictly wildlife problem areas, and where these domesticated animals may also be involved. The recommended wildlife mitigation that includes wildlife exclusion fences would be expected to reduce all these crashes, not just those with wildlife. Therefore, the total animal crashes are reported and then used in the benefit-cost analyses of the value of the recommended infrastructure. The reported wildlife crashes are those strictly with the six focal species: mule deer, elk, pronghorn, bighorn, black bear, and cougar.

6.5.2.2.1 *Wildlife-Vehicle Crashes per Mile per Year*

According to NMDOT data, there were 574 reported crashes with all animals, and 481 crashes with wildlife between 2009 and 2018. Of the reported animal-vehicle crashes, 465 (~81 percent) involved mule deer, 13 (~2 percent) involved elk, 2 (<1 percent) involved black bear, and 1 (<1 percent) involved cougar.

The numbers of crashes with the six large mammal focal species were determined in a GIS analysis, and are presented in Table 6-11.

Table 6-11. US 180 NM 90 Silver City WVC hotspot, NMDOT data for crashes with all animals and six focal wildlife species of interest, 2009-2018.

Length (miles)	Total Crashes with All Animals	Total Crashes with Focal Species	Wildlife Crashes per mile per year	Crashes with Six Focal Species					
				Deer	Elk	Black Bear	Cougar	Pronghorn	Bighorn Sheep
27	574	481	1.78	465	13	2	1	0	0

6.5.2.2.2 *Seasonality of Wildlife-Vehicle Crashes*

From 2009-2018, there were 481 recorded wildlife crashes with the six focal species in the Silver City hotspot. Most were with deer. It appears the vehicle-deer crashes are highest in May and June, but are high throughout the year in this area, indicating that there are local mule deer in the area, and probably also migrants that move through town to access seasonal habitat (Figure 6-10).

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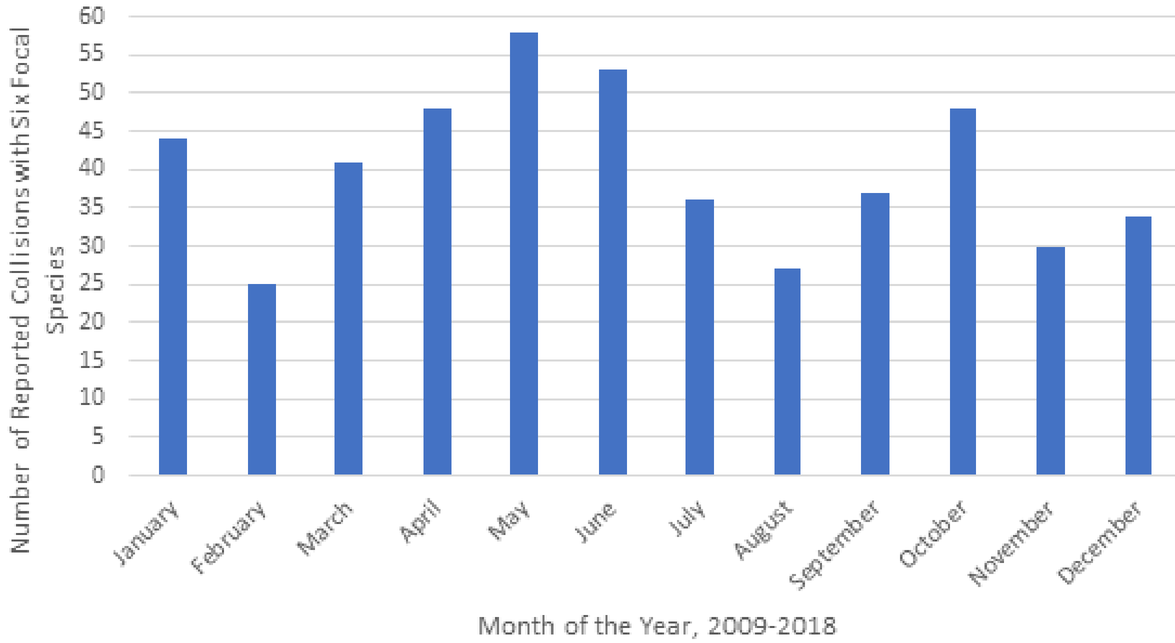

Figure 6-10. Wildlife-vehicle crashes by month in the US 180 NM 90 Silver City hotspot.

6.5.2.2.3 WVC Species Percentages

Of the WVCs in this hotspot, 97 percent involved mule deer and 2.7 percent involved elk.

6.5.2.2.4 Wildlife-Vehicle Crashes as Percentage of All Crashes

There were 1,440 crashes reported in this segment from 2009 to 2018; 574 of these were with animals. Of these crashes, 481 (33 percent of all crashes) were reported to involve focal species of wildlife.

6.5.2.2.5 Average Annual Daily Traffic (AADT)

AADT is important in estimating if large wild animals such as the six focal species have opportunities to cross the roads under scrutiny. Traffic volumes can form a complete barrier to wildlife movement all day and into the night once AADT reaches well above 20,000 vehicles per day. At 10,000 vehicles per day there is still a barrier, with some opportunity for nocturnal movements across roads. Wildlife can find limited opportunities to cross roads with AADT between 2,000 and 10,000 vehicles per day. However, at AADT of 2,000 and 10,000 per day, wildlife will try to cross roads, and will have greater mortality in some areas because of the lower perceived risk by wild animals but the continued presence of vehicles (Charry and Jones, 2009; Ng et al., 2004; Seiler, 2005).

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US 180 AADT ranged from 1,738 vehicles per day in the western section to 26,092 vehicles per day in the town of Silver City:

- MP 108-110 = 1,738 (2018); 1,604 (estimated 2038)
- MP 110-111 = 1,948 (2018); 1,798 (estimated 2038)
- MP 111-113 = 3,280 (2018); 4,331 (estimated 2038)
- MP 113-114 = 26,092 (2018); 34,456 (estimated 2038)
- MP 114-115 = 3,184 (2018); 4,205 (estimated 2038)
- MP 115-121 = 14,220 (2018); 18,778 (estimated 2038)
- MP 121-123 = 9,351 (2018); 12,349 (estimated 2038)

NM 90 AADT ranged from a low of 1,335 vehicles per day in the southern section to 9,066 vehicles per day at the junction with US 180 in Silver City:

- MP 42-42.5 = 9,066 (2018); 9,249 (estimated 2038)
- MP 40-42 = 4,730 (2018); 6,246 (estimated 2038)
- MP 40 and south = 1,335 (2018); 1,232 (estimated 2038)

On NM 15, MP 0-3, AADT was 4,682 vehicles per day in 2018, and is estimated to be 4,777 vehicles per day in 2038.

On NM 152, MP 0-3, AADT was 1,635 vehicles per day in 2018, and is estimated to be 1,284 vehicles per day in 2038.

6.5.2.2.6 Number of Lanes

- US 180:
  - MP 112.5 and west: two lanes
  - MP 112.5 and east: four lanes
- NM 90: four lanes
- NM 15: two lanes
- NM 152: two lanes

6.5.2.2.7 STIP Possibility

- STIP Control Number 1101011, US 180 Drainage Structure Phase 2, Bridge Rehab. MP 115–122. District 1, 2020 start. Total Programmed = $1,840,000
- STIP Control Number 1101450, Final Phase of US 180 Urban Project in Silver City, Road Reconstruction. MP 114.7-115.5. District 1, 2020 start. Total Programmed: $5,522,556
- STIP Control Number 1101800, Santa Clara Multimodal Project, Bicycle and Pedestrian. MP 120-122.5. District 1, 2020 start. Total Programmed: $4,119,046

6.5.2.3 Ecological and Feasibility Considerations

6.5.2.3.1 Species of Concern

A total of 11 species of concern could occur in this area: Black bear, cougar, mule deer, elk, American badger, white-nosed coati, kit fox, hog-nosed skunk, javelina, Gila monster, and ornate box turtle. Mule deer, elk, black bear, and cougar have been recorded in relation to WVCs in this hotspot.

6.5.2.3.2 Data

Data used included NMDOT crash data. NMDGF provided black bear and cougar mortality data, which included locations where these species were killed by vehicles on roads, and additional locations where mortality was related to other causes.

6.5.2.3.3 Public Land

There is SLO land on NM 90 (MP 36) for 0.54 mile on both sides of the road and on US 180 (MP 115.5) for 0.36 mile on one side of the road. There is DOD land on US 180 (MP 119) for 1.17 miles on both sides of the road and 1.22 miles on one side of the road. There is USFS land on NM 152 (MP 1.5) for 0.46 mile on both sides of the road. There is BLM land on US 180 (MP 121) for 0.35 mile on one side of the road.

6.5.2.3.4 Support

Several public comments received by NMDOT from citizens in and near Silver City expressed support for the Action Plan. This feedback was received despite cancellation of the public meeting due to the Covid-19 pandemic.

6.5.2.4 Recommendations Overview

This 27-mile hotspot consists of basically all roads to and through Silver City. Recommendations are predominantly in reference to replacement or retrofitting of the 17 box culverts and corrugated metal pipe culverts the field team examined. These include narrow or multi-celled box culverts that have some but perhaps limited use by mule deer. However, according to recent research on structure use by wildlife in New Mexico, there is evidence indicating that deer found in urban environments may be more likely to use smaller culverts than their more rural counterparts (Loberger et al., 2021). There are two recommendations for overpasses on US 180: one on the west side of Silver City and the other just west of Santa Clara. The presence of elk on the road and documented collisions with elk, especially in the area near Santa Clara, necessitate mitigation actions that provide connectivity for this species. These animals will not use a culvert or small span arch culvert in large numbers, based on research in the neighboring states of Arizona, Colorado, and Utah (Gagnon et al., 2015 and 2017; Kintsch et al., 2021; Cramer, 2014; Cramer and Hamlin, 2019a and 2019b). However, in Colorado as of 2021, a small herd of elk adapted to a large arch culvert 66 feet long over a period of five years (Kintsch et al., 2021), while elk in southern Colorado did not adapt to a similar arch culvert that was 139 feet long (Cramer and Hamlin 2021). Single span bridges and overpasses are highly recommended to be placed in the areas with elk near or on the road to ensure successful use by elk herds. These structures will help provide connectivity to help these animals move to habitat, food, and water resources throughout this US 180 road corridor.

An existing bridge south of Silver City on NM 90 could be retrofitted with the addition of wing fence to guide wildlife of all sizes to and through the riparian area. Two existing concrete box culverts along US 180 between Santa Clara and Bayard could also be retrofitted with wing fence. Some existing culverts have fences blocking them that could be taken down and replaced with wildlife friendly fence along the right-of-way boundary.

NM 15 and NM 152 currently have low traffic volumes, low occurrences of WVCs, and lack of existing infrastructure; therefore, no final mitigation project recommendations were made for these roads. However, if any of these factors change, wildlife crossing opportunities can be reevaluated for the NM 15 and NM 152 sections.

The 11 species of concern that may be in the area could all benefit from these recommended structures. The overpasses should be readily used by elk and mule deer, based on research in Colorado and Arizona (Kintsch et al., 2021; AZGFD, 2021). Black bear and cougar have been documented using underpass structures more readily than overpasses in Colorado (Kintsch et al., 2021), Arizona (Gagnon et al., 2011), and Utah (Cramer, 2014). These two carnivores may be best accommodated if the culverts are located along draws and water bodies in the landscape. This would also accommodate smaller animals that are associated with streams and rivers, and if stream natural flow was restored, fish connectivity could be improved. American badger will also benefit; this carnivore has been recorded using overpass structures in Colorado (Kintsch et al., 2021) and underpass structures in New Mexico (Loberger et al., 2021), Colorado (Kintsch et al., 2021; Cramer and Hamlin, 2021), and Utah (Cramer and Hamlin, 2019). Hog-nosed skunks have been documented using culverts in Arizona (Grandmaison et al., 2021), and can be expected to use structures in ways similar to striped skunks, which have been documented using culverts in Arizona (Gagnon et al., 2011), New Mexico, (Loberger et al., 2021), Utah (Cramer, 2012), and Colorado (Kintsch et al., 2021). Javelina are expected to use the culverts, and even overpasses, as documented in Arizona (AZGFD, 2021). Kit fox have been documented using wildlife crossing structures including overpasses (Gagnon et al., 2017), and may be expected to use underpasses in manners similar to red fox (*Vulpes vulpes*), which readily used them in other nearby states. Red fox have been documented using overpass structures in Colorado (Kintsch et al., 2021) and underpass structures in New Mexico (Loberger et al., 2021), Colorado (Kintsch et al., 2021; Cramer and Hamlin, 2021), and Utah (Cramer and Hamlin, 2019 and 2021). The white nosed coati has been photographed using a wildlife underpass outside of Tucson, Arizona (AZGFD, 2021), and is expected to use future New Mexico wildlife underpasses. The preference for structure types is not known for the white-nosed coati, Gila monster, and ornate box turtle. However, smaller animals such as these three species and other medium sized and small mammals, lizards, snakes, amphibians, and invertebrates would benefit from the placement of logs, tree stumps, large rocks and boulders, and native vegetation to the extent possible all along the structures. These animals can move through the structures much more readily with these structural and vegetative attributes, which provide cover and a more natural substrate for their movements.

Figure 6-11 displays the priority project recommendations for wildlife mitigation and the land ownership of this hotspot. The full complement of mitigation recommendations is provided in Table E-2 (Appendix E).

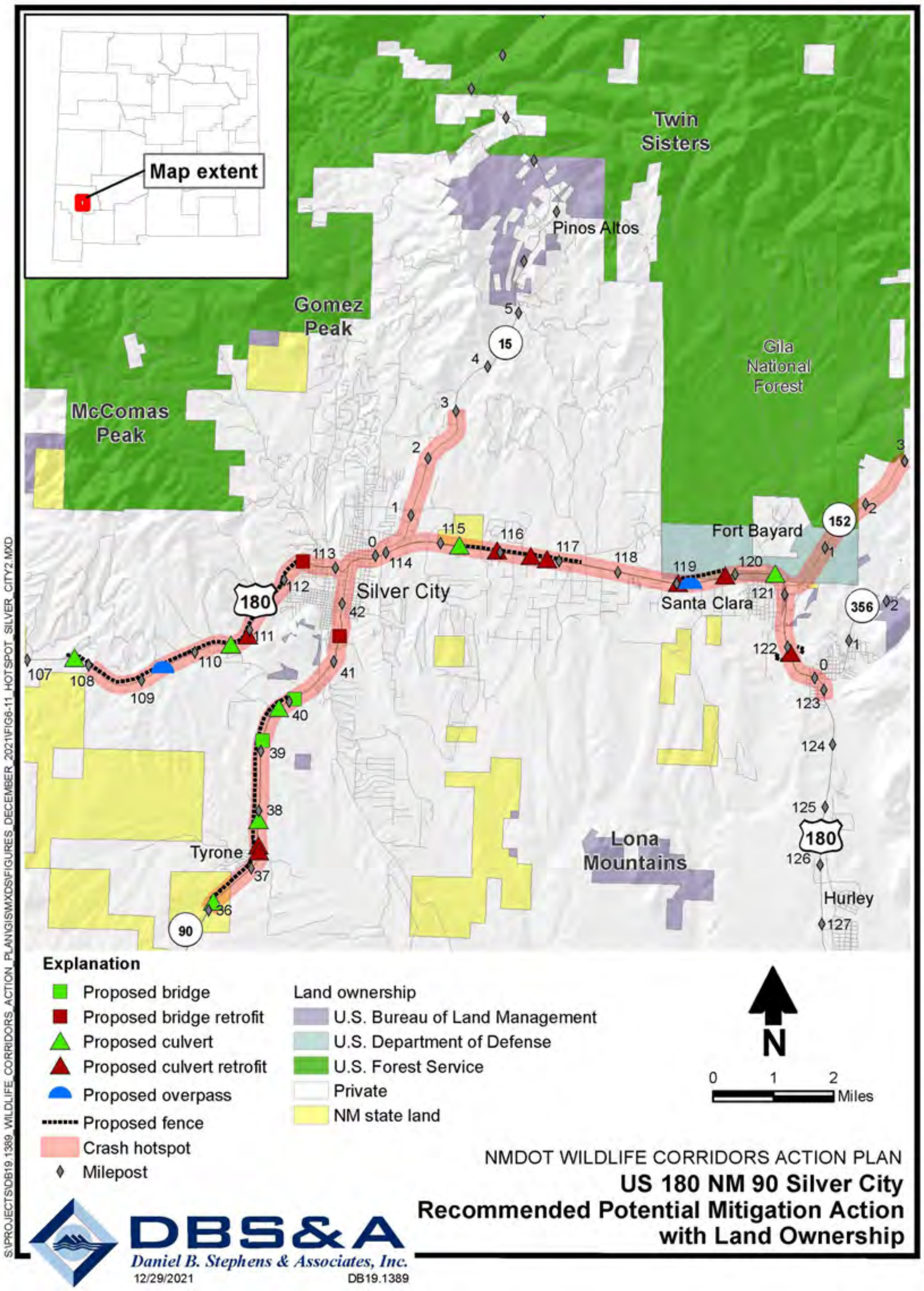

Figure 6-11. US 180 NM 90 Silver City hotspot recommended mitigation actions and land ownership.

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The top mitigation recommendations are presented on Figure 6-12.

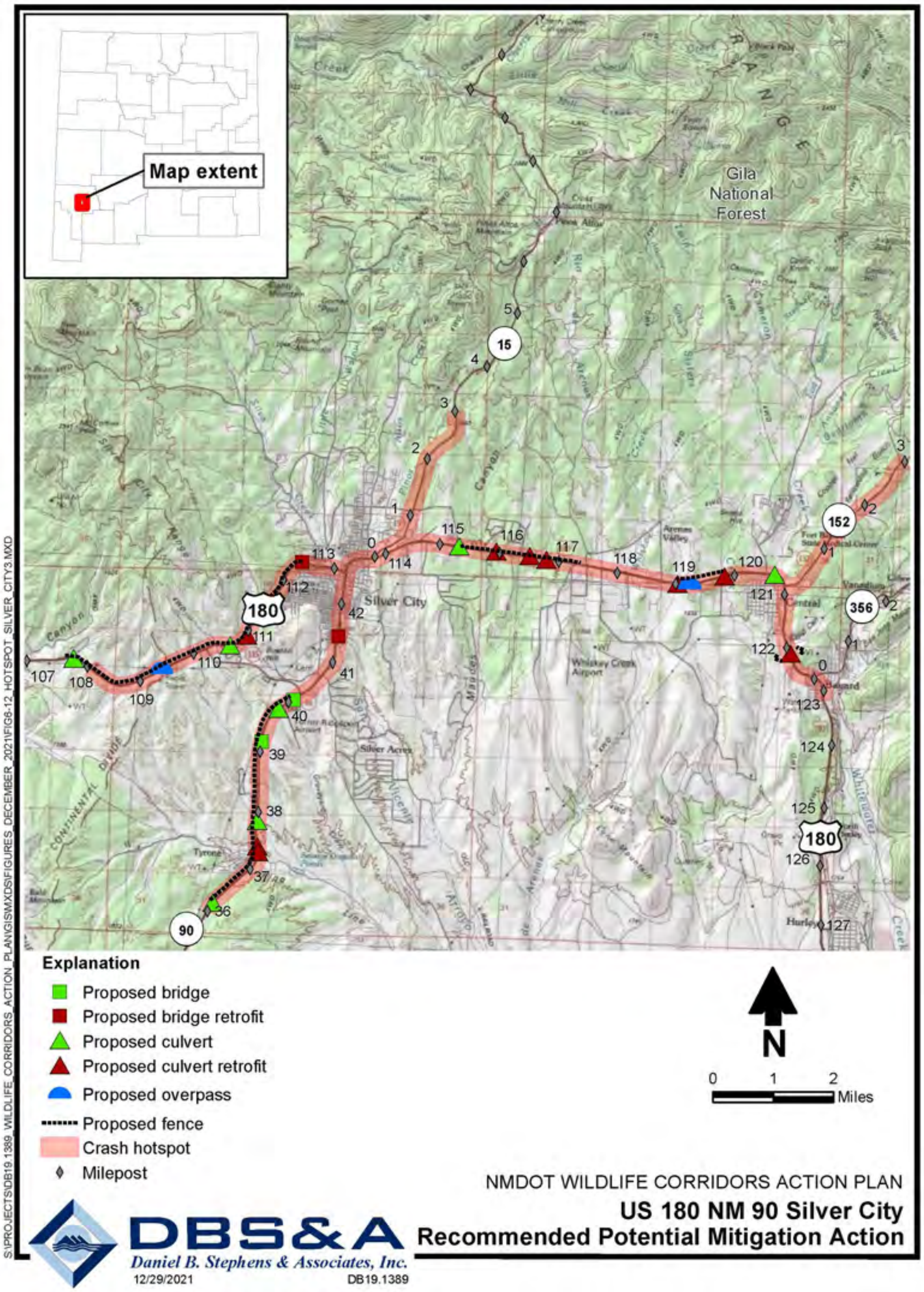

Figure 6-12. Top priority mitigation recommendations for US 180 NM 90 Silver City WVC hotspot.

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6.5.2.5 Specific Wildlife-Highway Mitigation Recommendations

The recommendations give an overview estimate of what can be done for wildlife mitigation. Many of the existing culverts and bridges are presented in Table E-2 (Appendix E) to provide evidence of opportunities to replace them with more wildlife-friendly structures—for example, when the infrastructure is replaced or when there is a transportation project nearby. The Action Plan team is not presenting these recommendations as the final and only opportunities for enhancing wildlife movement below and above the roads. Rather, these are the top recommendations based on a one-day field reconnaissance of each project area, existing road conditions, 2021 costs, and the current state of the science and practice of transportation ecology.

6.5.2.5.1 Cost-Effective Short-Term Solutions

Easy short-term solutions that could be addressed for this WVC hotspot include removing fence blocking culverts and replacing with wildlife-friendly right-of-way fence farther away from the culvert entrance.

Additionally, short sections of wing fence could be added relatively quickly to the existing structures to help guide wildlife to those structures:

- *US 180, MP 122.2:* Deer are present and using the culvert. Remove or bury the waterline through the structure.
- *NM 90, MP 41.4:* This large high bridge over a stream allows for multiple types of wildlife to move beneath NM 90.

6.5.2.5.2 Retrofit Existing Infrastructure

Large sections of the hotspot could be addressed in a phased approach by retrofitting culverts with wildlife exclusion fence. These efforts should focus on culverts that are currently large enough to potentially pass mule deer. To avoid end-run events around the fence ends, fence construction should terminate at a culvert or other location that would deter deer from entering the right-of-way at the fence end. The following locations have been identified as the most effective for these efforts:

- US 180
    - *MP 110.8 to MP 112.5:* This area has the greatest concentrations of mule deer in a wild setting rather than in the more urban area of Silver City. There are opportunities to

channel mule deer to several existing structures. Mule deer tracks were registered in the culverts at MP 110.8 and MP 112, and wildlife trails were located at MP 112.

- *MP 115.9 to MP 117.5:* This area is the urban zone of Silver City. However, sizable pieces of undeveloped land lie north of US 180 along this stretch, including a parcel owned by the SLO. WVCs appear to be somewhat concentrated near these areas, indicating that wildlife may be using the undeveloped spaces. Given the density of surrounding development, it was decided by the Action Plan team that this stretch of US 180 would provide the greatest balance between benefit and feasibility.
- *MP 119 to MP 119.8:* There are wildlife trails on the wild side of the right-of-way fence coming down to the road in this area. The area near MP 119.2 has undeveloped land on both sides, making it the only reasonable location for an overpass between Silver City and Bayard, where elk-vehicle crashes are concentrated. The north side of the roadway is owned by the DOD, but the south side is privately owned. It is strongly recommended that the state work with willing private landowners, and that a conservation easement be acquired to the south side before constructing a wildlife overpass.

6.5.2.5.3 Intermediate Solutions - New Structures

Numerous existing structures in the Silver City hotspot are marginal for deer use, and could better facilitate safe wildlife passage under the roadway and make the highway safer for motorists if they were replaced with larger structures. The most practical approach to accomplishing this would be to replace structures on an as-needed basis (when the structure requires replacement or repair) and then tie that structure into a nearby adjacent, previously retrofitted structure. In essence, this would extend mitigation efforts incrementally. Some segments of this hotspot do not have the convenience of occurring adjacent to one of the retrofitted sections described above, so they would need to be addressed as separate projects, likely using a phased approach. The following structures are in greatest need of replacement to provide effective wildlife passage:

- US 180
  - *MP 110.6 – Wildlife Underpass New Large Concrete Box Culvert:* The overpass at MP 109.4 would accommodate mule deer and elk for approximately 1 to 2 miles in each direction. The spacing of wildlife crossing structures is best if the distance animals travel in their daily and dispersal movements is taken into account (Bissonette and Adair, 2008). This new structure would not only be large enough to allow deer to pass through, but

would also provide access to the nearby Boston Hill Open Space by traversing the drainage.

- *MP 115.4 – Wildlife Underpass New Large Concrete Box Culvert*
- *MP 120.8 – Wildlife Underpass New Large Concrete Box Culvert:* There is a large wash here, and it is a naturally beneficial wildlife crossing location on the landscape. This culvert can function as a standalone structure with the addition of wing fence.

- NM 90
  - *MP 36.1 – Wildlife Underpass New Arch Culvert:* Few options exist at the southern end of the hotspot along NM 90 to upsize existing structures. This location is one of the few options available to construct a structure large enough to pass deer, and ensure mitigation through the majority of the hotspot along NM 90.
  - *MP 37.8 – Wildlife Underpass New Arch Culvert:* There is evidence that mule deer are likely using the existing structure.

6.5.2.5.4 Solutions Based on Best Management Practices

Large construction efforts would be required to address the entire identified hotspot to the greatest extent practicable. While complete fencing may not be feasible throughout the more than 27 mile length of the hotspot, a complete and thorough project would essentially include four (or more) sections of crossing structures connected by fence, and three additional standalone structures with wing fence. The addition of the following crossing structures would likely maximize mitigation project effectiveness for the Silver City hotspot:

- US 180
  - *MP 107.8 – Wildlife Underpass Large Concrete Box Culvert:* There is a large valley here with plenty of fill space to work with. Mule deer is the focal species most often recorded in WVCs here, and they would be expected to use this culvert.
  - *MP 109.4 – Wildlife Overpass:* This location was identified by the project team to be more suitable for an overpass than MP 108.1. Both locations are mostly undeveloped to the south but have a residential development to the north; however, MP 109.4 is close to a large, undivided parcel to the north (Turner R Ranch) that would likely provide better refuge for wildlife. Additionally, an overpass at MP 109.4 would provide more appropriate spacing between adjacent structures to maximize wildlife use and crossing success.

- *MP 119.2 – Wildlife Overpass:* Elk have been recorded as involved in WVCs in this area. Because the DOD owns land on the north side of the highway here, it is, to some degree, a partially protected area for potential wildlife movement. Overpasses work best for elk. The road cuts through the landscape place the road about 20 feet below, making an overpass a logical choice for a crossing structure here.

- NM 90
  - *MP 39.2 – Wildlife Underpass Span Bridge or Arch Culvert:* Very few locations within the hotspot along NM 90 provide sufficient overburden to construct structures large enough to ensure use by all wildlife. Some locations that had substantial fill and were strategically placed between adjacent crossing locations were recommended for large structure placement, even if no existing structure was present.
  - *MP 39.7 – Wildlife Underpass Arch Culvert:* The road is about 25 feet above the landscape, and there is no development on either side of the road. The existing CMP at this location is not suitable for deer passage. However, significant overburden is present, which would allow for a much larger structure in an area with less human disturbance.
  - *MP 40.1 – Wildlife Underpass Span Bridge or Arch Culvert:* This is in an area where there is enough overburden to place a bridge or culvert larger than the existing one. It is also a prime location for a fence end.

6.5.2.6 Benefit-Cost Analysis

There are several types of benefit-cost analyses. However, they all share the same basic premise, which is to use a benefit-cost ratio with the benefit in the numerator and the cost in the denominator. The cost is associated with the construction and maintenance of the proposed mitigation infrastructure. The estimated monetary benefit is derived from the reduction in the number of crashes over the lifetime of the mitigation.

The unique approach here is based on the Colorado DOT's new method of including the economic value of elk and mule deer not killed in crashes as a result of the mitigation among the benefits (Kintsch et al., 2019).

6.5.2.6.1 Ballpark Estimates for Costs of Infrastructure

Table 6-12 presents the costs per unit for overpasses, span bridges, arch culverts made of pipe, and concrete box culverts as estimated by the research team's engineers based on NMDOT 2019 cost estimates. The structure cost estimates are identified as being applicable to two- or four-lane highways. The price of 8-foot wildlife exclusion fence per mile for both sides of the highway, double cattle guards, also known as game guards, and escape ramps are all taken from Colorado DOT estimates in the West Slope Study (Kintsch et al., 2019).

Table 6-12. US 180 NM 90 Silver City hotspot project wildlife crossing structures and other mitigation rough cost estimates.

Infrastructure	Cost per unit	Cost for Infrastructure	Total for Segment
US 180 (MP 107.7-MP 123)			
One overpass (2-lane): MP 109.4	$4,460,000	$4,460,000	
One overpass (4-lane w/ median): MP 119.2	$7,280,000	$7,280,000	
One large CBC (2-lane): MP 107.8	$1,430,000	$1,430,000	
One large CBC (2-lane): MP 110.6	$1,430,000	$1,430,000	
One large CBC (4-lane): MP 115.4	$2,280,000	$2,280,000	
One large CBC (4-lane): MP 120.8	$2,280,000	$2,280,000	
Fence: MP 107.7-112.5, 115.4-117.5, 119-119.8, wing fence (¼ mile x 2) = 8.2 miles	$100,000	$820,000	
Approximately 60 double cattle guards	$60,000	$3,600,000	
Escape ramps @ 4/mile = 33 = $462,000	$14,000	$462,000	
Total for US 180			$24,038,000
NM 90 (MP 36.1-MP 41.4)			
One arch culvert (4-lane): MP 36.1	$3,230,000	$3,230,000	
One arch culvert (4-lane): MP 37.8	$3,230,000	$3,230,000	
One arch culvert (4-lane): MP 39.7	$3,230,000	$3,230,000	
One span bridge (4-lane): MP 39.2	$2,520,000	$2,520,000	
One span bridge (4-lane): MP 40.1	$2,520,000	$2,520,000	
Fence MP 36.1-MP 40.1 and wing fence (¼ mile) = 4.25 miles	$100,000	$425,000	
Escape ramps @ 4/mile = 17 = $238,000	$14,000	$238,000	
Total for NM 90			$15,393,000
Total for entire hotspot			$39,431,000

6.5.2.6.2 Animal-Vehicle Crash Costs

From 2009 to 2018, there were 574 crashes that included all animals. The crash severity of these included 549 property damage only or unknown crashes, 17 Class C injury crashes, 8 Class B injury crashes, 0 Class A injury crashes, and 0 fatal crashes.

The NMDOT 2019 and FHWA 2018 (Harmon et al., 2018) crash values for these crashes are presented in Table 6-5. Based on these values, the values of the animal crashes in this hotspot were calculated (Table 6-13).

Table 6-13. Calculation of wildlife-vehicle crash costs in US 180 NM 90 Silver City hotspot using NMDOT and FHWA crash values.

Crash Type	NMDOT-Estimated Individual Crash Costs to Society	Total NMDOT Value of Crashes	FHWA-Estimated Individual Crash Costs to Society Based on Harmon et al. (2018)	Total FHWA Value of Crashes
549 property damage only	$7,400	$4,062,600	$ 11,900	$6,533,100
17 possible injury (Type C)	$44,900	$763,300	$125,600	$2,135,200
8 minor injury (Type B)	$79,000	$632,000	$198,500	$1,588,000
0 incapacitating/serious injury (Type A)	$216,000	$0	$655,000	$0
0 fatality	$4,008,900	$0	$11,295,400	$0
Total		$5,457,900		$10,256,300

There was a different expected crash reduction in this WVC hotspot than a fully mitigated area would have. On US 180, the hotspot is 16 miles long. The mitigation on US 180 includes 8.2 miles of fence, which is approximately 50 percent of the hotspot length. The NM 90 hotspot is 7 miles long, with 4 miles of fence recommended for mitigation. This is approximately 57 percent of the hotspot length on NM 90. On both these highways, the mitigation is placed on approximately 50 percent of the length; therefore the mitigation will not be expected to reduce crashes with wildlife by 90 percent. We selected a reduction of 50 percent to match the fenced area percentage. Areas without fence are not necessarily the areas where the crashes are occurring, but rather the busier areas of downtown Silver City and the spurs of NM 15 and NM 152.

The benefits portion of the ratio is estimated by examining the expected reduction in crash costs. These benefits are estimated by taking the crash costs, the 50 percent reduction of crashes the mitigation can be expected to provide, the expected time frame of 75 years for the mitigation to be on the landscape, and the value of mule deer and elk saved by the mitigation over 75 years (Table 6-14)

Table 6-14. Estimating value of mitigation for benefits, US 180 NM 90 Silver City hotspot.

	NMDOT Crash Values	FHWA Crash Values
Total value of crash costs over 10 years	$5,457,900	$10,256,300
Crash cost per mile per year	$20,214	$37,986
Crash cost for 27 miles of project over 75 years of infrastructure (Cost/mile/year x 27 x 75)	$40,933,350	$76,921,650
If mitigation reduced crashes by 50%, over 75 years, that value would be:	$20,466,675	$38,460,825
Wildlife Lost and Saved Values		Estimated Value of Elk and Mule Deer Saved over 75 years of Mitigation
If 2% of animal crashes were with elk (13 of 574 animal crashes), and 81% were with deer (465 of 574 animal crashes), and there have been 57.4 crashes with animals per year, and the number prevented would be 50% of 57.4 there would be 28.7 animal crashes prevented per year. This would roughly equate to 0.5 elk and 23 mule deer saved each year. At a value of $2,392 for each elk and $2,061 for each mule deer, the value of animals saved each year x 75 years of mitigation= Elk ($2,392 x 0.5 x 75 years) + Mule deer ($2,061 x 23 x 75 years) = Elk - $89,700 + Deer - $3,555,225 = $ 3,644,925		$3,644,925

6.5.2.6.3 Benefit-Cost Ratio

- NMDOT values for crashes:
  Benefit/Cost Equation = $20,466,675 + $3,644,925/$39,431,000 = 0.61
- FHWA Values for Crashes
  Benefit/Cost Equation = $38,460,825 + $3,644,925/$39,431,000 = 1.07

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The mitigation in this WVC hotspot would not be expected to pay for itself over 75 years if using the NMDOT crash values. However, the mitigation would be expected to pay for itself with FHWA values, with a ratio value of 1.07. If the full list of mitigation measures equaled approximately $24.11 million, the project would be expected to possibly pay for itself over the same time period based on NMDOT crash costs.

6.5.3 US 70 and NM 48 Ruidoso WVC Hotspot Recommendations for Wildlife Mitigation Projects

- *US 70 MP 257–271, NM 48 MP 0–17, NM 220 MP 0–3, NM 532 MP 0–1, NM 37 MP 0–1*
- *34 mile-hotspot, 9 miles of mitigation*
- *Lincoln and Otero Counties*
- *NMDOT District 2*

6.5.3.1 Project Area Overview

The US 70 and NM 48 Ruidoso WVC hotspot is located in the White Mountains of south-central New Mexico. The hotspot is 33 miles long and includes multiple roads. This hotspot was analyzed looking at three road segments: Ruidoso Downs to Mescalero Apache Tribal lands, Ruidoso, and Alto-Angus to the Lincoln National Forest. The species of concern for the hotspot are shown in Figure 6-13.

Figure 6-13. Mule deer, elk, and black bear are the species of concern in the Ruidoso hotspot (photo credit: NMDGF).

The roads in this hotspot wind through the mountains and lowlands surrounded by a mixture of natural communities. The ecoregion corresponds to the Rocky Mountain Coniferous Forest, which is dominated by ponderosa pine and Gambel oak. Most of the lowlands are privately owned, while the higher elevations are located predominantly within the boundaries of the Lincoln National Forest. Public lands around Ruidoso receive high year-round visitation from recreationists, including for downhill skiing in the winter at Ski Apache on Sierra Blanca.

Relatively high traffic volumes year-round on these rural, forested and wooded roads and highways create the potential for large wild animal-vehicle collisions throughout the year. The east side of the Mescalero Apache Indian Reservation is part of the hotspot on US 70. Recorded crashes with the focal species were mapped on the Ruidoso regional map in Figure 6-14.

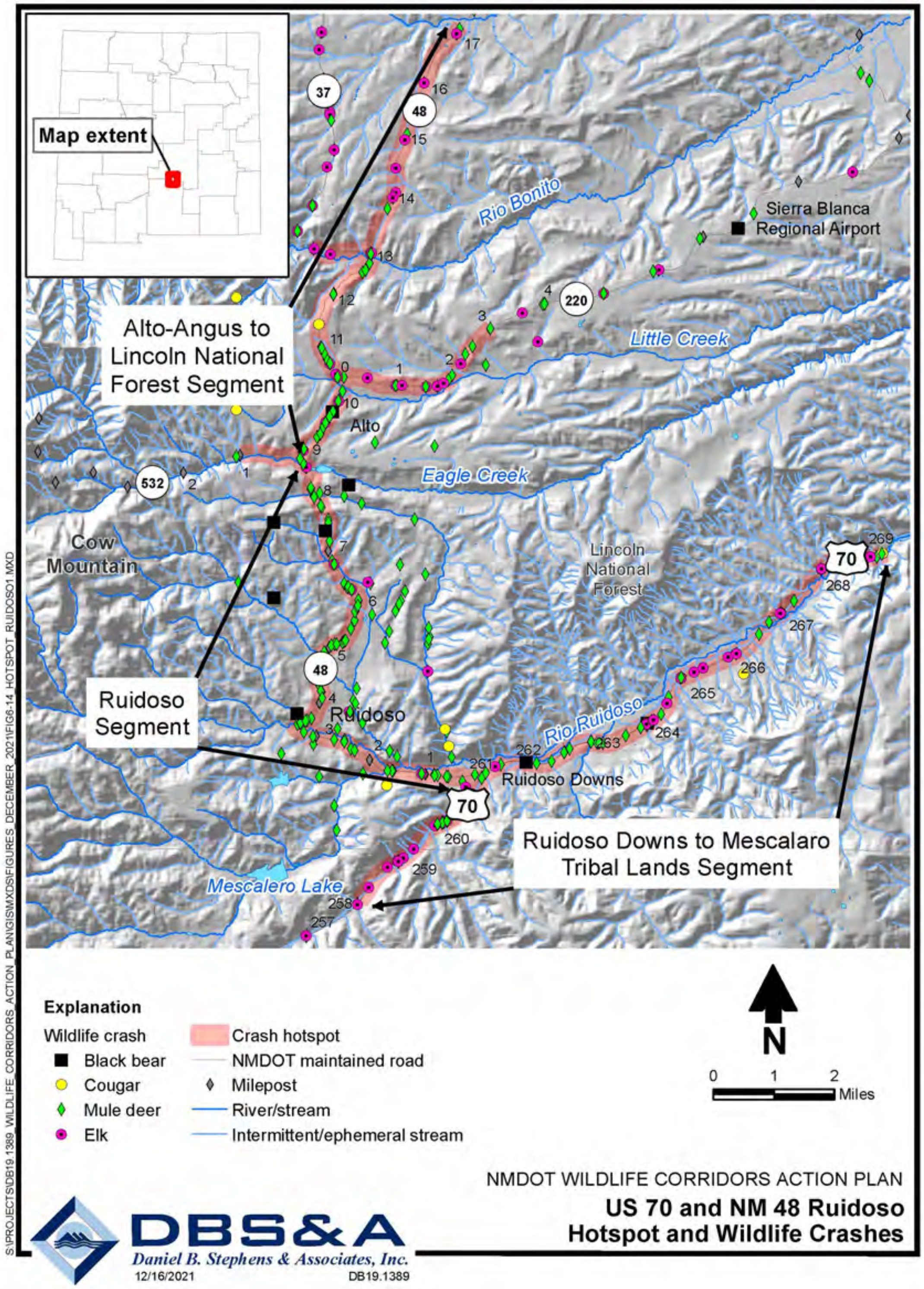

Figure 6-14. Wildlife-vehicle crashes in the US 70 and NM 48 Ruidoso hotspot.

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6.5.3.2 *Transportation – Safety Statistics*

The crash data reported in the following subsections include both animal-vehicle crashes and wildlife-vehicle crashes to better reflect the impact of collisions with all animals. Animal-vehicle crashes include wild and domestic animals and livestock. Using all animal statistics to evaluate the situation helps the reader to differentiate where there are strictly wildlife problem areas, and where these domesticated animals may also be involved. The recommended wildlife mitigation that includes wildlife exclusion fences would be expected to reduce all these crashes, not just those with wildlife. Therefore, the total animal crashes are reported and then used in the benefit-cost analyses of the value of the recommended infrastructure. The reported wildlife crashes are those strictly with the six focal species: mule deer, elk, pronghorn, bighorn, black bear, and cougar.

6.5.3.2.1 *Wildlife-Vehicle Crashes per Mile per Year*

According to NMDOT data (2009-2018), 358 crashes were reported involving four of the focal species in the hotspot: 256 with deer, 97 with elk, 4 with black bear, and 1 with cougar (Table 6-15).

Table 6-15. US 70 and NM 48 Ruidoso WVC hotspot, NMDOT crashes with all animals and with the six focal species, 2009-2018.

Length (miles)	Total Crashes with All Animals	Total Crashes with Focal Species	Wildlife Crashes per mile per year	Crashes with Six Focal Species					
				Deer	Elk	Black Bear	Cougar	Pronghorn	Bighorn Sheep
33	413	366	1.11	258	97	6	5	0	0

6.5.3.2.2 *Seasonality of Wildlife-Vehicle Crashes*

The months with the greatest number of reported wildlife-vehicle crashes in this hotspot were November and December (Figure 6-15).

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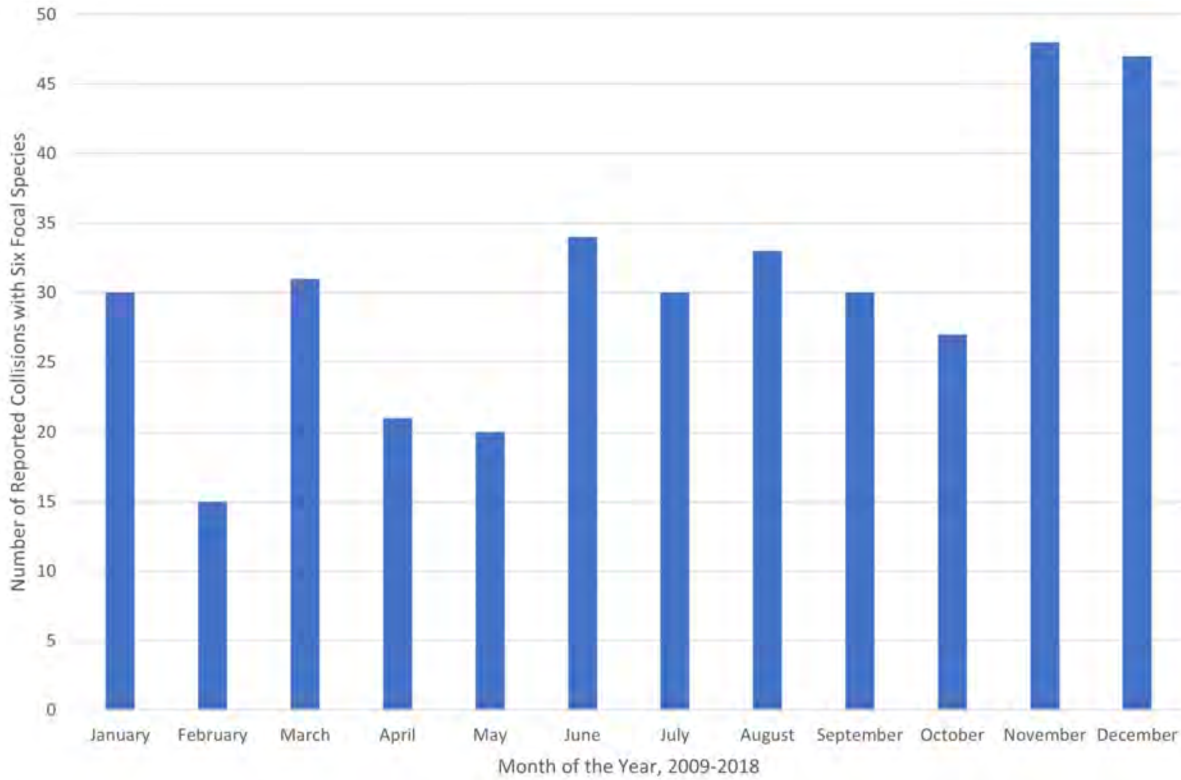

Figure 6-15. Wildlife-vehicle crashes by month in the US 70 and NM 48 Ruidoso hotspot.

6.5.3.2.3 WVC Species Percentages

Of all the WVCs recorded in this hotspot, 70 percent involved mule deer, 27 percent involved elk, 1 percent involved black bear, and 1 percent involved cougar.

6.5.3.2.4 Wildlife-Vehicle Crashes as Percentage of All Crashes

There were 1,235 total crashes in the hotspot from 2009 to 2018. Of these, 413 crashes were the result of collisions with animals. There were 366 reported crashes with the focal species, representing 30 percent of all crashes.

The five roads in this hotspot are associated with varying degrees of wildlife crashes. Table 6-16 summarizes the crashes with different wildlife species for each road and concentrated hotspots within the larger roads. The data for this table were extracted from an NMDOT crash data Excel file, and are considered to be estimates due to limitation in the data extraction methods.

Table 6-16. Crash summary for the four highways in the US 70 and NM 48 Ruidoso hotspot.

Factor	Road				
	US 70	NM 48	NM 220	NM 532	NM 37
Location	MP 258–269	MP 0–17	MP 0–3	MP 0–1	MP 0–1
Total crashes	345	832	34	0	24
Total wildlife-vehicle crashes	124	218	20		4
Black bear	2	4	0		0
Deer	71	175	11		1
Elk	49	37	9		2
Cougar	2	2	0		1
Percentage of crashes involving wildlife	36%	26%	59%	0%	17%
Injury crashes with wildlife					
Type A	0	1 - deer	0		0
Type B	3 - elk	2 - deer, 1 - elk	0		0
Type C	5 - deer, 3 - elk	4 - deer, 2 - elk	0		0
Property damage crashes with wildlife	113	207	20		4
Bear concentrations	MP 262, 264				
Deer concentrations	MP 264–266	MP 10–13	MP 0.5–2		
Elk concentrations	MP 264–266	MP 14–16	MP 0.5–2		

The percentages of all crashes that involved wildlife for each highway as presented in Table 6-16 are as follows:

- US 70: 36 percent
- NM 48: 26 percent
- NM 220: 59 percent
- NM 532: no wildlife crashes
- NM 37: 17 percent

There was one fatal crash with elk on US 70 at MP 208 on September 20, 2013. This location is outside the hotspot, but is important to note. Another fatal crash involving a deer was recorded at US 70 MP 308 on October 12, 2011.

6.5.3.2.5 Average Annual Daily Traffic (AADT)

AADT is important in estimating if large wild animals such as the six focal species have opportunities to cross the roads under scrutiny. Traffic volumes can form a complete barrier to wildlife movement all day and into the night once AADT reaches well above 20,000 vehicles per day. At 10,000 vehicles per day there is still a barrier, with some opportunity for nocturnal movements across roads. Wildlife can find limited opportunities to cross roads with AADT between 2,000 and 10,000 vehicles per day. However, at AADT of 2,000 and 10,000 per day, wildlife will try to cross roads, and will have greater mortality in some areas because of the lower perceived risk by wild animals but the continued presence of vehicles (Charry and Jones, 2009; Ng et al., 2004; Seiler, 2005).

AADT in the hotspot is as follows:

- US 70, south of MP 261: Current = 8,714 (2018), Future = 11,507 (estimated 2038)
- US 70, MP 261 to NE: Current = 12,180 (2018), Future = 10,372 (estimated 2038)
- NM 48, MP 0 to 13: Current = 10,169 (2018), Future = 9,077 (estimated 2038)
- NM 48, MP 13 to 22: Current = 2,274 (2018), Future = 2,099 (estimated 2038)
- NM 220, MP 0 to 1.5: Current = 1,885 (2018), Future = 1,481 (estimated 2038)
- NM 220, MP 1.5 eastward: Current = 173 (2018), Future = 136 (estimated 2038)
- NM 532, MP 0 to 1: Current = 781 (2018), Future = 721 (estimated 2038)
- NM 37, MP 0 to 1: Current = 1,557 (2018), Future = 1,223 (estimated 2038)

6.5.3.2.6 Number of Lanes

- US 70: four lanes
- NM 48, MP 0 to 3.5, 4.3 to 5.3: four lanes
- NM 48, MP 3.5 to MP 4.3, 5.3 to 6.8, 12.7 to 17+: two lanes
- NM 48, MP 6.8 to 12.7: three lanes
- NM 220: two lanes
- NM 532: two lanes

- NM 37: two lanes

6.5.3.2.7 STIP Possibility

This long hotspot is embedded in a landscape of hotspots, so there is a need to look holistically at the situation beyond the boundaries of the designated hotspots.

- STIP Control Number 2101480, Hondo Valley Pavement Rehabilitation, Minor Road Rehabilitation. MP 264-275. District 2, 2020 start. Total Programmed = $12,700,000.

6.5.3.3 Ecological and Feasibility Considerations

6.5.3.3.1 Species of Concern

There are potentially 12 species of concern in the hotspot: mule deer, elk, black bear, cougar, badger, hog nosed skunk, kit fox, swift fox, red fox, javelina, ornate box turtle, and the western massasauga rattlesnake. Mule deer, elk, black bear, and cougar have been recorded associated with WVCs in the hotspot.

6.5.3.3.2 Data

Data used included NMDOT crash data. NMDGF provided bear and cougar mortality data, which included locations where these species were killed by vehicles on roads, and additional locations where mortality was related to other causes.

6.5.3.3.3 Public Land

There is 1.3 miles of USFS land along US 70 at MP 268, and 0.15 mile of USFS land between MP 11 and MP 12 on NM 48.

In the Las Cruces public meeting in March 2020, citizens were concerned about the problem of WVCs and vehicle-horse crashes in the Ruidoso area. There were also several letters of support for mitigating for feral horses near Alto, from the non-profit Animal Protection of New Mexico. The Wild Horse Observers Association's D. Wilcox suggested that a radar speed sign be used to help protect the same feral horses.

6.5.3.4 Recommendations Overview

The Ruidoso hotspot was divided into three segments for ease of evaluation. In total, two overpasses and eight bridges were recommended for construction, along with retrofits of five existing bridges and culverts. There are many residences and small towns within this hotspot, so there are not as many opportunities for mitigation solutions that would need protected land on both sides of the highways as there would be in a landscape with more public land. There is one wildlife crossing bridge recommended for placement on the Mescalero Apache Tribal lands. Many of the recommended structures would be adjacent to private lands, making it necessary to work with landowners for land protection.

6.5.3.4.1 Ruidoso Downs to Mescalero Tribal Lands, US 70 MP 258–269

According to the NMDOT data, there were approximately 71 crashes with deer, 49 crashes with elk, 2 crashes with black bear, and 2 crashes with cougar in this segment between 2009 and 2018.

The Ruidoso Downs hotspot is embedded in a landscape full of hotspots. Thus, the field ecologists checked potential wildlife crossing areas outside of the hotspot in all directions. Mescalero Apache Conservation Officer Tyner Cervantes provided wildlife crash data for crashes on Tribal land. These were added to the NMDOT crash maps.

Ruidoso Downs human development extends from approximately MP 259.5 in the southwest to MP 264 toward the northeast. The highest intensity crash area for mule deer and elk is from MP 264 to MP 266. This area should be the focus of providing wildlife crossing opportunities. US 70 MP 266.1 is the priority overpass location on US 70. There is undeveloped land on both sides of the road, although it is privately owned and would have to be placed in conservation easements before structures could be constructed. The MP 267.9 new wildlife underpass bridge would be another priority location and structure. The land on both sides is owned by USFS. Both mule deer and elk were recorded in the crash records, and these species would both benefit from this bridge.

6.5.3.4.2 Ruidoso, NM 48 MP 0–9

According to the NMDOT data, there were 115 crashes with deer, 6 crashes with elk, 3 crashes with black bear, and 1 crash with cougar in this segment between 2009 and 2018.

Ruidoso is another hotspot embedded in an area full of WVC hotspots. There are homes and private land all along this segment; it was therefore difficult to find wildlife mitigation solutions. Landowners will need to be willing to place conservation easements on their land to facilitate wildlife movement before structures are built. The priority action in this segment is to place wing fences on each corner of the Eagle Creek Bridge at MP 8.6. This is a stream and riparian area embedded within a high-density neighborhood. There is limited wildlife movement opportunity here, but it is the only location on this segment that could accommodate wildlife.

6.5.3.4.3 Alto-Angus-Lincoln National Forest, NM 48 MP 9-17, NM 220 MP 0-3, NM 532 MP 0-1, NM 37 MP 0-1

According to the NMDOT data, there were 72 crashes with deer, 42 crashes with elk, 1 crash with black bear, and 1 crash with cougar in this segment between 2009 and 2018.

From NM 48 MP 13 northward, the majority of crashes were with elk. From the south, NM 48 MP 9 to MP 11, the majority of crashes were with deer.

This area changes from highly suburbanized in the south to more wild and undeveloped in the north, with largely private lands along the entire stretch. The number one priority overpass location in this segment is on NM 48 at MP 13.1. The topography and ample signs of deer were the evidence the field team used to make this recommendation. The private landowners on both sides would need to agree to conservation easements before this structure could be planned. NMDOT would work to establish a construction maintenance easement (CME) to maintain the structure and purchase the CME from the landowner. There are also recommendations for placing wildlife underpass bridges at MP 11.9, MP 13.8, and MP 15.8. However, like the overpass location, details of protecting lands in conservation easements will need to be worked out with willing landowners.

NM 220 MP 0.9 has two corrugated metal pipes beneath the road that are recommended to be replaced with a wildlife underpass bridge. This bridge would need to accommodate elk. The landowners of the land here would need to be consulted for feasibility of land protection for wildlife.

The 12 species of concern that may be in the area could all benefit from the proposed project recommendations. The overpass should be readily used by elk and mule deer based on research in Colorado and Arizona (Kintsch et al., 2021; AZGFD, 2021). Black bears and cougars have been documented using underpass structures more readily than overpasses in Colorado (Kintsch et al., 2021), Arizona (Gagnon et al., 2011), and Utah (Cramer, 2012). The needs of these two carnivores may be best accommodated if the culverts are along draws and streams. This would also benefit smaller animals that are similarly associated with streams and rivers, and if stream natural flow were to be restored, fish connectivity could also be improved. American badger and red fox will also benefit. Both of these carnivores have been recorded using overpass structures in Colorado (Kintsch et al., 2021) and underpass structures in New Mexico (Loberger et al., 2021), Colorado (Kintsch et al., 2021; Cramer and Hamlin, 2021), and Utah (Cramer and Hamlin, 2019). Kit fox have been documented using wildlife crossing structures including overpasses (Gagnon et al. 2017) and may be expected to use underpasses in manners similar to red fox. Swift fox have not been documented using wildlife crossing structures but may be expected to use underpasses in manners similar to red fox. Hog-nosed skunks have been documented using culverts in Arizona (Grandmaison et al., 2021), and can be expected to use structures in ways similar to striped skunks, which have been documented using culverts in Arizona (Gagnon et al., 2011), New Mexico (Loberger et al., 2021), Utah (Cramer, 2012), and Colorado (Kintsch et al., 2021). Javelina are expected to use both the culverts and the overpasses based on research in Arizona (AZGFD, 2021). The ornate box turtle and the western massasauga have not yet been found using road-crossing structures. However, they would be expected to more readily use overpasses and underpasses if these contained logs, tree stumps, large rocks and boulders, and native vegetation to the extent possible, to provide cover and a more natural substrate enhancing their movements.

Figure 6-16 shows the priority mitigation actions along with land ownership information. The full complement of mitigation recommendations is provided in Table E-3 (Appendix E).

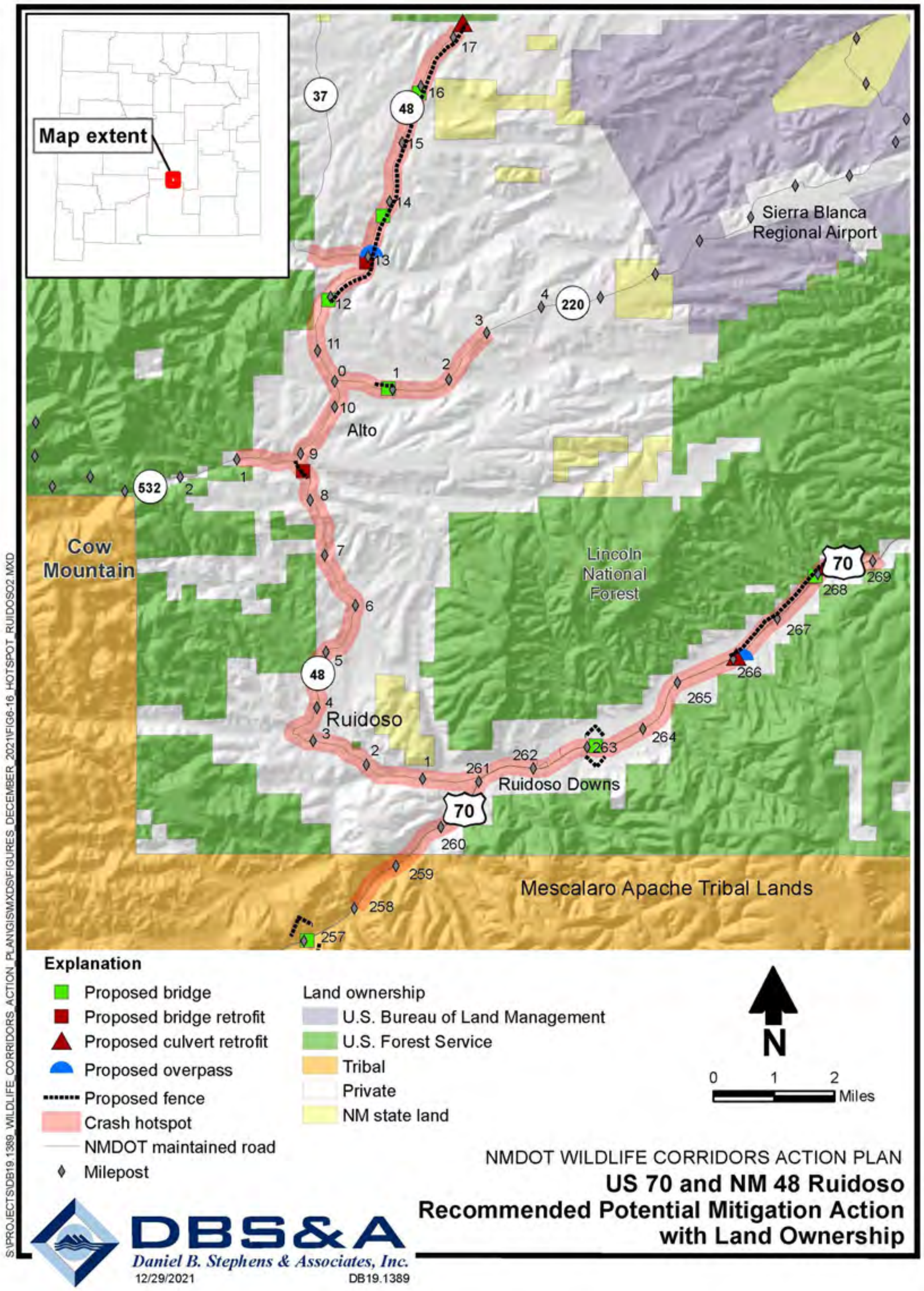

Figure 6-16. Land ownership and recommended project mitigation actions in US 70 and NM 48 Ruidoso hotspot.

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The top priority recommendations for overpasses, bridges, culverts, and fences are presented in Figure 6-17.

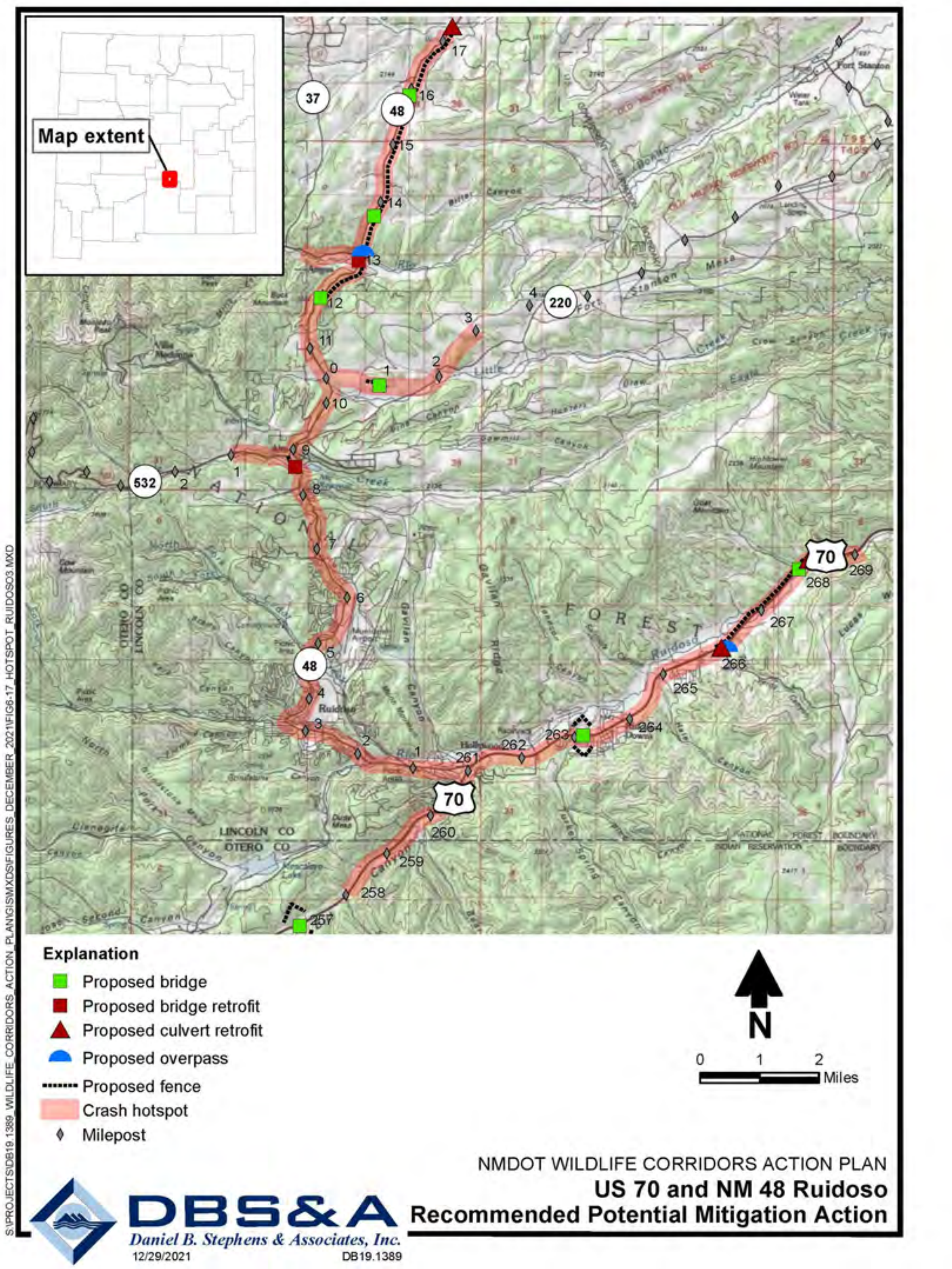

Figure 6-17. Top priority mitigation recommendations for US 70 and NM 48 Ruidoso hotspot.

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6.5.3.5 Specific Wildlife-Highway Mitigation Recommendations

The recommendations give an overview estimate of what can be done for wildlife mitigation. Many of the existing culverts and bridges are presented in Table E-3 (Appendix E) to provide evidence of opportunities to replace them with more wildlife-friendly structures—for example, when the infrastructure is replaced or when there is a transportation project nearby. The Action Plan team is not presenting these recommendations as the final and only opportunities for enhancing wildlife movement below and above the roads. Rather, these are the top recommendations based on a one-day field reconnaissance of each project area, existing road conditions, 2021 costs, and the current state of the science and practice of transportation ecology.

6.5.3.5.1 Cost-Effective Short-Term Solutions

The concrete box culvert at US 70 MP 258 is not a priority area, but it is recommended that until such time as a wildlife bridge is built, a wildlife detection driver warning system be installed. The existing culvert is a tunnel that is too long for ungulates. This is not the best place for wildlife crossing mitigation, but there are few options for structure placement in this area for the benefit of elk. Some housing is present nearby. Mescalero Apache Tribal data show crashes occurring near this location at MP 259. It may thus represent a good opportunity to reduce the number of crashes and extend the fence out in both directions. The area is located on Mescalero Apache Tribal land.

6.5.3.5.2 Retrofit Existing Infrastructure

Retrofit with fence, clearing culverts/bridges of silt, remove private landowner fences from entrances from the following structures. The following retrofits were prioritized:

- *NM 48 MP 8.6 Eagle Creek Bridge:* This is an important location for elk and deer, which have adapted to people and are always present around homes and golf courses in this suburban area. The existing seven-chambered concrete box culvert bridge has cells that are 5 feet high by 10 feet wide by 70 feet long. Short wing fences would guide mule deer and smaller animals to it, but would not facilitate elk movement. There is water in Eagle Creek, which runs through here, so it is an important movement corridor for many types of wildlife. The short wing fences only represent a short-term solution until a new bridge is built to accommodate the passage of wildlife.
- *NM 48 MP 12.9 Existing Bridge:* This is a very important area and includes a bridge over Rio Bonito. The existing bridge should be retrofitted by placing a fence to it. Wildlife paths

occur below the bridges, and fresh elk tracks were observed. Riprap occurs below the bridge, which can hinder ungulate use. The location is near a commercial area, and the riparian corridor is narrow. It is located in a deer collision hotspot and provides a good fence end location. On the west side, the fence should be constructed northward to the turnout and down NM 37 to the MP 0.3 culvert, then back up to the north on NM 48, so that animals are funneled to the Bonito Creek bridge. On the east side, the fence should be brought to the Copper Canyon development gate. There is a potential for wetland mitigation credit.

- *NM 48 MP 17.2 Existing Culvert:* This culvert is a new structure. The existing 8-foot private landowner fence could potentially block the east side of the culvert, although it is about 15 feet above ground. An NMDOT fence should be redesigned to allow wildlife to get to the undeveloped habitat on the east side. The existing culvert is a good structure for mule deer, but is probably not suitable for elk. If possible, natural substrate should be added, although this is along an arroyo and water moves through it. When the road is rebuilt, place a larger structure—a bridge—to accommodate elk. Fence to the north 0.1 mile, to MP 17.3. Work with landowners to ensure wildlife is welcome to traverse their land.

6.5.3.5.3 *Intermediate Solutions - New Structures*

All priority recommended structures would be conducive to elk movement, and would be expected to be long-term solutions. These are listed in the following subsection.

6.5.3.5.4 *Solutions Based on Best Management Practices*

- *US 70 MP 257.2 New Wildlife Underpass Bridge 4 Lanes:* This is the only priority new structure for wildlife on Mescalero Apache Tribe land in this hotspot. Replace the existing culvert with a bridge. It is a priority for elk. The current culvert conveys water, an indication that the new bridge would allow water flow and the passage of elk, mule deer, and other wildlife. There is a home about 200 feet downstream from the culvert. Mescalero Apache Tribal data show crashes occurring in the vicinity. Wing fences are recommended, just past the driveway to the west, with the installation of a guard in the driveway. To the east, wing fence should be installed to driveways. Fence end runs are possible unless the road-crossing structure is upgraded. Increased human activity has been noted at the lake to the north over the years due to casino and recreation opportunities. This new development and increase in human activity may affect wildlife. Landowners should be approached for mitigation planning.

- *US 70 MP 263.2 New Wildlife Underpass Bridge 4 Lanes:* This riparian corridor north to south through Ruidoso Downs would be a good location for a new culvert/bridge to provide mule deer habitat connectivity. Right now it is a drainage area with a very small 3-foot culvert. Every WVC near this location is likely the result of animals following the riparian corridor and going over the road at this location. The existing culvert is full of shallow water. It goes diagonally across the road. It would need to be 300 to 400 feet long if it were to be replaced. In the future, when NMDOT is replacing the culvert, a bridge should be installed instead.

  A fence can only extend from this future structure a few feet because there are too many driveways and homes nearby. The riparian area should be protected from future development, making it the perfect in-town movement corridor for wildlife. A new structure would be a concern in terms of logistics and cost, and there is also homeless people activity. Grassy fields in the area, including near a church, may explain some of the crashes as they would represent a wildlife attractant. In theory, it is a good location for mitigation, but more difficult in practice. As a possible retrofit, the floodplain forest contains Chinese elm, which is an invasive non-native. It should be replaced with native willows. Water may sheet flow through this area. Wetland mitigation credits could be used at this site, and cooperation with private landowners is needed.

- *US 70 MP 266.1 New Wildlife Overpass 4 Lanes:* This is the priority overpass for US 70. There is undeveloped land on both sides. NMDOT, alongside partners would need to work with private landowners for the establishment of conservation easements. USFS manages the land at a distance on both sides of the road. The private land separating the USFS lands from the road would need to be left open or conserved. The north side would need additional fill. This is an important alternative because the bulk of mule deer and elk collisions are between MP 264 and 266, and this is the only opportunity for wildlife crossing mitigation outside of all the businesses and homes in this stretch of US 70. At this site, one side of US 70 looks like an NMDOT staging area, with possibly a widened right-of-way. This may be enough land to cover an overpass without additional right-of-way acquisition. The west fence end would be located at MP 265.9.

- *US 70 MP 267.9 New Wildlife Underpass Bridge 4 Lanes:* This is a priority location. Replace existing culvert with bridge suitable for elk. This location is on USFS land on both sides. A field fence has been installed across the entrance of the existing culvert and needs to be removed immediately. There is a slight bend in the culvert, which is much too long and too small for ungulates. It has some concrete on the bottom. There is a natural draw or maybe an arroyo nearby that could lead wildlife to this structure.

- *US 48 MP 8.6 Eagle Creek New Wildlife Underpass Bridge 4 Lanes:* A short wing fence should be placed on either side of the existing eight-chambered bridge/multiple box culvert. NMDOT as-built plans should be examined to determine whether this is an 8-foot box culvert chamber; if so, the fill should be excavated out of the two central chambers to regain some height. The next step would be to excavate the outer ones 1 to 2 feet, thereby restoring a creek with a deep area in the center, and more shallow along its edges. This retrofit could be temporary, until a longer, higher bridge can be installed. The new bridge could accommodate wildlife but would have to raise the level of the road. At this location Eagle Creek leads to a reservoir, so it should always contain some water and not be developed. Although homes, baseball fields, a mine operation, and lots of human activity occur in the area, an adequate structure is there for water and could help wildlife under the road. Elk and deer have adapted to people and readily approach homes and golf courses. A wildlife detection system at fence ends might be advisable. Below the lake to the east is a candidate wetland restoration area for NMDOT. A wing fence could be installed along the drainage on the southwest side. On the southeast side, a fence should be placed to the access road. On the northeast side, fencing should be installed to the building, and on the northwest side, to the driveway or wall of an existing business. The area could be the focus of a wetland mitigation credit project with the potential to place low-height check dams downstream of the lake. The area could therefore be integrated as a wetland and wildlife project with added habitat restoration. Private landowners should be approached before any planning for a wildlife crossing bridge can begin.
- *US 48 MP 11.9 New Wildlife Underpass Bridge 4 Lanes:* This project is a secondary priority bridge in this segment of hotspot. The proposed underpass bridge should be designed high and wide enough to accommodate elk. A fresh elk trail was observed paralleling southbound lanes 25 feet below the highway. The topography is suitable, and few homes were observed. A recent fire occurred at this location, which is also within an area noted for the highest numbers of deer and elk-vehicle crashes. In the deer hotspot, the fence should start 0.1 mile from the south at MP 11.8, and then come from the north from the MP 13 overpass. Double cattle guards would be needed in driveways. Contacting landowners must happen prior to bridge placement to ensure land and wildlife protections.

- *US 48 MP 13.1 New Wildlife Overpass 2 Lanes:* This is a number one priority overpass location in this segment. There are suitable hill cuts on both sides with a 15-foot cut on the east side and at least as high on the west. There is evidence of deer paths on both sides of the roadway indicating that deer cross the highway at this location.. The area has suitable topography, but it is privately owned, and a sizeable swath of open space across the private land would be needed to maintain a wildlife corridor. We recommend placing the fence from this location north to MP 17.3. It is also recommended to install the fence south to the Copper Canyon gate and then to the bridge at MP 12.9. Working with landowners in order to establish conservation easements on both sides is therefore essential.
- *US 48 MP 13.8 New Wildlife Underpass Bridge 2 Lanes:* This project is a secondary priority bridge needed for spacing between the MP 13.1 overpass and the MP 15.8 bridge. An elk underpass is the goal at this location. It is in the elk hotspot area. The drainage should be more gradual as it is currently too steep. There is a building 100 yards to the northeast. Wildlife exclusion fencing should be brought to this future bridge. Consulting with private landowners on feasibility is again a necessity before planning.
- *US 48 MP 15.8 New Wildlife Underpass Bridge 2 Lanes:* Priority bridge. The small pipe should be replaced with a single span bridge with elk fencing added to it. There is a lot of elk sign in the area, which happens to be in an elk heavy WVC area, with state land to the east but not adjacent. The drainage appears to be a natural draw or an arroyo. Only a bridge will meet the road crossing needs of elk. The fence should be extended from MP 13 at the proposed overpass location to this structure. Working with landowners on both sides is necessary prior to the placement of the new bridge. The first step should be to ensure that wildlife movements are welcome on private lands and to reduce the chances of development.
- *NM 220 MP 0.9 New Wildlife Underpass Bridge 2 Lanes:* First priority bridge on NM 220. There is enough depth to the fill below the road to insert an arch culvert or a bridge. The current culvert entrances are beyond NMDOT right-of-way. There are homes nearby, but not as close to the road as in south NM 48. A wing fence, 0.1 mile in each direction, is recommended here. Landowners should be approached on both sides of the road.

6.5.3.6 Benefit-Cost Analysis

There are several types of benefit-cost analyses. However, they all share the same basic premise, which is to use a benefit-cost ratio with the benefit in the numerator and the cost in the denominator. The cost is associated with the construction and maintenance of the proposed mitigation infrastructure. The estimated monetary benefit is derived from the reduction in the number of crashes over the lifetime of the mitigation.

The unique approach here is based on the Colorado DOT's new method of including the economic value of elk and mule deer not killed in crashes as a result of the mitigation among the benefits (Kintsch et al., 2019).

6.5.3.6.1 Ballpark Estimates for Costs of Infrastructure

Table 6-17 presents the costs per unit for overpasses, bridges, and culverts placed on a four-lane highway as estimated by the Action Plan development team's engineers, based on NMDOT 2019 cost estimates. The price of 8-foot wildlife exclusion fence per mile for both sides of the highway, double cattle guards, also known as game guards, and escape ramps are all taken from Colorado DOT estimates in the West Slope Study (Kintsch et al., 2019).

Table 6-17. US 70 and NM 48 Ruidoso hotspot project wildlife mitigation rough cost estimates.

Infrastructure	Cost per unit	Cost for Infrastructure	Total for Segment
US 70 MP 257 – 271 (14 miles)			
US 70 MP 266.1 Overpass 4 Lanes	$7,280,000	$7,280,000	
US 70 MP 257.2 Bridge 4 Lanes	$2,520,000	$2,520,000	
US 70 MP 263.2 Bridge 4 Lanes	$2,520,000	$2,520,000	
US 70 MP 267.9 Bridge 4 Lanes	$2,520,000	$2,520,000	
Fence: MP 256.9 – 257.5 = 0.6 miles	$100,000	$60,000	
Fence: MP 263.1 – 263.4 = 0.2 mile	$100,000	$20,000	
Fence: MP 265.9 – 268 = 2.1 mile	$100,000	$210,000	
Escape ramps @ 4/mile = 3 miles x 4 = 12	$ 14,000	$ 168,000	
Double cattle guards approximate 15 sets	$ 60,000	$ 900,000	
Total for US 70			$16,198,000
NM 48 MP 0 – 17 (17 miles)			
NM 48 MP 13.1 Overpass 2 Lanes	$4,460,000	$4,460,000	
NM 48 MP Bridge 8.6 4 Lanes	$2,520,000	$2,520,000	
NM 48 MP Bridge 11.9 4 Lanes	$2,520,000	$2,520,000	
NM 48 MP Bridge 13.8 2 Lanes	$1,070,000	$1,070,000	
NM 48 MP Bridge 15.8 2 Lanes	$1,070,000	$1,070,000	
Fence: MP 8.5 – 8.7 = 0.2 miles	$100,000	$20,000	
Fence: MP 11.9 – 17.3 = 5.4 miles	$100,000	$540,000	
Escape ramps 5 miles @ 4/mile = 20	$14,000	$280,000	
Double cattle guards@ 4/mile = approximate 15 sets	$60,000	$900,000	
Total for NM 48			$13,380,000
NM 220 MP 0 – 3 (3 miles)			
NM 220 MP 0.9 Bridge 2 Lanes	$1,070,000	$1,070,000	
Fence: MP 0.8 – 1.0 = 0.2 miles	$100,000	$20,000	
Total for NM 220			$1,090,000
Total			$30,668,000

6.5.3.6.2 Animal-Vehicle Crash Costs

From 2009 to 2018, a total of 413 recorded crashes were the result of collisions with all animals. Crash severity varied. A total of 388 crashes resulted only in property damage only crashes. Also documented were 17 Class C injury crashes, 7 Class B injury crashes, 1 Class A injury crash, and 0 fatal crashes.

The NMDOT 2019 and FHWA 2018 (Harmon et al., 2018) costs associated with these crashes are presented in Table 6-5. Based on them, the costs associated with the animal-vehicle crashes in this hotspot were calculated (Table 6-18).

Table 6-18. Calculation of wildlife-vehicle crash costs in US 70 and NM 48 Ruidoso hotspot using NMDOT and FHWA crash cost values.

Crash Type	NMDOT-Estimated Individual Crash Costs to Society	Total NMDOT Value of Crashes	FHWA-Estimated Individual Crash Costs to Society Based on Harmon et al. (2018)	Total FHWA Value of Crashes
388 property damage only	$7,400	$2,871,200	$ 11,900	$4,617,200
17 possible injury (Type C)	$44,900	$763,300	$125,600	$2,135,200
7 minor injury (Type B)	$79,000	$553,000	$198,500	$1,389,500
1 incapacitating/serious injury (Type A)	$216,000	$216,000	$655,000	$655,000
0 fatality	$4,008,900	$0	$11,295,400	$0
Total		$4,403,500		$8,796,900

The expected crash reduction in this hotspot is less than a fully mitigated area would have. Along US 70, the length of the hotspot is 13 miles, significantly more than the 2.9 miles of fence and crossing structures. This equates to just under 25 percent of the hotspot expected to be mitigated. Along NM 48, the hotspot is 17 miles long, compare to the extent of fence and proposed mitigation, which extends for 5.7 miles, or 34 percent of the total length. We selected a reduction of 30 percent in animal crashes to roughly match the lengths of fenced areas within the hotspot.

The benefits portion of the ratio is estimated by examining the expected reduction in crash costs. These benefits are estimated by taking the total annual value of all animal crash costs, the

30 percent reduction of crashes the mitigation can be expected to provide, the expected 75-year mitigation lifespan, and the economic values of mule deer and elk saved by the mitigation over 75 years (Table 6-19).

Table 6-19. Estimating the benefit of mitigation, US 70 and NM 48 Ruidoso hotspot.

	NMDOT Crash Values	FHWA Crash Values
Total value of crash costs over 10 years	$4,403,500	$8,796,900
Crash cost per mile per year	$12,951	$25,873
Crash cost for 34 miles of project over 75 years of infrastructure (Cost/mile/year x 34 x 75)	$33,025,050	$65,976,150
If mitigation reduced crashes by 30%, over 75 years, that value would be:	$9,907,515	$19,792,845
Wildlife Lost and Saved Values		Estimated Value of Elk and Mule Deer Saved over 75 years of Mitigation
If 23% of animal crashes were with elk (97 elk out of 413 animal crashes), and 62% were with deer (258 deer out of 413 animal crashes), and there have been 41.3 crashes with animals per year on average, and the number prevented would be 30% of 41.5; there would be 12.5 animal crashes prevented annually. This would roughly equate to 3 elk and 8 mule deer saved each year. At a value of: $2,392 for each elk, and $2,061 for each mule deer, the value of animals saved each year x 75 years of mitigation= Elk ($2,392 x 3 x 75 years) + Mule deer ($2,061 x 8 x 75 years) = Elk - $538,200 + Deer - $1,236,600 = $1,774,800		$1,774,800

6.5.3.6.3 Benefit-Cost Ratio

- NMDOT values for crashes:
  Benefit/Cost Equation = $9,907,515+ $1,774,800/$30,668,000 = 0.38
- FHWA Values for Crashes
  Benefit/Cost Equation = $19,792,845+ $1,774,800/$30,668,000 = 0.70

The NMDOT and FHWA benefit-cost ratios were both well below 1, indicating that the recommended mitigation would not be expected to pay for itself in terms of crashes prevented over 75 years. If the full list of mitigation measures equaled approximately $11.68 million, the project would be expected to possibly pay for itself over the same time period based on NMDOT crash costs.

6.5.4 I-25 Glorieta Pass WVC Hotspot Recommendations for Wildlife Mitigation Projects

- *I-25 MP 297-300*
- *3-mile hotspot, 7 miles of mitigation*
- *Santa Fe County*
- *NMDOT District 5*

6.5.4.1 Project Area Overview

This WVC hotspot is located along I-25 at Glorieta Pass in the southern Santa Fe Mountain subrange of the Sangre de Cristo Mountains. This hotspot ranked 10th in the state for the number of crashes per mile and extends from MP 297 to 300, or for a distance of about 3 miles. This area was also one of the top 10 wildlife corridors chosen in the Action Plan. The area is critically important for wildlife movement north and south in the Sangre de Cristo Mountains, and will become especially important as climate change continues to affect New Mexico. Mule deer and black bear are the two species most often recorded as involved in WVCs in this area (Figure 6-18).

Figure 6-18. Mule deer and black bear will greatly benefit from wildlife crossing structures at Glorieta Pass (photo credit: Colorado DOT, Colorado Parks and Wildlife, and Eco-Resolutions).

Glorieta Pass is characterized by mountain terrain and a mix of juniper woodland and coniferous forest. Though technically located within the Southern Rocky Mountain ecoregion, the hotspot is in close proximity to the High Plains and Tablelands ecoregion and shares several charicteristics with this ecoregion. Vegetation in the immediate vicinity is dominated by Rocky Mountain juniper (*Juniperus scopulorum*) and ponderosa pine. Most of the roadway within this hotspot borders private property, but some portions abut the Santa Fe National Forest (western and eastern termini) and Pecos National Historical Park (eastern terminus). The village of Glorieta is within the hotspot and has seen an approximately 43 percent increase in population between 2010 and 2019, with the current population estimated at 618. Outdoor recreation and tourism generate significant visitation to the national forest, historical park, and the nonprofit-owned Glorieta Adventure Camps, which are partially open to the public. Peak visitation to the area is expected to occur in the summer; however, I-25 is a major transportation corridor connecting large New Mexico cities (Las Cruces, Albuquerque, and Santa Fe) to large Colorado cities (Colorado Springs and Denver).

Crashes in the hotspot are shown on Figure 6-19.

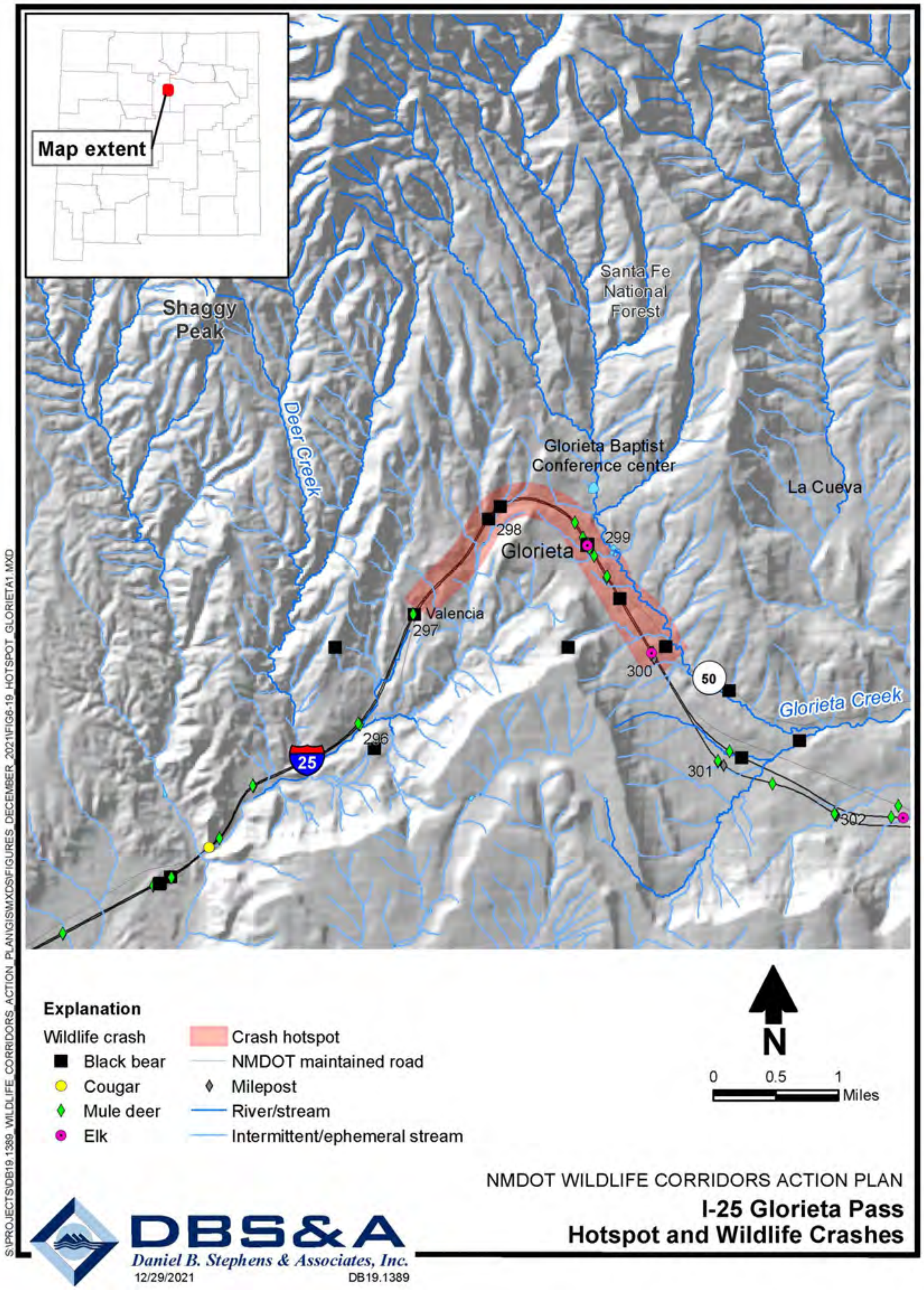

Figure 6-19. Wildlife-vehicle crashes in the I-25 Glorieta Pass hotspot.

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6.5.4.2 Transportation – Safety Statistics

The crash data reported in the following subsections include both animal-vehicle crashes and wildlife-vehicle crashes to better reflect the impact of collisions with all animals. Animal-vehicle crashes include wild and domestic animals and livestock. Using all animal statistics to evaluate the situation helps the reader to differentiate where there are strictly wildlife problem areas, and where these domesticated animals may also be involved. The recommended wildlife mitigation that includes wildlife exclusion fences would be expected to reduce all these crashes, not just those with wildlife. Therefore, the total animal crashes are reported and then used in the benefit-cost analyses of the value of the recommended infrastructure. The reported wildlife crashes are those strictly with the six focal species: mule deer, elk, pronghorn, bighorn, black bear, and cougar.

6.5.4.2.1 Wildlife-Vehicle Crashes per Mile per Year

NMDOT data from 2009-2018 documented 43 reported crashes involving the focal species: 33 with mule deer, 2 with elk, and 8 with black bear (Table 6-20). Note that this hotspot had more recorded crashes with black bear than any of the other top WVC hotspots or wildlife corridors.

Table 6-20. I-25 Glorieta Pass WVC hotspot, NMDOT crashes with all animals and six focal species, 2009-2018.

Length (miles)	Total Crashes with All Animals	Total Crashes with Focal Species	Wildlife Crashes per mile per year	Crashes with Six Focal Species					
				Deer	Elk	Black Bear	Cougar	Pronghorn	Bighorn Sheep
3	49	43	1.43	33	2	8	0	0	0

6.5.4.2.2 Seasonality of Wildlife-Vehicle Crashes

Most reported wildlife crashes were with deer. August represented the month with the highest number of crashes. There appeared to be a summer increase in crashes (May through August) (Figure 6-20).

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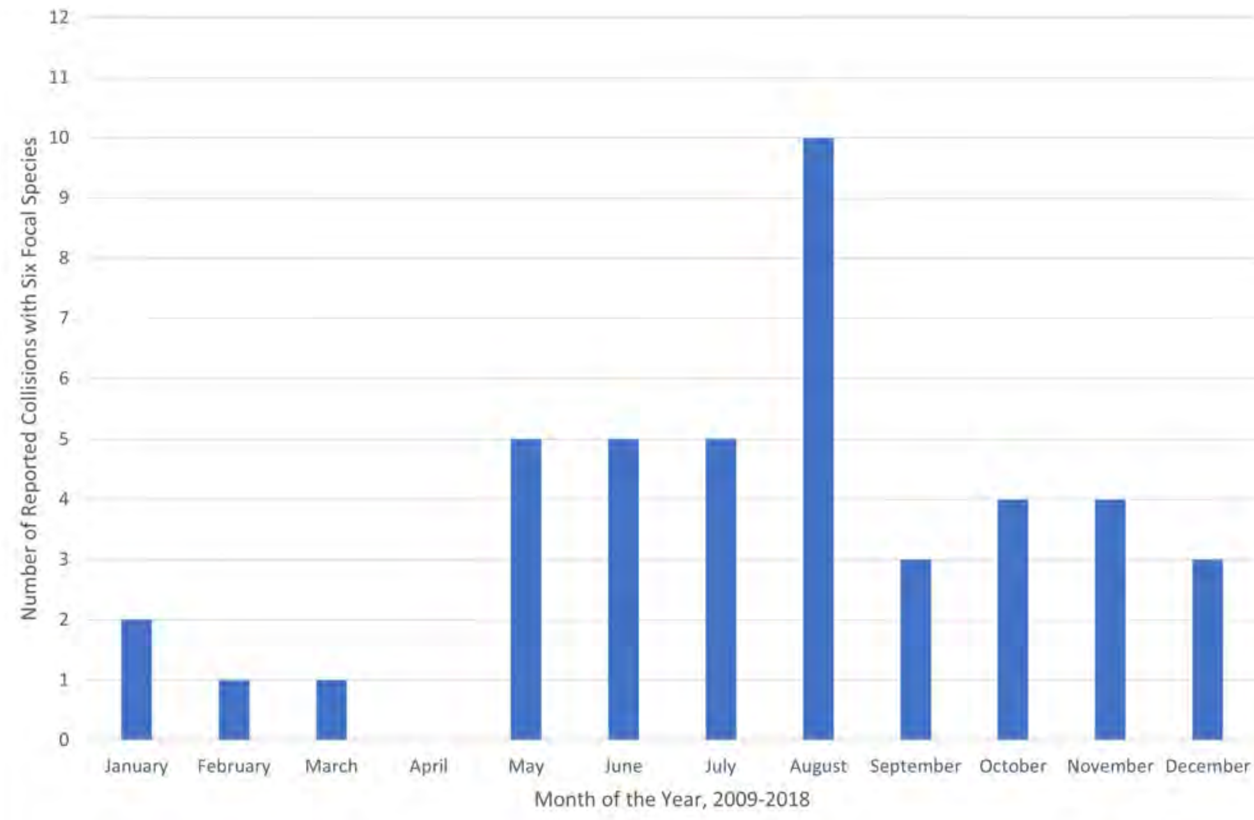

Figure 6-20. Wildlife-vehicle crashes by month in the I-25 Glorieta Pass hotspot.

6.5.4.2.3 WVC Species Percentages

Of the WVCs in this hotspot, 77 percent involved mule deer, 5 percent involved elk, and 18 percent involved black bear.

6.5.4.2.4 Wildlife-Vehicle Crashes as Percentage of All Crashes

There were 119 total crashes in the hotspot from 2009 to 2018. Of these, 49 crashes were with animals. There were 43 reported crashes with the focal species, representing 36 percent of all crashes.

6.5.4.2.5 Average Annual Daily Traffic (AADT)

AADT is important in estimating if large wild animals such as the six focal species have opportunities to cross the roads under scrutiny. Traffic volumes can form a complete barrier to wildlife movement all day and into the night once AADT reaches well above 20,000 vehicles per day. At 10,000 vehicles per day there is still a barrier, with some opportunity for nocturnal movements across roads. Wildlife can find limited opportunities to cross roads with AADT

between 2,000 and 10,000 vehicles per day. However, at AADT of 2,000 and 10,000 per day, wildlife will try to cross roads, and will have greater mortality in some areas because of the lower perceived risk by wild animals but the continued presence of vehicles (Charry and Jones, 2009; Ng et al., 2004; Seiler, 2005).

AADT in the hotspot is as follows:

- MP 297 to 299: Current = 15,694 (2018), Future = 23,320 (estimated 2038)
- MP 299 to 300: Current = 10,061 (2018), Future = 14,950 (estimated 2038)

6.5.4.2.6 *Number of Lanes*

The road has four lanes through this hotspot.

6.5.4.2.7 *STIP Possibility*

- STIP Control Number 4101370, I-25 North of Glorieta, Minor Road Rehabilitation. MP 299.55-309. 2023 start. District 4, Total Programmed: $10,000,000.

6.5.4.3 *Ecological and Feasibility Considerations*

6.5.4.3.1 *Species of Concern*

Species of concern known from, or likely to occur in, this area include black bear, mule deer, elk, cougar, American badger, red fox, and hog-nosed skunk (see distribution maps in Chapter 2; the topography is too steep for the ornate box turtle). Mule deer, elk, and black bear in particular have been recorded as being involved in WVCs in the hotspot.

6.5.4.3.2 *Data*

NMDOT crash data were used in this analysis. Cougar and black bear mortality data were obtained from NMDGF and added to the wildlife-vehicle crash map. Some of the recorded locations were deaths due to causes other than vehicle collisions when they occurred away from roads.

6.5.4.3.3 *Public Land*

There is 0.59 mile of USFS land along one side of I-25, an additional 0.33 mile of USFS land along both sides of it, and 0.35 mile of National Park Service (NPS) land along one side.

6.5.4.3.4 *Support*

This hotspot received support for mitigation from the USFS Santa Fe National Forest.
Mr. Melonas, the Forest Supervisor, wrote:

> We have recently identified two high priority areas on the Santa Fe National Forest for your consideration as wildlife crossings projects.
>
> Glorieta Pass (Attachment 1.a.) – located on I-25, east of Santa Fe. This area is identified as a mule deer corridor in our habitat mapping data. The primary species affected are mule deer, black bear, and mountain lion, but wildlife crossings would also benefit numerous other species, such as elk, fox, skunk and coyote, just to name a few. These species are frequently observed as roadkilled carcasses throughout this area. The interstate has National Forest System land on both sides (Sangres/Santa Fe Mountain to the north and Glorieta/Rowe Mesa to the south) where Forest Service restoration projects are being planned. These vegetation projects would include improvement of wildlife habitat and connectivity. This section of the interstate also has multiple underpasses that could be used as primary crossing points if connectivity mitigation steps are implemented, such as the installation of adequate wildlife fencing. The public and our partners have voiced their concerns for habitat connectivity needs and wildlife passage in this area. Lastly, since it is such a short drive from the State Capitol, it can serve as a showpiece demonstration project.

A private citizen sent in a letter of support, stating they continue to see animals killed on I-25 from MP 290 to 299. That person also stated the "old-timers" say there is an established wildlife trail through this area.

6.5.4.4 Recommendations Overview

Due to the short length of the Glorieta Pass hotspot, mitigation strategies may have to extend beyond the hotspot boundaries to identify potential crossing features and their exact placement to effectively capture wildlife movement needs through this region. An opportunity exists to complete mitigation efforts for this hotspot in two phases. The first phase would focus primarily on the 3-mile hotspot where collisions are most severe. It would place a wildlife exclusion fence from MP 297 to MP 300. The second phase would extend the mitigation efforts from each side of the hotspot to facilitate safe passage of wildlife across I-25 across a greater area, with new fence extending from MP 294 to MP 297 and out from MP 300 to MP 301.4. The biggest focus will be around MP 299, where there is a concentration of collisions. This may be in part due to available resources for wildlife located at Glorieta Adventure Camps.

Elk that cross the highway will not use a culvert or small span arch culvert in large numbers, based on research in the neighboring states of Arizona, Colorado, Utah (Gagnon et al., 2015 and 2017; Kintsch et al., 2021; Cramer and Hamlin, 2019a and 2021; Cramer, 2014). Thus, single span bridges and overpasses are highly recommended to be placed in the areas with known elk movement to ensure successful use by elk herds.

Ungulates need crossing structures approximately every mile (Bissonette and Adair, 2008), although Dodd et al. (2007a) found that 2 miles between crossing structures was acceptable for elk in Arizona. Thus, replacement of some aging smaller culverts with span bridges and a wildlife overpass is necessary for successful passage of herds of mule deer and elk.

In total, one overpass, three arch culverts, and one bridge are recommended for construction across both phases. There are some residences in the area, but a significant amount of land is currently undeveloped and actively used as open space. An opportunity exists to partner with USFS, NPS, and Glorieta Adventure Camps to ensure that proposed wildlife crossings are protected in perpetuity. Other private landowners in the area may be critical for providing crossing opportunities across I-25 and getting the animals to and from those locations.

There are seven potential species of concern in the area that could benefit from the proposed project recommendations. The overpass should be readily used by elk and mule deer based on research in Colorado and Arizona (Kintsch et al., 2021; AZGFD, 2021). Black bears and cougars have been documented using underpass structures more readily than overpasses in Colorado (Kintsch et al., 2021), Arizona (Gagnon et al., 2011), and Utah (Cramer, 2012). The needs of these two carnivores may be best met if the culverts are along arroyos, canyons, and water bodies in the landscape the landscape. American badgers and red foxes will also benefit. Both of these mesocarnivores have been recorded using overpass structures in Colorado (Kintsch et al., 2021) and underpass structures in New Mexico (Loberger et al., 2021), Colorado (Kintsch et al., 2021; Cramer and Hamlin, 2021), and Utah (Cramer and Hamlin, 2019). Hog-nosed skunks have been documented using culverts in Arizona (Grandmaison et al., 2021), and can be expected to use structures in ways similar to striped skunks, which have been documented using culverts in Arizona (Gagnon et al., 2011), New Mexico (Loberger et al., 2021), Utah (Cramer, 2012), and Colorado (Kintsch et al., 2021). The ornate box turtle has not yet been shown to use road-crossing structures, but would be expected to more readily use the overpasses and underpasses if they contained logs, tree stumps, large rocks and boulders, and native vegetation all along their lengths. Logs, tree stumps, rocks, boulders, and native vegetation provide cover and a more natural substrate for enhancing the movements of small animals.

Figure 6-21 shows the priority mitigation actions along with land ownership information. The recommended projects are summarized in Table E-4 (Appendix E).

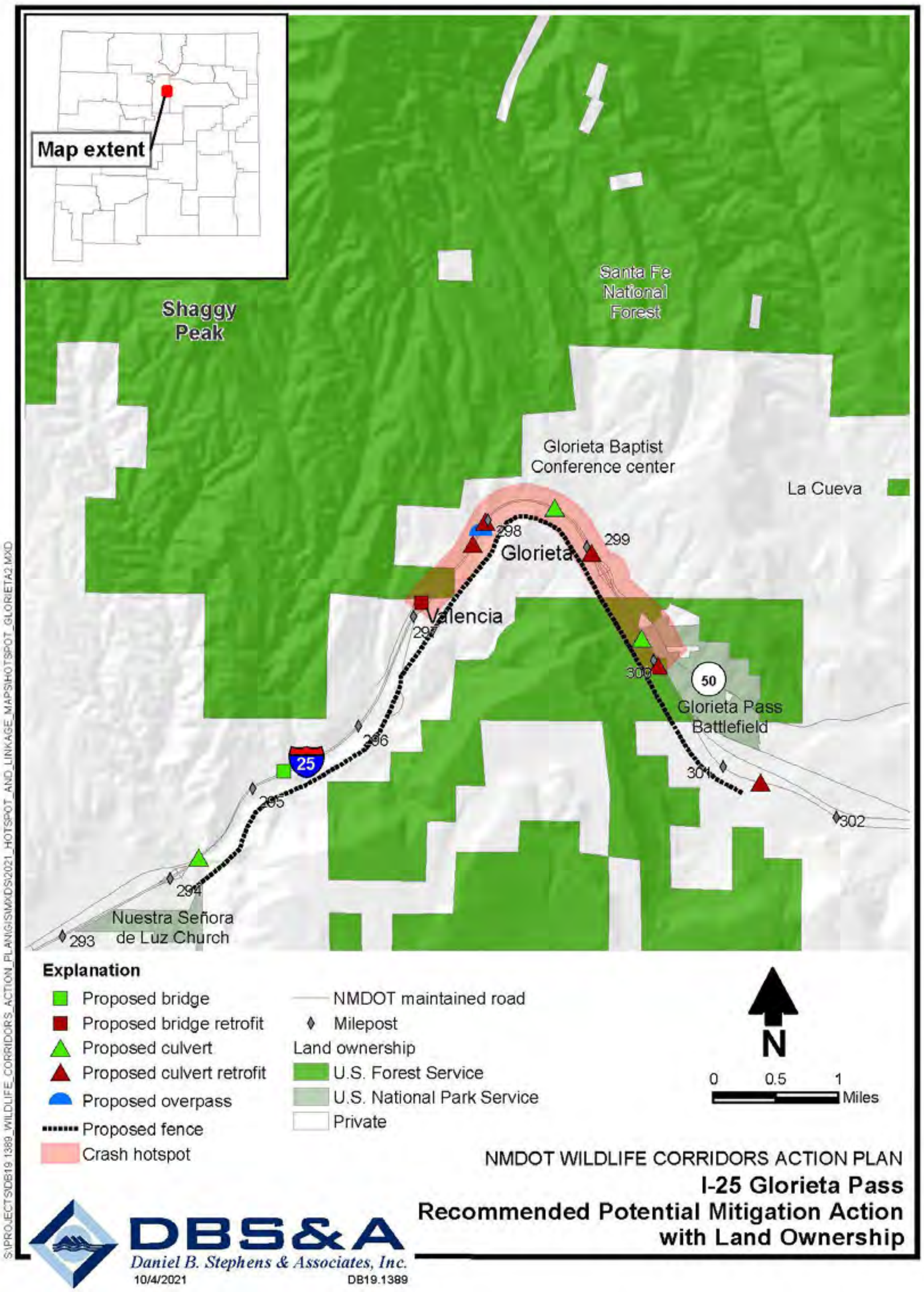

Figure 6-21. Land ownership and recommended project mitigation actions in the I-25 Glorieta Pass hotspot.

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The priority recommendations are presented in Figure 6-22.

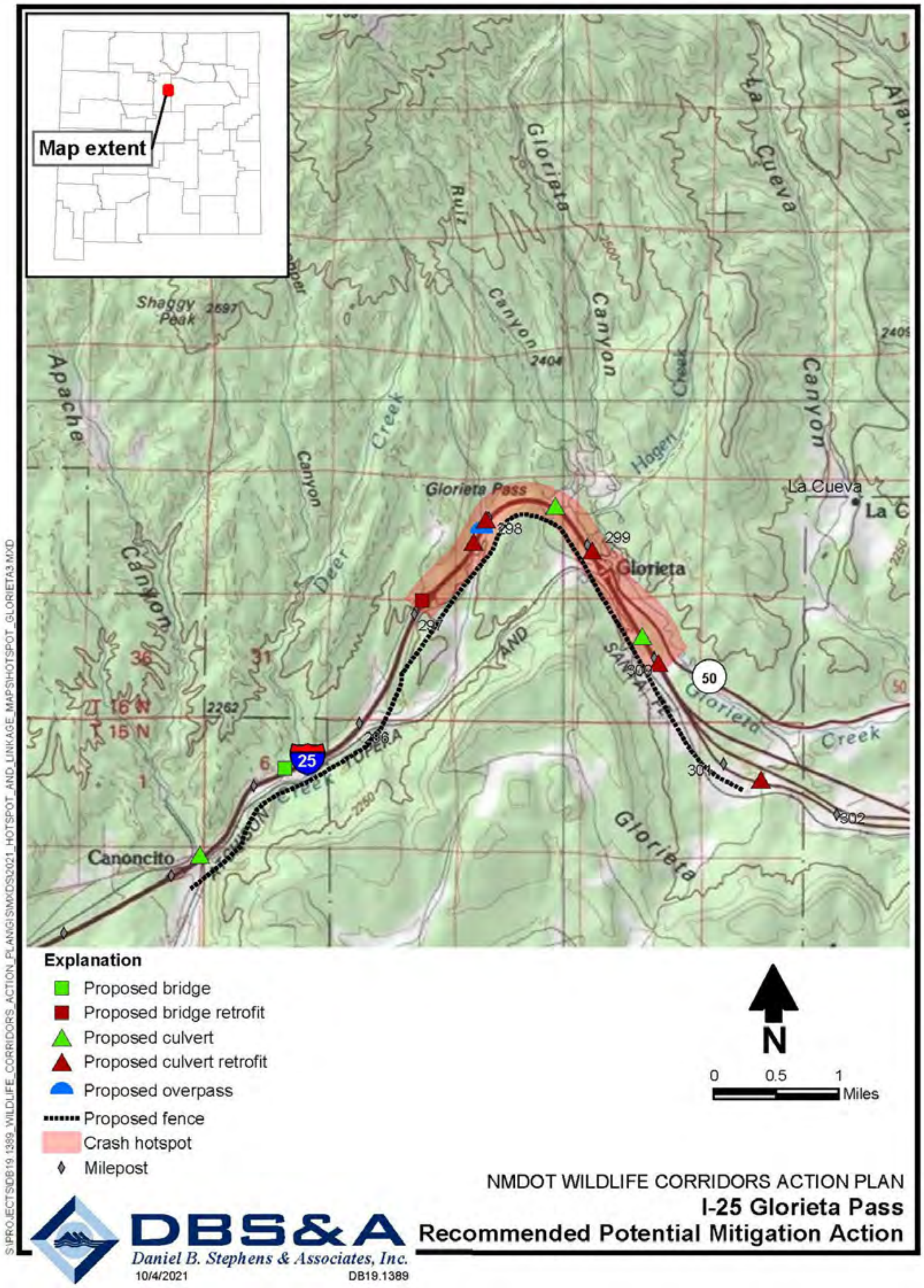

Figure 6-22. Top priority mitigation recommendations for the I-25 Glorieta Pass hotspot.

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6.5.4.5 Specific Wildlife-Highway Mitigation Recommendations

The recommendations give an overview estimate of what can be done for wildlife mitigation. Many of the existing culverts and bridges are presented in Table E-4 (Appendix E) to provide evidence of opportunities to replace them with more wildlife-friendly structures—for example, when the infrastructure is replaced or when there is a transportation project nearby. The Action Plan team is not presenting these recommendations as the final and only opportunities for enhancing wildlife movement below and above the roads. Rather, these are the top recommendations based on a one-day field reconnaissance of each project area, existing road conditions, 2021 costs, and the current state of the science and practice of transportation ecology.

6.5.4.5.1 Cost-Effective Short-Term Solutions

Place variable message boards in Glorieta (MP 297 and MP 300) area from May through August and from October through November migrations. Warn drivers of wildlife migrations and large wildlife on the road.

Wildlife warning signs are currently located at MP 300 (northbound lanes) and MP 307.4 (southbound lanes), alerting drivers of potential wildlife movements across the highway in this approximately 8-mile stretch of I-25. However, these signs fail to encompass the Glorieta Pass hotspot location. Solar flashing signs could be used within the hotspot area in addition to or in place of mobile variable message boards.

6.5.4.5.2 Retrofit Existing Infrastructure

Short segments of the hotspot could be retrofitted with wildlife exclusion fence to join structures that are currently usable "as-is." Care must be taken to not create end-run events with open fence ends or fences terminating at inappropriate crossing locations. The potential retrofitting of existing culverts with wildlife exclusion fence would be placed in two phases:

- Phase I
    - *MP 297.1 Retrofit Bridge:* This is a vehicle interchange bridge. The Phase I west fence end would begin here and extend eastward. Wildlife or double cattle guards would need to be installed on all entrance and exit ramps here.
    - *MP 297.7 Retrofit Culvert:* This retrofit would be to place wildlife exclusion fence in Phase I, and then replace this long culvert in Phase II.

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- ◇ *MP 297.9 Retrofit Culvert:* The existing culvert, although only 5.5 feet high, appears to be important to cougar and black bear. The sandy bottom had tracks of these species when the field reconnaissance team visited the culvert. Installing wildlife fence would help guide these animals and others to use this culvert. Mule deer may use it as is.

- Phase II
  - ◇ *MP 300 Retrofit Culvert:* This culvert is being used by wildlife, with bear and small mammal tracks evident when visited by the field reconnaissance team. It has value for these species, but at 200 feet long, little use is expected by mule deer or other ungulates. It would be of value for black bear, cougar, and small- to medium-sized mammals.
  - ◇ *MP 301.4 Retrofit Culvert:* This is a vehicle interchange. The Phase II fence would end here, with wildlife or double cattle guards placed on the entrance and exit ramps. There is a small chance that ungulates would use this interchange during night hours when traffic volume on the highway and at the interchange is low.

6.5.4.5.3 Intermediate Solutions - New Structures

New structures should be prioritized in the MP 297 to MP 300 hotspot. Based on the width of the highway and the size of the median, new arch culverts, box culverts, or bridges would be most effective as two separate units: one for the northbound lanes and one for the southbound lanes, with the median excavated as an atrium. Fencing the median atrium is important to keep wildlife off the highway.

- *MP 297.9 Culvert Retrofit and Replacement Underpass:* If overpass at MP 297.8 is not feasible, replace this culvert with a wildlife underpass bridge.
- *MP 298.6 – New Wildlife Underpass Arch Culvert:* This would be a brand new structure at this location, placed during Phase I. There is enough overburden present to install strategically placed, sizable underpass for large mammals. It is located on the north edge of the greatest concentration of reported crashes with wildlife. The availability of water at the camp north of the highway may be a potential source of collisions.
- *MP 299.9 Arch Culvert:* Existing culvert has concrete floor, but there are small mammal signs of use. There is residential development nearby. Make new culvert into two structures for opposing lanes of traffic and create an open atrium to add light and encourage use.

6.5.4.5.4 Solutions Based on Best Management Practices

Extending the project area to include additional roadway on each side of the hotspot could provide an opportunity to assist additional wildlife in safely crossing I-25. Care should be taken to avoid fence end run events; therefore, fence termini should be prioritized. Extending the project area could be accomplished in an additional phase or as a separate project. The Acton Plan recommends that new structures within the hotspot (MP 297 to 300) take precedence.

- Phase I
  - *MP 297.8 New Wildlife Overpass:* This overpass would be most effective if installed during the first phase of the mitigation project. If this overpass is not feasible, replace MP 297.9 culvert with a wildlife underpass bridge.
- Phase II
  - *MP 294.2 – Arch Culvert:* This would allow wildlife to the southwest of the hotspot to cross I-25 in this wildlife corridor.
  - *MP 295.2 – Bridge:* This bridge is important for wildlife habitat connectivity southwest of the hotspot. It would allow elk, mule deer, and other wildlife movement beneath the highway.

6.5.4.6 Benefit-Cost Analysis

There are several types of benefit-cost analyses. However, they all share the same basic premise, which is to use a benefit-cost ratio with the benefit in the numerator and the cost in the denominator. The cost is associated with the construction and maintenance of the proposed mitigation infrastructure. The estimated monetary benefit is derived from the reduction in the number of crashes over the lifetime of the mitigation.

The unique approach here is based on the Colorado DOT's new method of including the economic value of elk and mule deer not killed in crashes as a result of the mitigation among the benefits (Kintsch et al., 2019).

6.5.4.6.1 Ballpark Estimates for Costs of Infrastructure

Table 6-21 presents the costs per unit for overpasses, bridges, and culverts placed on a four-lane highway as estimated by the Action Plan development team's engineers, based on NMDOT 2019 cost estimates. The price of 8-foot wildlife exclusion fence per mile for both sides of the highway, double cattle guards, also known as game guards, and escape ramps are all taken from Colorado DOT estimates in the West Slope Study (Kintsch et al., 2019).

Table 6-21. I-25 Glorieta Pass hotspot project wildlife mitigation rough cost estimates.

Infrastructure	Cost per unit	Cost for Infrastructure	Total for Segment
I-25 Phase I (MP 297-300)			
One overpass (4-lane): MP 297.8	$7,280,000	$7,280,000	
1 Arch culvert (4-lane): MP 298.6	$3,230,000	$3,230,000	
1 Arch culvert (4-lane): MP 299.8	$3,230,000	$3,230,000	
Fence MP 297.1 to 300.1 = 3 miles	$100,000	$300,000	
Approximate 6 double cattle guards	$60,000	$360,000	
Escape ramps @ 4/mile = 3 x 4 = 12	$14,000	$168,000	
Total for Phase I			$14,568,000
I-25 Phase II (MP 294.1-297 and MP 300-301.4)			
1 Arch culvert (4-lane): MP 294.2	$3,230,000	$3,230,000	
One Span bridge (4-lane): MP 295.2	$2,520,000	$2,520,000	
Fence MP 294.1 to 297 and MP 300 to 301.4 = 4.3 miles	$100,000	$430,000	
Escape ramps @ 4/mile = 4.3 x 4 = 18	$14,000	$252,000	
Total for Phase II			$6,432,000
Total for Entire Hotspot			$ 21,000,000

6.5.4.6.2 *Animal-Vehicle Crash Costs*

From 2009 to 2018, there were 49 crashes that included all animals in this hotspot. The crash severities of these were all property damage only or unknown crashes.

The NMDOT 2019 and FHWA 2018 (Harmon et al., 2018) costs associated with each category of crash severity are presented in Table 6-5. The costs associated with the animal-vehicle crashes in this hotspot were calculated based on these values (Table 6-22).

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Table 6-22. Calculation of wildlife-vehicle crash costs in the I-25 Glorieta Pass hotspot using NMDOT and FHWA crash cost values.

Crash Type	NMDOT-Estimated Individual Crash Costs to Society	Total NMDOT Value of Crashes	FHWA-Estimated Individual Crash Costs to Society Based on Harmon et al. (2018)	Total FHWA Value of Crashes
49 property damage only	$7,400	$362,600	$ 11,900	$583,100
0 possible injury (Type C)	$44,900	$0	$125,600	$0
0 minor injury (Type B)	$79,000	$0	$198,500	$0
0 incapacitating/serious injury (Type A)	$216,000	$0	$655,000	$0
0 fatality	$4,008,900	$0	$11,295,400	$0
Total		$362,600		$583,100

The benefits portion of the ratio is estimated by examining the expected reduction in crash costs. These benefits are estimated by taking the crash costs and multiplying by the 90 percent reduction of crashes the mitigation can be expected to provide, expected 75-year lifespan for the mitigation, and economic values of mule deer and elk saved by the mitigation over 75 years (Table 6-23). It is important to note that the total value of animal crashes was only taken for the 3 miles in the hotspot, and not for the full 7.3 miles of fence to be placed in the two phases of construction. In future iterations of these estimates, the number of crashes in the full 7.3 miles will be examined.

Table 6-23. Estimating the value of mitigation for benefits, I-25 Glorieta Pass hotspot.

	NMDOT Crash Values	FHWA Crash Values
Total value of crash costs over 10 years	$362,600	$583,100
Crash cost per mile per year	$12,087	$19,437
Crash cost for 3 miles of project over 75 years of infrastructure (Cost/mile/year x 3 x 75)	$2,719,575	$4,373,325
If mitigation reduced crashes by 90%, over 75 years, that value would be:	$2,447,618	$3,935,993
Wildlife Lost and Saved Values		Estimated Value of Elk and Mule Deer Saved over 75 years of Mitigation
If 4% of animal crashes were with elk (2 elk out of 49 animal crashes), and 67% were with deer (33 deer out of 49 animal crashes), and there have been 4.9 crashes with animals per year on average, and the number prevented would be 90% of 4.9; there would be 4.4 animal crashes prevented. This would roughly equate to 0.2 elk and 3 mule deer saved each year. At a value of: $2,392 for each elk, and $2,061 for each mule deer, the value of animals saved each year x 75 years of mitigation= Elk ($2,392 x 0.2 x 75 years) + Mule deer ($2,061 x 3 x 75 years) = Elk - $35,880 + Deer - $463,725 = $ 499,605		$499,605

6.5.4.6.3 Benefit-Cost Ratio

This cost benefit takes into consideration only Phase 1 mitigation, in the three miles of the hotspot.

- NMDOT values for crashes:
  Benefit/Cost Equation = $2,447,618 + $499,605/$14,568,000 = 0.20
- FHWA Values for Crashes
  Benefit/Cost Equation = $3,935,993 + $499,605/$14,568,000 = 0.30

The wildlife mitigation in Phase I would not be expected to pay for itself in saved crashes over 75 years, whether NMDOT or FHWA crash costs are used. All benefit-cost evaluations were well below a value of 1, which is when a project is expected to pay for itself. If the full list of mitigation measures equaled approximately $2.94 million, the project would be expected to possibly pay for itself over the same time period based on NMDOT crash costs.

6.5.5 US 70 Bent Sacramento Mountains WVC Hotspot Recommendations for Wildlife Mitigation Projects

- *US 70 MP 237–242*
- *5-mile hotspot, 6 miles of mitigation*
- *Otero County*
- *NMDOT District 2*

6.5.5.1 Project Area Overview

This was identified as the number 1 WVC hotspot in New Mexico based on number of reported crashes per mile annually (1.8). Elk is the species most involved in these crashes (Figure 6-23).

Figure 6-23. Elk is the target species for wildlife mitigation in this hotspot (photo credit: NMDGF).

This WVC hotspot extends for 5 miles along US 70 from MP 237 in the west to MP 242 in the east. It is located in the foothills on the west side of the Sacramento Mountains of south-central New Mexico. The general area is thought by NMDGF biologists to represent an historical elk elevational migration corridor used by herds moving downslope from their summer range in the high elevations of the Sierra Blanca and White Mountains.

Resident elk and mule deer are also thought to occur here year-round, but no research has been conducted with the use of GPS collars to test these hypotheses. The lower elevation winter range holds limited water for wildlife, and elk and mule deer often cross US 70 presumably to

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access water in the Rio Tularosa, which parallels and crosses US 70. The Mescalero Apache Indian Reservation lies on the east side of this WVC hotspot, and elk vehicle-collision challenges exist along US 70 on the Tribal lands as well.

NMDGF and NMDOT are aware of the high number of elk-vehicle crashes in this WVC hotspot from November through March. NMDGF purchased variable message boards and placed these with NMDOT assistance to warn drivers about elk crossings at MP 237.5 on the west end and MP 241 on the east end (Figure 6-24) during the winters of 2019–2021. The stretch of road between MP 239 and MP 240 is especially dangerous, with 9 of the 13 injury crashes reported in this WVC hotspot occurring between these mileposts. The Mescalero Apache Conservation Officers shared wildlife-vehicle crash data with the Action Plan development team, showing that wildlife-vehicle crashes also occurred east of MP 242.

Figure 6-24. M. Watson of NMDGF together with NMDOT maintenance personnel, installed a driver-warning variable message board on US 70 in the wildlife-vehicle hotspot (photo credit: NMDGF).

Figure 6-25 shows the crash data for this hotspot.

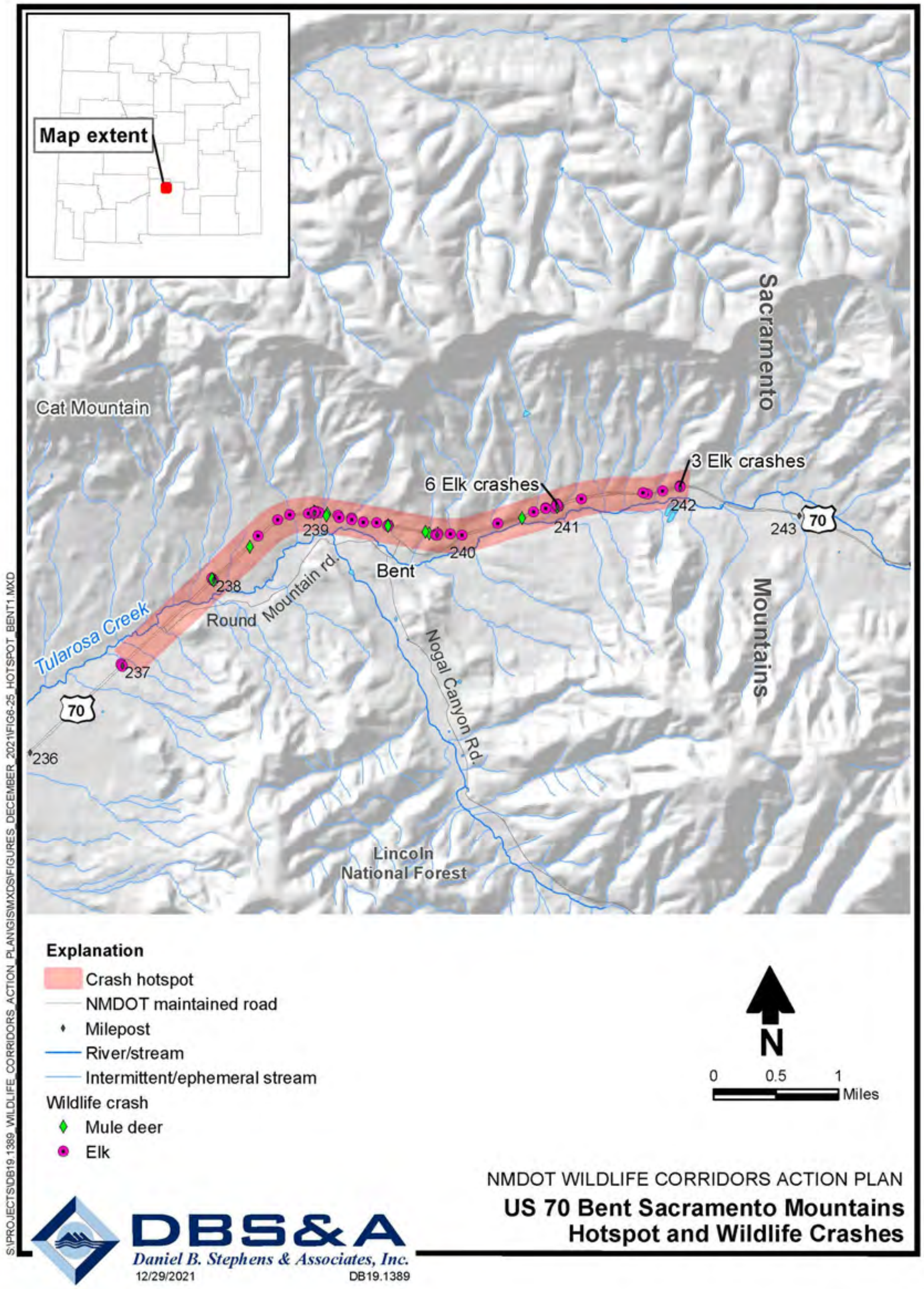

Figure 6-25. US 70 Bent hotspot, mileposts, riparian areas, and mule deer and elk crashes.

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6.5.5.2 *Transportation – Safety Statistics*

The crash data reported in the following subsections include both animal-vehicle crashes and wildlife-vehicle crashes to better reflect the impact of collisions with all animals. Animal-vehicle crashes include wild and domestic animals and livestock. Using all animal statistics to evaluate the situation helps the reader to differentiate where there are strictly wildlife problem areas, and where these domesticated animals may also be involved. The recommended wildlife mitigation that includes wildlife exclusion fences would be expected to reduce all these crashes, not just those with wildlife. Therefore, the total animal crashes are reported and then used in the benefit-cost analyses of the value of the recommended infrastructure. The reported wildlife crashes are those strictly with the six focal species: mule deer, elk, pronghorn, bighorn, black bear, and cougar.

6.5.5.2.1 *Wildlife-Vehicle Crashes per Mile per Year*

There were 90 wildlife crashes reported to NMDOT in 10 years over the 5 miles of the hotspot—1.8 reported crashes per mile per year: 72 elk crashes, and 18 crashes with mule deer (Table 6-24). In addition, a Mescalero Apache Reservation Tribal Conservation Officer shared two years of crash data, showing more than 10 crashes between MP 242 and MP 244. These crashes were not included in Table 6-24.

Table 6-24. US 70 Bent WVC hotspot, NMDOT crashes with all animals and with the six focal wildlife species, 2009-2018.

Length (miles)	Total Crashes with All Animals	Total Crashes with Focal Species	Wildlife Crashes per mile per year	Crashes with the Six Focal Species					
				Deer	Elk	Black Bear	Cougar	Pronghorn	Bighorn Sheep
5	100	90	1.8	18	72	0	0	0	0

6.5.5.2.2 *Seasonality of Wildlife-Vehicle Crashes*

The numbers of crashes from 2009 to 2018 by month indicate a spike in November (Figure 6-26).

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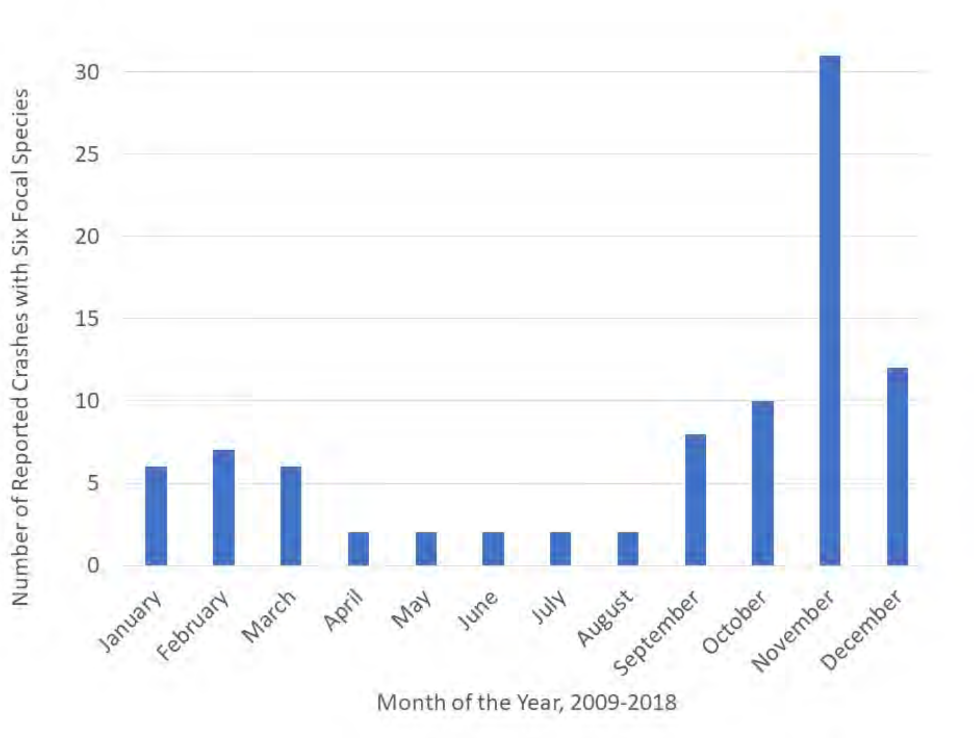

Figure 6-26. Wildlife-vehicle crashes by month in the US 70 Bent WVC hotspot.

6.5.5.2.3 WVC Species Percentages

Of the WVCs in this hotspot, 80 percent involved elk and 20 percent involved mule deer.

6.5.5.2.4 Wildlife-Vehicle Crashes as Percentage of All Crashes

A total of 144 crashes were reported in the hotspot; 100 (69 percent) of these involved collisions with animals. Of the 100 crashes caused by animals, 90 percent involved the focal species—either mule deer (20 percent) or elk (80 percent).

6.5.5.2.5 Average Annual Daily Traffic (AADT)

AADT is important in estimating if large wild animals such as the six focal species have opportunities to cross the roads under scrutiny. Traffic volumes can form a complete barrier to wildlife movement all day and into the night once AADT reaches well above 20,000 vehicles per day. At 10,000 vehicles per day there is still a barrier, with some opportunity for nocturnal movements across roads. Wildlife can find limited opportunities to cross roads with AADT between 2,000 and 10,000 vehicles per day. However, at AADT of 2,000 and 10,000 per day, wildlife will try to cross roads, and will have greater mortality in some areas because of the lower perceived risk by wild animals but the continued presence of vehicles (Charry and Jones, 2009; Ng et al., 2004; Seiler, 2005).The AADT for this hotspot was 6,512 vehicles per day in 2018, and is projected to reach 8,600 vehicles per day by 2038.

6.5.5.2.6 Number of Lanes

There are four lanes in this hotspot.

6.5.5.2.7 Statewide Transportation Improvement Program (STIP) Possibility

- STIP Control Number 9900809, Dynamic message signs through Mescalero. MP 230 to MP 262 (32 miles). HSIP funds. Cost - $910,000, Construction Year 2021, 2022. This could be a prime opportunity to place signs and verbiage encouraging caution about possible wildlife on the road, especially in November and December, in addition to the variable message board sign that NMDGF installs at that time of year.

6.5.5.3 Ecological and Feasibility Considerations

6.5.5.3.1 Species of Concern

Nine species of concern have been documented or could occur in this hotspot area: black bear, cougar, mule deer, elk, kit fox, hog-nosed skunk, javelina (collared peccary), ornate box turtle, and the western massasauga rattlesnake.

6.5.5.3.2 Data

Data used included NMDOT crash data. The Action Plan development team received data from the Mescalero Apache Tribe. The Mescalero Apache Conservation Law Enforcement Office’s Chief Conservation Officer, Tyner Cervantes, conveyed that in 2013-2014, the Tribe conducted a study examining if elk could be persuaded to move away from the highway for access to water. It installed rain catchments on both sides of US 70 near MP 249 and MP 252. The sites were considered a success in providing water for elk and helping to reduce WVCs. However, the study ended. Mr. Cervantes also provided two years of crash data for US 70 on the Mescalero Apache Reservation, just east of the hotspot from MP 242 to just east of MP 244.

Mescalero Apache Tribe and NMDOT crash data were both taken into consideration for identifying specific recommendations in this hotspot. Also factored in were NMDGF’s black bear and cougar mortality data, which included locations where these species were killed by vehicles on roads and additional locations where mortality was related to other causes.

6.5.5.3.3 *Public Land*

A total of 0.8 mile of the WVC hotspot (in discontinuous segments) is characterized by the presence of public land on both sides. It is found primarily at MP 238, where the BLM manages the surrounding land. There are other, small parcels of BLM land scattered along the area. BLM land lies approximately 246 feet from the highway at MP 240, where an overpass is recommended.

6.5.5.3.4 *Public Support*

The Mescalero Apache Tribal Conservation Department Director, Thora Padilla, gave a verbal confirmation of support for mitigation efforts in this WVC hotspot and eastward onto Tribal lands.

One citizen submitted a letter in support of mitigation in this area.

6.5.5.4 *Recommendations Overview*

In this number one hotspot for wildlife crashes in New Mexico, based solely on the number of wildlife crashes per mile per year, mitigation solutions should be implemented both with a sense of urgency and as a complete project. The presence of elk on the road and collisions involving this species necessitate mitigation actions that provide habitat connectivity for elk herds. Elk will not use a culvert or small span arch culvert in large numbers, based on research in the neighboring states of Arizona, Colorado, and Utah (Gagnon et al., 2015 and 2017; Kintsch et al., 2021; Cramer, 2014; Cramer and Hamlin, 2019a and 2019b). In Colorado, as of 2021, a small herd of elk had started to use a large arch culvert 66 feet long over a five-year period (Kintsch et al., 2021), whereas elk in southern Colorado have not adapted to a similar arch culvert that was 139 feet long (Cramer and Hamlin, 2021). Single span bridges and overpasses are highly recommended in areas where elk are found near or on the road, to ensure successful use by elk herds. These structures will help provide habitat connectivity to help these animals move to adjacent patches of habitat with food and water resources throughout this US 70 road corridor along the Rio Tularosa.

The recommendations for this hotspot include potential warning systems for motorists, and (in order of decreasing priority) one overpass, five bridges to replace existing culverts, two arch culverts, and adding fences to existing structures that would extend for the 6 miles in the WVC hotspot and beyond.

Although the bridge at the west end (MP 237.5) of the hotspot will work for elk and other wildlife as a retrofit by placing wildlife exclusion fencing to it from the east, it will not be effective as a standalone solution based on where the collisions with elk have occurred to the east at MP 239 and MP 240. This MP 237.5 bridge represents more of a fence end opportunity and will contribute to habitat connectivity for deer and elk as they pass beneath it. The fence would start at this bridge on the west, and extend approximately 6 miles to the east to MP 243.

An overpass near MP 239.9 to MP 240 is the top mitigation choice to accommodate elk and reduce elk-vehicle collisions. The rock cut on the north side is as high as 70 feet above the highway, and the width of the right-of-way, a church property on the north side, a natural drainage near this ridge, and the fact that the BLM manages land 75 meters from the north side of US 70 at this location all make this the top location for an overpass. The MP 239 to MP 240 stretch has also seen the majority of wildlife-vehicle crashes resulting in injuries for motorists.

The existing bridge at MP 237.5 and the overpass would not be enough to accommodate the needs for wildlife to cross US 70 in this WVC hotspot. Ungulates need structures approximately every mile (Bissonette and Adair, 2008), although Dodd et al. (2007) found that 2 miles between crossing structures was acceptable for elk in Arizona. Thus, additional wildlife-friendly structures are needed to replace some aging smaller culverts. The Action Plan development team's specific recommendations include five new span bridges and two arch culverts to help ensure successful passage of herds of mule deer and elk. The east end of this WVC hotspot and farther eastward are on Mescalero Apache Tribe land. The Tribe is interested in working with NMDOT to implement wildlife mitigation; therefore, the field crews examined additional bridge and culvert opportunities on Mescalero Apache Tribe lands for approximately 2 miles beyond the east end of the WVC hotspot. Tribal input will help finalize these plans.

The nine species of concern that may occur in the area could all benefit from these recommended structures. The overpass should be readily used by elk and mule deer based on research in Colorado and Arizona (Kintsch et al., 2021; AZGFD, 2021). Black bears and cougars have been documented using underpass structures more readily than overpasses in Colorado (Kintsch et al., 2021) and Utah (Cramer, 2014) and underpasses in Arizona (Gagnon et al., 2011) and New Mexico (Loberger et al., 2021). These two carnivores may be best accommodated if the culverts are along arroyos, canyons, and other natural corridors, and water bodies in the landscape. Culverts along drainages would also accommodate smaller animals that are associated with streams and rivers, and if stream natural flow was restored, fish connectivity could be improved. Hog-nosed skunks have been documented using culverts in Arizona

(Grandmaison et al., 2021), and can be expected to use structures in ways similar to striped skunks, which have been documented using culverts in Arizona (Gagnon et al., 2011), New Mexico (Loberger et al., 2021), Utah (Cramer, 2012), and Colorado (Kintsch et al., 2021). Javelina are also expected to use the culverts for crossing the road, as documented in Arizona (AZGFD, 2021). The ornate box turtle and the western massasauga have not yet been recorded using road-crossing structures, but would be expected to more readily use the overpasses and underpasses if they contained logs, tree stumps, large rocks and boulders, and native vegetation to the extent possible, all along the structures. Movements of these and other smaller animals through the proposed structures is more likely with structural and vegetative features in place, both as cover and to enhance the natural substrate.

Wildlife mitigation actions recommended as a priority for this WVC hotspot are presented in Figure 6-27. The full complement of mitigation recommendations is provided in Table E-5 (Appendix E).

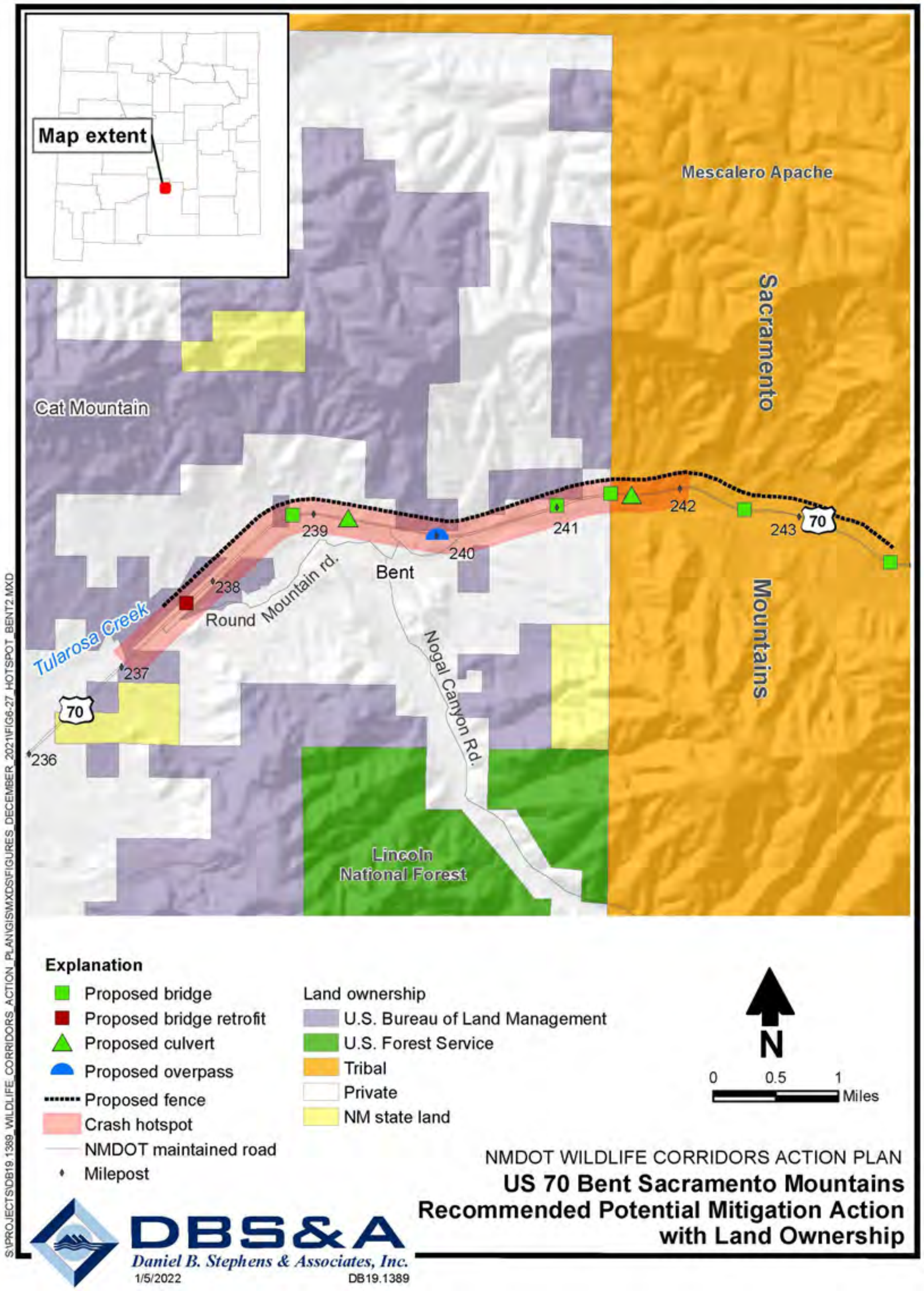

Figure 6-27. US 70 Bent hotspot and locations for potential mitigation actions, with land ownership.

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The top mitigation recommendations are presented on Figure 6-28.

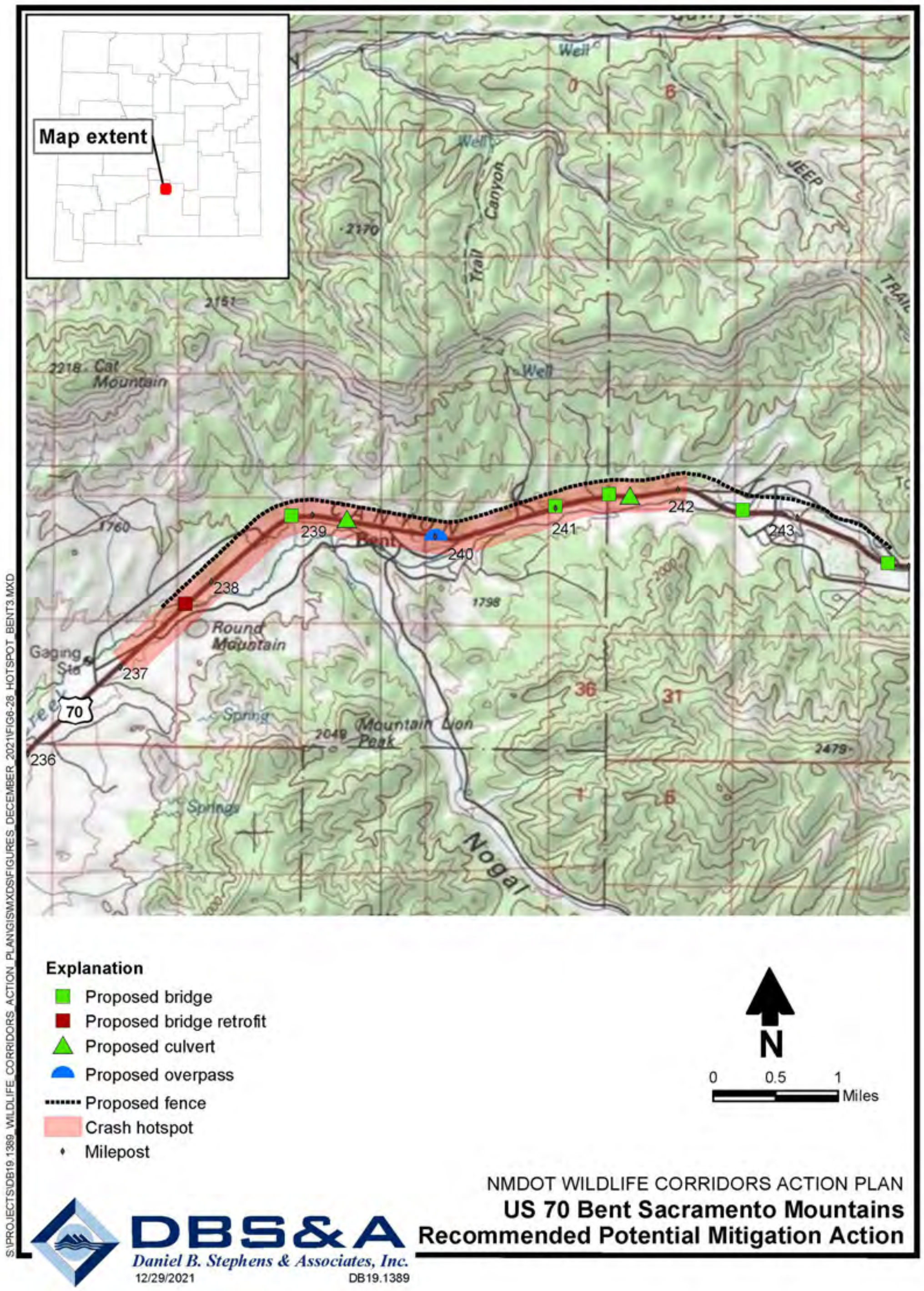

Figure 6-28. Top-priority mitigation recommendations for US 70 Bent WVC hotspot.

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6.5.5.5 Specific Wildlife-Highway Mitigation Recommendations

The recommendations give an overview estimate of what can be done for wildlife mitigation. Many of the existing culverts and bridges are presented in Table E-5 (Appendix E) to provide evidence of opportunities to replace them with more wildlife-friendly structures—for example, when the infrastructure is replaced or when there is a transportation project nearby. The Action Plan team is not presenting these recommendations as the final and only opportunities for enhancing wildlife movement below and above the roads. Rather, these are the top recommendations based on a one-day field reconnaissance of each project area, existing road conditions, 2021 costs, and the current state of the science and practice of transportation ecology.

6.5.5.5.1 Cost-Effective Short-Term Solutions

In the short term, and depending on snow levels in the higher elevations, the Action Plan development team recommends that variable message boards be installed in this area from October through January or February. The message boards should warn drivers of a high risk of elk and other wildlife crossing the road in the area, and keep a tally of crashes to keep local drivers engaged. A message board should be placed at MP 237.5 for eastbound traffic, another at MP 242 for westbound traffic. The message boards should indicate the length of the road segment associated with the elevated danger level. The scope of future STIP projects should include message boards and the timing for deploying them. Debris and sediment accumulating in existing culverts should be cleared to help wildlife move through them. This is especially needed at the MP 241.8 culvert.

Wildlife-detection driver warning systems with thermal or radar detection are also a possibility for use in the short term, until a full mitigation system with structures and fencing is implemented. When the detection technologies are robust and dependable, it is recommended that a system be placed at approximately MP 238.9 with sensors looking in both directions, together with appropriately located motorist warning signs. These systems may not be ready for deployment yet, but wildlife detection technology is advancing rapidly.

6.5.5.5.2 Retrofit Existing Infrastructure

Due to the limited number of existing structures large enough to pass ungulates at this WVC hotspot, retrofit opportunities are limited. The existing bridge at MP 237.6 on the west end of the WVC hotspot could have fencing added to both ends. With fencing just placed on the east side, the bridge would be the official west fence end structure.

6.5.5.5.3 Intermediate Solutions – Priority New Structures

Replace existing culverts at multiple sites.

- *MP 239.4 New Arch Culvert:* A large arch culvert is needed to possibly accommodate elk herds, although use of culverts by elk may be limited. This location would only be suggested as a culvert if the overpass were to be placed at MP 239.9. This is a hotspot area within the WVC hotspot, in terms of crashes involving elk and resulting in injuries.
- *MP 241.6 New Arch Culvert:* The proposed new structure needs to be an arch culvert because the 200-foot length of the existing culvert likely deters wildlife from using it. The new structure has to offer lots of room beneath it to encourage ungulate use. There is a big perpendicular metal culvert carrying water within 15 feet of the entrance of the existing concrete box culvert. This may work for deer, but likely not elk. This location is on Mescalero Apache land, so NMDOT would need to work with the Tribe to coordinate mitigation.

6.5.5.5.4 Priority Solutions Based on Best Management Practices

- *MP 238.8 New Span Bridge:* This is in an arroyo area. The replacement underpass has to be a bridge to accommodate elk under 150 feet of highway. There are approximately 38 elk crashes within 0.75 mile from MP 39, the largest cluster of elk crashes in this hotspot, and possibly in a single 1.5-mile stretch in the whole state. Whether the span bridge is built here or at MP 239.4, the next, nearest location has to accommodate elk as well. With a 40-foot height from road to bottom of fill, this area offers the opportunity to build a bridge with openness under it to accommodate elk herds. The arroyo edges near the underpass would need to be sloped back to allow access to the underpass; otherwise, it is too steep for wildlife.
- *MP 239.9 New Wildlife Overpass:* This is the prime location for an overpass based on topography, the observed concentration of elk crashes, BLM land ownership near the north side, and a nearby drainage that would function as a movement corridor and help bring animals in toward the road. The south side would need to be built up, but the north side of the rock cut is approximately 70 feet above the highway. There is a church property on the southwest corner that would represent minimal disturbance most of the time with a low probability of future development.
- *MP 241 New Span Bridge:* A span bridge is needed for elk and mule deer habitat connectivity. It needs to be a bridge because the length of the crossing under the highway

is 200 feet. The new structure has to offer lots of room beneath it to encourage ungulate use.

- *MP 241.4 New Span Bridge:* The span bridge is needed because the length animals have to traverse beneath the highway is currently approximately 200 feet. The new structure has to offer lots of room beneath it to encourage ungulate use. There is a need to address the eastbound outlet erosion issue; the existing culvert has a 3-foot drop at its opening.
- *MP 242.5 New Span Bridge:* Replace the four-chambered culvert with a bridge that spans the water flow while also long enough to allow terrestrial passage, even during 200-year flood events. The predicted and current climatic changes in New Mexico dictate planning for these events. This location could also serve as an eastern fence end; however, this is on Mescalero Apache land, so NMDOT would need to work with the Tribe on bridge replacement and wildlife movement, and on a possible fence end at any place east of MP 241.4.
- *MP 243.8 New Span Bridge:* The existing three chambered culvert/bridge would need to be replaced with an open span bridge that would accommodate wildlife and water. This structure in on Mescalero Tribal land. The WVC hotspot was not extended here because there is no official sharing of wildlife-vehicle crash data between the Mescalero Apache Tribe and NMDOT. However, the Mescalero Conservation Office provided ample evidence of wildlife crashes in the area. Thus, this location could be considered for a fence end.

6.5.5.6 *Benefit-Cost Analysis*

There are several types of benefit-cost analyses. However, they all share the same basic premise, which is to use a benefit-cost ratio with the benefit in the numerator and the cost in the denominator. The cost is associated with the construction and maintenance of the proposed mitigation infrastructure. The estimated monetary benefit is derived from the reduction in the number of crashes over the lifetime of the mitigation.

The unique approach here is based on the Colorado DOT's new method of including the economic value of elk and mule deer not killed in crashes as a result of the mitigation among the benefits (Kintsch et al., 2019).

6.5.5.6.1 *Ballpark Estimates for Costs of Infrastructure*

Table 6-25 presents the costs per unit for overpasses, bridges, and culverts placed on a four-lane highway as estimated by the Action Plan development team's engineers based on NMDOT 2019 cost estimates. The structure cost estimates are identified as being applicable to four-lane highways. The price of 8-foot wildlife exclusion fence per mile for both sides of the highway, double cattle guards, also known as game guards, and escape ramps are all taken from Colorado DOT estimates in the West Slope Study (Kintsch et al., 2019).

Table 6-25. US 70 Bent hotspot project wildlife crossing structures and other mitigation rough cost estimates.

Preferred Structure / Infrastructure	Cost per Unit	Total
MP 238.8 Span Bridge 4-lane	$2,520,000	$2,520,000
MP 239.4 Arch Culvert 4-lane (may need two culverts for opposing lanes, but estimated as one)	$3,230,000	$3,230,000
MP 240 Wildlife Overpass 4-lane	$7,280,000	$7,280,000
MP 241 Span bridge 4-lane	$2,520,000	$2,520,000
MP 241.4 Span bridge 4-lane	$2,520,000	$2,520,000
MP 241.6 Arch culvert 4-lane	$3,230,000	$3,230,000
MP 242.5 Span bridge 4-lane	$2,520,000	$2,520,000
MP 243.8 Span bridge 4-lane	$2,520,000	$2,520,000
7 miles of fence	$100,000	$700,000
Escape ramps @ 4/mile = 7 x 4 = 25	$14,000	$350,000
Approximately 10 Double cattle guards	$60,000	$600,000
Total		$27,990,000

6.5.5.6.2 Animal-Vehicle Crash Costs

From 2009 to 2018, there were 100 animal crashes within this WVC hotspot that included any animals. Crash severity varied. A total of 87 crashes resulted only in property damage, 13 in some level of injury. Of all the injury crashes, 5 were at MP 239 and 4 were at MP 240. A total of 2 were Class A injury crashes, (severe), 4 were Class B minor injury crashes, and 7 were Class C possible injury crashes.

The NMDOT 2019 and FHWA 2018 (Harmon et al., 2018) crash cost values are presented in Table 6-5. Using these values, the costs associated with the animal crashes in this hotspot were calculated (Table 6-26).

Table 6-26. Calculation of wildlife-vehicle crash costs in US 70 Bent hotspot using NMDOT and FHWA crash values.

Crash Type	NMDOT-Estimated Individual Crash Costs to Society	Total NMDOT Value of Crashes	FHWA-Estimated Individual Crash Costs to Society Based on Harmon et al. (2018)	Total FHWA Value of Crashes
87 property damage only	$7,400	$643,800	$ 11,900	$1,035,300
7 possible injury (Type C)	$44,900	$314,300	$125,600	$879,200
4 minor injury (Type B)	$79,000	$316,000	$198,500	$794,000
2 incapacitating/serious injury (Type A)	$216,000	$432,000	$655,000	$1,310,000
0 fatality	$4,008,900	$0	$11,295,400	$0
Total		$1,706,100		$4,018,500

The benefits portion of the ratio is estimated by examining the expected reduction in crash costs. These benefits are estimated by taking the crash costs, multiplying them by a 90 percent reduction in the number of crashes the mitigation can be expected to provide, expected lifespan of 75 years for the mitigation, and economic monetary value associated with mule deer and elk saved by the mitigation over 75 years (Table 6-27). The project recommendations include approximately 6.3 miles of mitigation, which will all be included in the cost portion of the benefit-cost analysis. The benefits will only focus on the identified 5-mile WVC hotspot. This method is considered to be conservative, yet appropriate, as mitigation of the identified WVC hotspot is the priority, and the extended project could be shortened to focus exclusively on the WVC hotspot.

Table 6-27. Estimating value of mitigation for benefits, US 70 Bent hotspot.

	NMDOT Crash Values	FHWA Crash Values
Total value of crash costs over 10 years	$1,706,100	$4,018,500
Crash cost per mile per year	$34,122	$80,370
Crash cost for 5 miles of project over 75 years of infrastructure (Cost/mile/year x 5 x 75)	$12,795,750	$30,138,750
If mitigation reduced crashes by 90%, over 75 years, that value would be:	$11,516,175	$27,124,875
Wildlife Lost and Saved Values		Estimated Value of Elk and Mule Deer Saved over 75 years of Mitigation
If 72% of animal crashes were with elk (72 of 100 animal crashes), and 18% were with deer (18 of 100 animal crashes), and there have been 10 crashes with animals per year, and the number prevented would be 90% of 10, there would be 9 animal crashes prevented per year. This would roughly equate to 6.5 elk and 1.6 mule deer saved each year. At a value of $2,392 for each elk and $2,061 for each mule deer, the value of animals saved each year x 75 years of mitigation= Elk ($2,392 x 6.5 x 75 years) + Mule deer ($2,061 x 1.6 x 75 years) = Elk - $ 1,166,100 + Deer - $ 247,320 = $ 1,413,420		$1,413,420

6.5.5.6.3 Benefit-Cost Ratio

- NMDOT values for crashes:
  Benefit/Cost Equation = $11,516,175 + $1,413,420/$27,990,000 = 0.46
- FHWA Values for Crashes
  Benefit/Cost Equation = $27,124,875 + $1,413,420/$27,990,000 = 1.02

The mitigation would not be expected to pay for itself if using the NMDOT crash values. However, the mitigation would be expected to pay for itself with FHWA values, with a ratio value of 1.02. If the full list of mitigation measures equaled approximately $12.93 million, the project would be expected to possibly pay for itself over the same time period based on NMDOT crash costs.

6.5.6 US 64/84 South of Tierra Amarilla to Chama to US 64/84 Junction to Colorado Border Wildlife Corridor Recommendations for Wildlife Mitigation Projects

- *US 84 MP 248.5–255 = 6.5 miles, US 64 MP 149–175 = 26 miles, US 84 MP 281.5 –287 = 5.5 miles*
- *38-mile corridor, 34.8 miles of mitigation*
- *Rio Arriba County*
- *NMDOT District 5*

6.5.6.1 *Project Area Overview*

This corridor (the Chama wildlife corridor) in northern New Mexico is bisected by US 84 and US 64. The project area extends from just south of Tierra Amarilla in the south, north to Chama, west to the junction of US 64 and US 84, and north to the Colorado border on US 84, for a total of 38 miles. This project area was selected based on NMDGF input, GPS data from collars on mule deer and elk placed in multiple studies since the 1980s, GPS data and maps from the Jicarilla Apache Nation's studies on mule deer and elk in the area, the S.O. 3362 Action Plan, and linkage modeling and hotspot analyses conducted for the Action Plan. The highway segments that define this corridor are US 84 MP 249 south of Tierra Amarilla to MP 287 near the Colorado border in the north. This stretch of US 84 overlaps with US 64 MP 149 to 176. Elk and mule deer are the main focal species in this corridor (Figure 6-29).

Figure 6-29. Elk and mule deer are the main focal species in the Chama wildlife corridor (photo credit: AZGFD [elk], P. Cramer [mule deer]).

The area encompasses the Tusas Mountains on the northeast and east sides, the San Juan Mountains to the north in Colorado, and the lower elevation Chama Valley central to this corridor. Jicarilla Apache Nation lands are within this corridor. Several different studies have identified mule deer and elk movements across this corridor (NMDGF unpublished data; Sawyer et al., 2011; Tator, 2016 and 2020). Ongoing studies by the Jicarilla Apache Nation Department of Game and Fish starting in 1983 have revealed mule deer and elk movements across US 64 and US 84 in numerous spots in this corridor (Watts, 2014). Elk have consistently been radio and GPS tracked crossing US 64/ US 84 at the Humphries State Wildlife Management Area (WMA) (MP 148 to 151), and have overwintered on the south and west side of US 64 from Humphries WMA south to Tierra Amarilla. The 2011 Rosa mule deer study (Sawyer et al., 2011) tracked mule deer west of the area, and also demonstrated mule deer crossing US 84 just south of the Colorado border (Watts, 2014).

According to NMDGF unpublished data, elk and mule deer winter near El Vado and Heron Reservoirs on the south and west sides of this corridor. This information, together with the studies mentioned above, demonstrate that elk and mule deer have distinct migratory patterns for accessing summer and winter ranges, while resident populations occur on the landscape here year round. Depending on weather conditions and snow levels in Colorado, migratory mule deer begin heading for their winter range in the fall to early winter and begin the migration toward their summer range in late winter to early spring. Elk tend to wait until snow depth is increased to the point where they are forced to move to lower elevations. Telemetry data suggest that these overall migration patterns have remained similar for the past 40 years. Figure 6-30 shows some of the overall wildlife movement across this corridor in relation to the locations of recorded crashes.

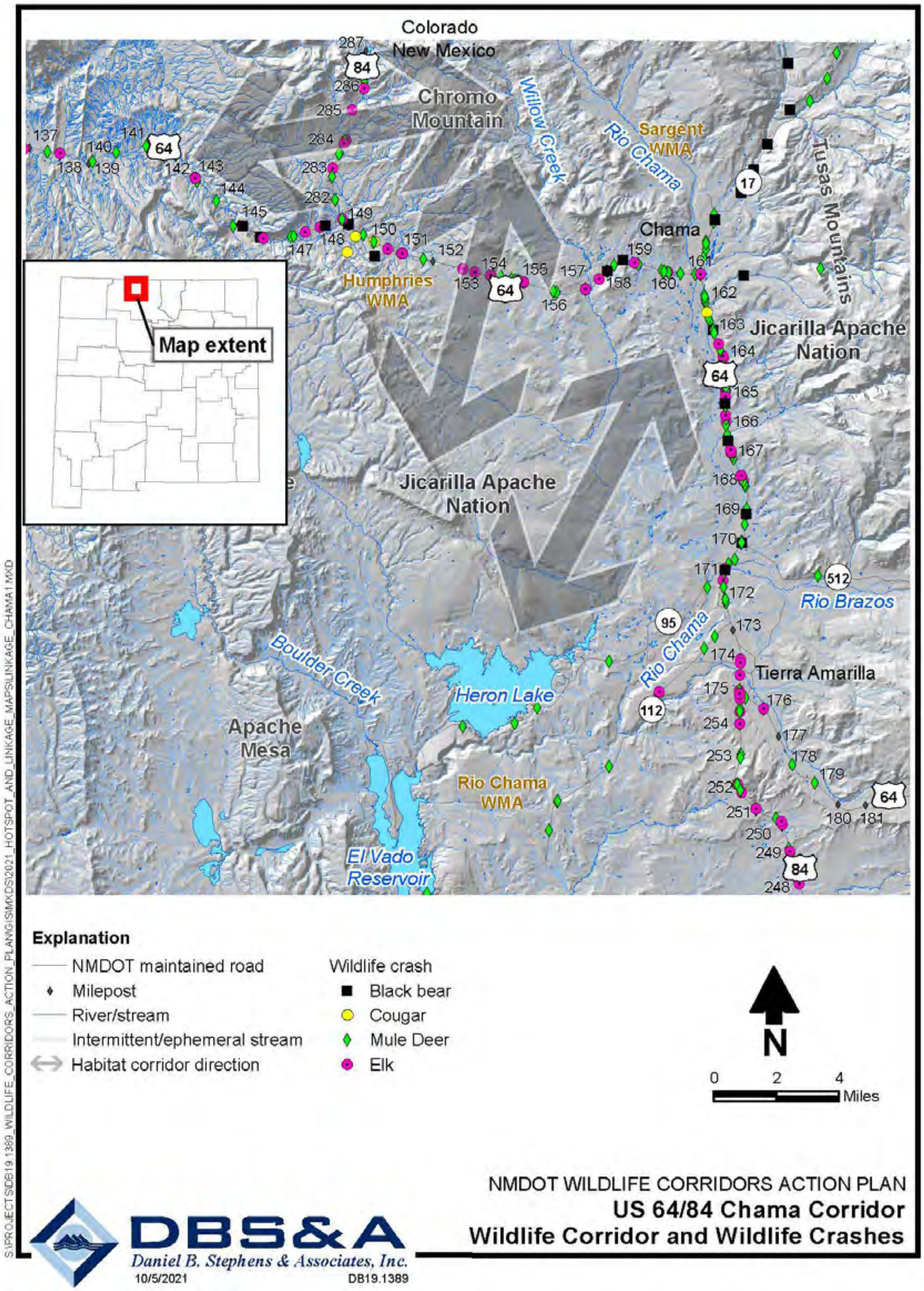

Figure 6-30. Wildlife-vehicle crashes and wildlife movement in the Chama wildlife corridor.

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6.5.6.2 Transportation – Safety Statistics

The crash data reported in the following subsections include both animal-vehicle crashes and wildlife-vehicle crashes to better reflect the impact of collisions with all animals. Animal-vehicle crashes include wild and domestic animals and livestock. Using all animal statistics to evaluate the situation helps the reader to differentiate where there are strictly wildlife problem areas, and where these domesticated animals may also be involved. The recommended wildlife mitigation that includes wildlife exclusion fences would be expected to reduce all these crashes, not just those with wildlife. Therefore, the total animal crashes are reported and then used in the benefit-cost analyses of the value of the recommended infrastructure. The reported wildlife crashes are those strictly with the six focal species: mule deer, elk, pronghorn, bighorn, black bear, and cougar.

6.5.6.2.1 Wildlife-Vehicle Crashes per Mile per Year

According to NMDOT data (2009-2018), there were 244 reported crashes involving the focal species (Table 6-28), and 270 crashes with all animals.

Table 6-28. Chama wildlife corridor, NMDOT crashes with all animals and with the six focal wildlife species, 2009-2018.

Length (miles)	Total Crashes with All Animals	Total Crashes with Focal Species	Wildlife Crashes per mile per year	Crashes with Six Focal Species					
				Deer	Elk	Black Bear	Cougar	Pronghorn	Bighorn Sheep
38.8	270	244	0.63	154	75	11	4	0	0

6.5.6.2.2 Seasonality of Wildlife-Vehicle Crashes

The greatest numbers of reported crashes occurred in May through November (Figure 6-31).

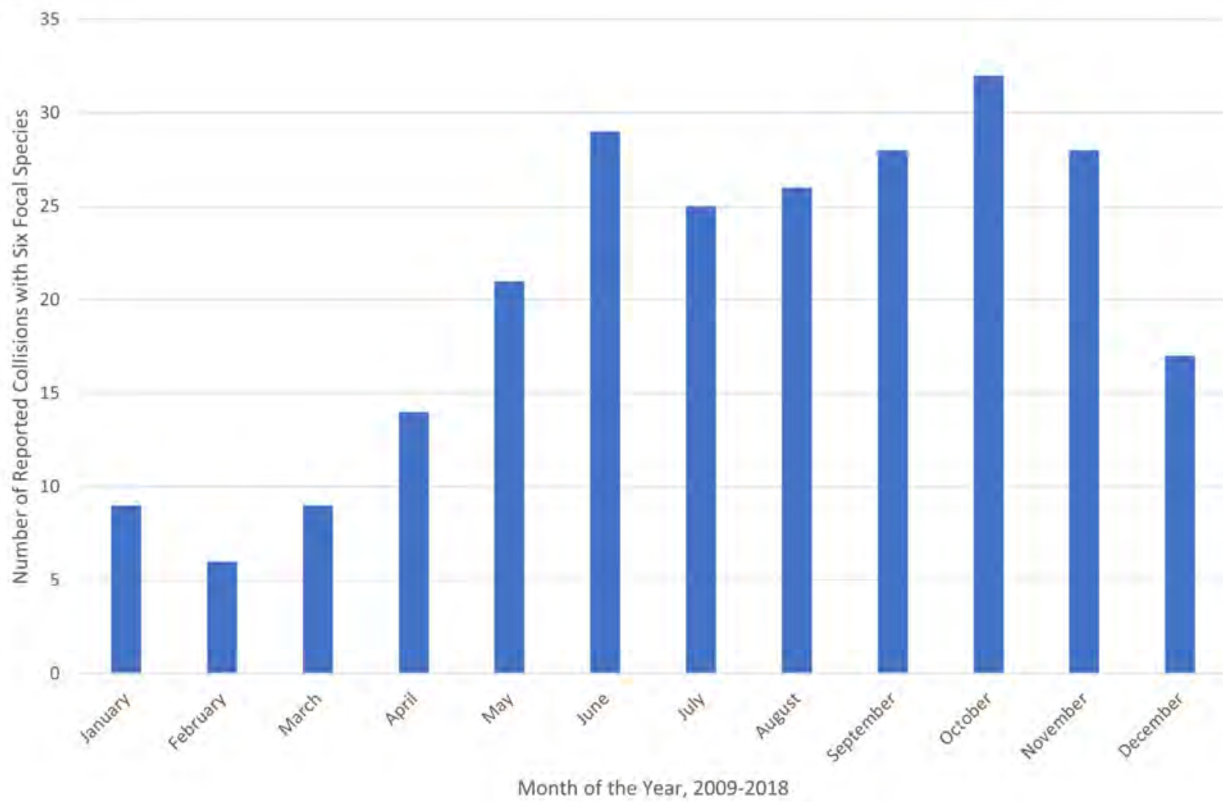

Figure 6-31. Wildlife-vehicle crashes by month in the Chama wildlife corridor.

6.5.6.2.3 WVC Species Percentages

Of the WVCs in this wildlife corridor, 63 percent involved mule deer, 31 percent involved elk, 5 percent involved black bear, and 2 percent involved cougar.

6.5.6.2.4 Wildlife-Vehicle Crashes as Percentage of All Crashes

There were 326 total crashes in the corridor from 2009 to 2018. Of these, 270 crashes involved collisions with animals. There were 244 reported crashes involving the focal species, representing 75 percent of all crashes.

6.5.6.2.5 Average Annual Daily Traffic (AADT)

AADT is important in estimating if large wild animals such as the six focal species have opportunities to cross the roads under scrutiny. Traffic volumes can form a complete barrier to wildlife movement all day and into the night once AADT reaches well above 20,000 vehicles per day. At 10,000 vehicles per day there is still a barrier, with some opportunity for nocturnal movements across roads. Wildlife can find limited opportunities to cross roads with AADT

between 2,000 and 10,000 vehicles per day. However, at AADT of 2,000 and 10,000 per day, wildlife will try to cross roads, and will have greater mortality in some areas because of the lower perceived risk by wild animals but the continued presence of vehicles (Charry and Jones, 2009; Ng et al., 2004; Seiler, 2005).

AADT in the corridor is as follows:

- US 84 south of Tierra Amarilla: Current = 1,245 (2018), Future = 1,149 (estimated 2038)
- US 64 south of Chama: Current = 2,600 (2018)
- US 64 west of Chama to the junction of US 64/84: Current = 1,948, Future = 1,798 (estimated 2038)
- US 84 to the Colorado border: Current = 1,221 (2018), Future = 1,127 (estimated 2038)

6.5.6.2.6 *Number of Lanes*

The road has two lanes through this corridor.

6.5.6.2.7 *STIP Possibility*

- STIP Control Number 5100830 US 64/NM 17 Chama Minor Rehabilitation, MP 0 to 1.32. and US 64 MP 161.35 to 161.55, US 64 bridge 7932 MP 161.53, $493,757; FY 2020-2021.

6.5.6.3 *Ecological and Feasibility Considerations*

6.5.6.3.1 *Species of Concern*

Species of concern in this area include mule deer, elk, black bear, cougar, red fox, American badger, and white-tailed jackrabbit. Mule deer, elk, black bear, and cougar have been recorded in relation to wildlife-vehicle crashes.

6.5.6.3.2 *Data*

NMDOT crash data were used in this analysis. Cougar and black bear mortality data were obtained from NMDGF and added to the wildlife-vehicle crash map. Some of the recorded locations were deaths due to other causes than vehicle collisions when they occurred away from roads. Jicarilla Apache Nation GPS collar data from mule deer and elk demonstrate that for decades, animals have crossed US 64 both west and south of Chama. NMDGF data (NMDGF unpublished data) show mule deer crossing US 64 south of Chama to reach the Tusas Mountains on the east side of the road, just south of Chama.

6.5.6.3.3 Public Land

There are 3.5 miles along NMDGF Humphries WMA; for 1.5 miles of this length, the WMA is on both sides of the road.

6.5.6.3.4 Support

The Jicarilla Apache Nation supports wildlife corridors and transportation mitigation projects in this area. NMDGF strongly supports this corridor and mitigation to US 84/64.

6.5.6.4 Recommendations Overview

Recommended projects across this 38-mile corridor are broken up into four distinct sections of the two highways: (1) US 84 Colorado to US 64 Junction, (2) US 64/US 84 Junction East to Chama, (3) US 64/84 South of Chama to the Tierra Amarilla US 64/84 junction, and (4) US 84 South of Tierra Amarilla to approximately MP 249. All four sections are known to bisect movements of mule deer and elk in various GPS and radio collar studies. Movement data and collision data for both mule deer and elk are known to indicate that the animals cross all four segments of the highways both during migration from summer to winter range and back and in daily movements. The project recommendations take into account the GPS locational data points for elk and mule deer, as well as WVC hotspots. These data helped to prioritize project recommendations for overpasses and bridges.

Wild animals need structures placed at distances that match the scale of their daily movements (Bissonette and Adair, 2008), or within distances related to their willingness to move along a fence line to find road-crossing structures. Mule deer in southern Utah were documented to change their migration movements by moving one mile in either direction along a new wildlife exclusion fence (Cramer and Hamlin, 2019a). This should be considered the maximum distance the project would allow for mule deer to move toward a crossing structure when encountering a fence. Herds of elk are very reluctant to use most underpass structures (Cramer, 2014; Cramer and Hamlin, 2017 and 2019; Gagnon et al., 2015; Kintsch et al., 2021) unless they are span bridges (Gagnon et al., 2015 and 2017) or overpasses (Kintsch et al., 2021), or an elk herd adapts over time to an underpass (Kintsch et al., 2021; Sawyer and LeBeau, 2011). One goal of the Action Plan is to allow herds of mule deer and elk to move beneath or above the highway in their daily and migration movements. The recommendations here are prescribed specifically for the species of concern along various segments of US 64/84. Mule deer will use culverts that are large and short enough for them, span bridge underpasses, and overpasses. Elk herds will use span bridge underpasses and overpasses. Single elk may use culvert underpasses, but culvert underpasses are not sufficient for providing connectivity for the herds of elk in this area.

For the road segment of US 84 from the Colorado border, the Action Plan recommends an overpass at MP 284 where GPS data demonstrate mule deer cross the road, in addition to a new wildlife underpass bridge at MP 284.9.

From the US 64/84 junction east to Chama, three underpass bridges and three overpasses are recommended. This area is critical to both mule deer and elk movements north and south, with the western portion of these movements occurring across the Humphries WMA. The top overpass location at MP 151.8 is the priority, including in terms of its placement here. MP 150.6 and MP 154.6 represent the second and third choice locations for an overpass, respectively. The third choice overpass was chosen based on input from the Jicarilla Apache Nation.

From Chama southward, two wildlife underpass bridges are recommended in this largely private landscape. The bridge recommended at MP 165.9 is located where the Jicarilla Apache Nation owns both sides of the road and supports the placement of this structure.

Along the segment south of Tierra Amarilla, the Action Plan development team recommends four wildlife underpass bridges and one culvert for wildlife mitigation.

There are seven potential species of concern in the area that could all benefit from the proposed project recommendations. The overpasses should be readily used by elk and mule deer based on research in Colorado and Arizona (Kintsch et al., 2021; AZGFD, 2021). Black bears and cougars should readily use all the culverts, especially those along washes and streams. This would also accommodate smaller animals that are associated with streams and rivers, and if stream natural flow were to be restored, fish habitat connectivity could be improved. Mule deer could readily use culverts that are both larger and short. Elk would be expected to use areas under larger bridges and over overpasses. American badger and red fox will also benefit. Both of these carnivores have been recorded using overpasses in Colorado (Kintsch et al., 2021) and underpasses in New Mexico (Loberger et al., 2021), Colorado (Kintsch et al., 2021; Cramer and Hamlin, 2021), and Utah (Cramer and Hamlin, 2019). The white-tailed jack rabbit is expected to use both underpass and overpass structures, as is the case with other species of jackrabbit in Colorado (Cramer and Hamlin, 2021; Kintsch et al., 2021), Arizona (AZGFD, 2021), and Utah (Cramer and Hamlin, 2019). Smaller animals such as medium-sized and small mammals, lizards, snakes, amphibians, and invertebrates would benefit from the placement of logs, tree stumps, large rocks and boulders, and native vegetation all along road-crossing structures. Movements of these and other smaller animals would be enhanced by logs, tree stumps, rocks, and native vegetation providing cover and a more natural substrate.

Figure 6-32 shows the priority mitigation actions along with land ownership information. The full complement of mitigation recommendations is provided in Table E-6 (Appendix E).

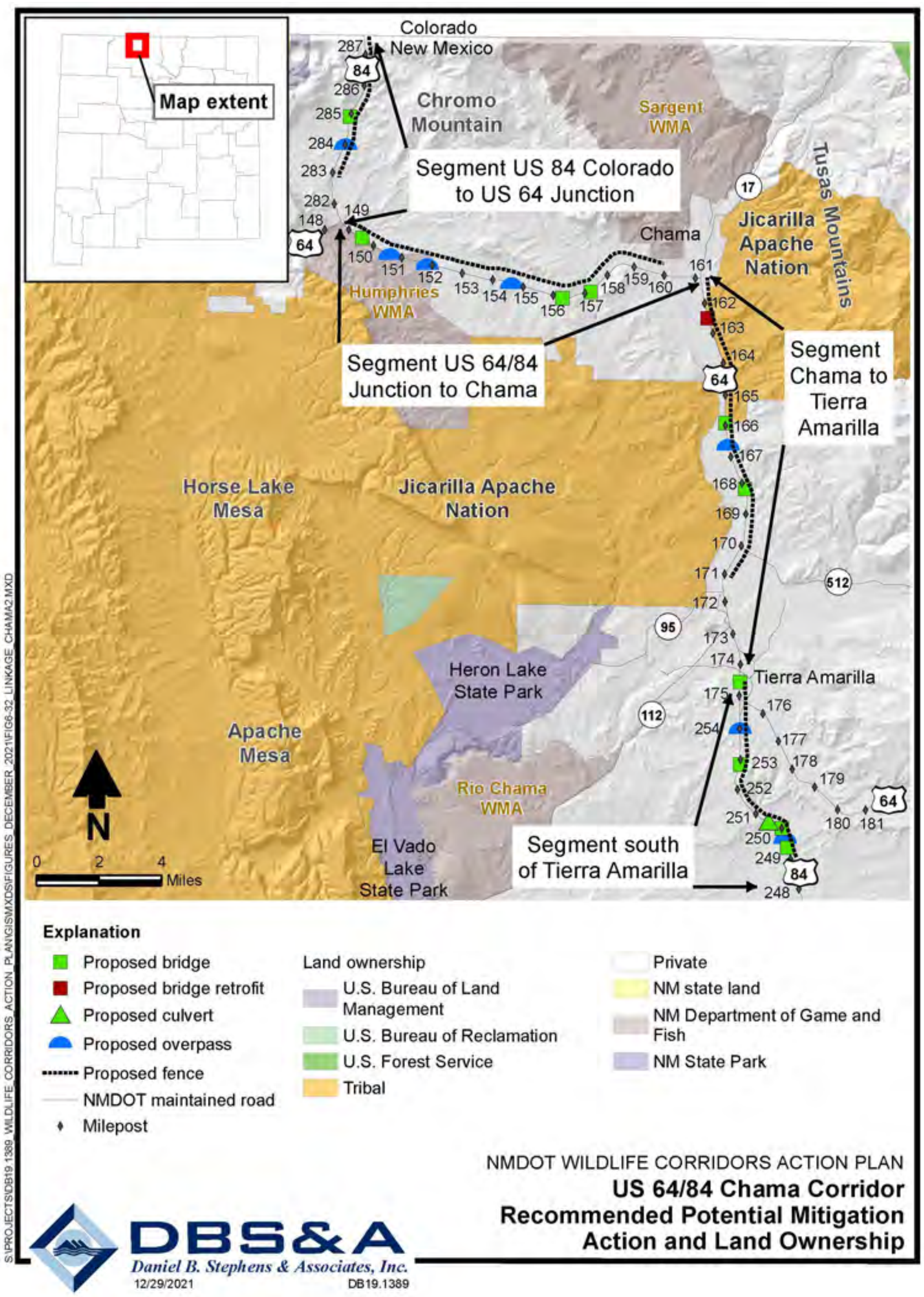

Figure 6-32. Land ownership and recommended project mitigation actions in the Chama wildlife corridor.

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The priority recommendations are presented in Figure 6-33.

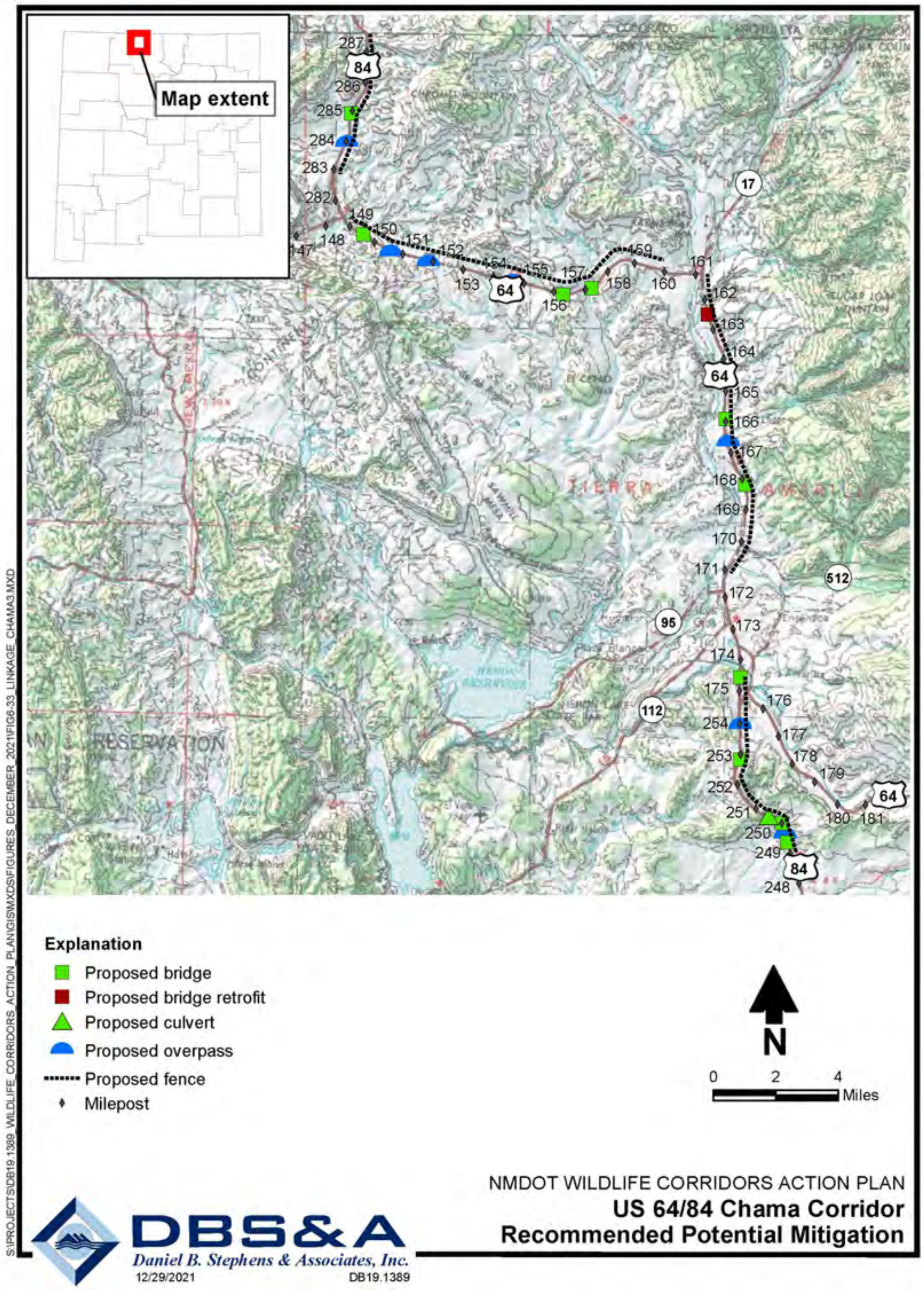

Figure 6-33. Top priority mitigation recommendations for the Chama wildlife corridor.

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Figure 6-34 shows views of wildlife and mitigation activity near Chama.

Figure 6-34. Elk cow along US 64 and US 84 west of Chama, June 2020 (top) and US 84/64 looking south of Chama with motorist deer warning sign (bottom).

6.5.6.5 *Specific Wildlife-Highway Mitigation Recommendations*

The recommendations give an overview estimate of what can be done for wildlife mitigation. Many of the existing culverts and bridges are presented in Table E-6 (Appendix E) to provide evidence of opportunities to replace them with more wildlife-friendly structures—for example, when the infrastructure is replaced or when there is a transportation project nearby. The Action Plan team is not presenting these recommendations as the final and only opportunities for enhancing wildlife movement below and above the roads. Rather, these are the top recommendations based on a one-day field reconnaissance of each project area, existing road conditions, 2021 costs, and the current state of the science and practice of transportation ecology.

6.5.6.5.1 Cost-Effective Short-Term Solutions

Mobile variable message boards could be placed in the Chama area during migrations in the fall, (October-November) and spring (April-May). It is understood that these are not the high seasons for crashes, but the message boards would nonetheless help local residents driving through the area to become more aware of wildlife movements across the road. The summer seasons when the traffic volumes are higher could also see another type of message on these message boards.

Solar flashing signs are slated to be placed at MP 149.04 (eastbound), 0.3 mile east of the west US 64/84 junction and at MP 160.56 (westbound) on US 64/84, just outside Chama city limits. A static sign with flashing lights along its edges is recommended based on previous memorials from the state legislature about 10 years ago.

If a decision was reached to lay down fences (i.e., unhook them and lay one of the posts at each end on the ground) during migration times, it would be important to approach not just NMDOT District 5 Maintenance, but also local landowners and consult with them about the possibility of incorporating laydown fencing or types of wildlife friendly fence.

On US 64/84 west of Chama, NMDOT and NMDGF will need to approach ranch owners where we propose overpasses on private land and work with them on implementing conservation easements. There is collaboration between the agencies and land trust community here to help initiate this approach. South of Chama, there are more small-property landowners to contact than to the northwest, but also some large properties. The Jicarilla Apache Nation could be a willing partner in this effort.

6.5.6.5.2 Retrofit Existing Infrastructure

- *US 64 MP 161.5 Bridge – Fence & Pathway:* Add wildlife exclusion fence to the existing bridge, even if it consists of just wing fence because of all the driveways. Place fines or soil on the rocky substrate beneath the bridge to facilitate mule deer movement. Place enough soil for a structured pathway as high up on the slope as possible for a mule deer, to avoid being washed away during flooding, or remove the riprap in a path, 10 feet wide (5 feet wide minimum). However, the substrate is the problem and all the proposed measures just listed may not be feasible.

6.5.6.5.3 Intermediate Solutions - New Structures

Intermediate solutions include the agencies working with private landowners to provide permanent protection for wildlife movements and crossing structures at these locations.

- US 84 Colorado to US 64 Junction
    - *US 84 MP 284.9 – Arch Culvert:* The existing culvert conveys water through deeply incised banks. There is a 7-foot-long plunge down to the stream bottom from the culvert on the west side. The landowners will need to work with agencies to restore stream function and allow wildlife and fish to move across their lands.
- US 64 South of Chama to the Tierra Amarilla US64/84 junction
    - *US 64 MP 168.2 Concrete Box Culvert:* This is the top choice location for a structure south of Chama. There is enough fill for this culvert. It is also adjacent to some wet meadows that may be the wildlife attractant causing the WVCs.
- US 64/84 South of Tierra Amarilla
    - *US 84 MP 252.8 Arch Culvert:* This could be a culvert or span bridge specifically for carnivores.
    - *US 84 MP 250.5 Arch Culvert:* Although elk are in the area, there is not enough overburden to build a bridge. This structure would largely be for carnivores, and possibly mule deer.

6.5.6.5.4 Solutions Based on Best Management Practices

- US 84 Colorado to US 64 Junction
    - *US 84 MP 284 Overpass:* The topography here is prime for an overpass. There is good cut height on both sides. It is located on private land, like most of the corridor, but there are good cut banks. It sounds like a good spot, as far as constructability. There is a water tank about 300 feet to the west. The location seems to have deeper cut than the four potential overpass locations to the north. Private lands all around necessitate working with landowners.
- US 64/US 84 Junction East to Chama
    - *US 64 MP 149.5 Span Bridge:* This bridge must accommodate elk. It is near the Humphries WMA. Highly recommend span bridge, similar to what has worked in Arizona on SR 260 for elk.

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- *US 64 MP 150.6 New Wildlife Overpass:* This is the second choice overpass for this segment. This is another important location for elk and other wildlife in the Humphries WMA.
- *US 64 MP 151.8 New Wildlife Overpass:* First choice for overpass location in this segment and it is on Humphries WMA land.
- *US 64 MP 154.6 New Wildlife Overpass:* This is the third choice for an overpass location in this segment, based on Jicarilla Apache Tribe GPS data on mule deer and elk, crash data for these species, WVC hotspot data, and feasibility. It is located on open rangeland with a stock pond south of the road. Both sides are under private ownership, with little to no human activity. There is a 30-foot cut/ridge on the north side of the road, but is level with the ground (at-grade) on the south side. This location is a priority based on both Jicarilla Apache Nation data on mule deer and elk movements and crashes involving these animals. It is just inside the west boundary of the Chama WVC hotspot. Place overpass between MP 154.6 and MP 154.9.
- *US 64 MP 156.2 New Wildlife Underpass Bridge:* Replace the corrugated metal culvert with a span bridge. Small dam immediately upstream presumed to be for the benefit of a water tank. Important for mule deer movement and a preferred place suggested by NMDGF and Jicarilla Apache Nation to enhance wildlife movement.
- *US 64 MP 157 Single Span Bridge:* There is about 8 feet of overburden. Culvert will need a U.S. Army Corps of Engineers 404 permit because this is a major drainage wetland. A bridge may therefore be preferred by NMDOT, and it is certainly a better choice for elk. This location is in the hotspot.

- US 64 South of Chama to the Tierra Amarilla US 64/84 Junction
  - *US 64 MP 165.9 New Wildlife Underpass Bridge:* The Jicarilla Apache Nation owns the land on both sides of the highway and would be open to a span bridge underpass at this location. This is a high mule deer use area. The river is not far, on the west side of the road.
  - *US 64 MP 166.6 Overpass:* Top overpass location south of Chama. The road is about 5 to 6 feet below grade, but an overpass remains the best option because there are so few opportunities to place culverts below the road. However, there are extensive private properties and residences on both sides of the road here. This is where mule deer cross the road and elk concentrate on the west side of the road, and where Jicarilla Apache

Tribal land lies to the east side of the road. More Tribal land is found on the west side, but separated from the road by a sliver of private lands. Private landowner buy-in is therefore pivotal for building an overpass.

- US 64/84 South of Tierra Amarilla
  - ◇ *US 64 MP 174.5 New Wildlife Underpass Bridge:* This bridge would replace the five-chambered box culvert bridge, and span over the Tierra Amarilla Creek. A bridge would work well to straddle the creek and provide terrestrial passage. The bridge would have low clearance, however, because the road is not far above the surrounding landscape. Channelization of the stream should be considered in order to decrease the bridge footprint. The current stream channel is becoming filled with sediment. A single span bridge would work best to cross the stream. However, right now the road may be too low for a span girder bridge. A single span bridge would stand about 50 feet long over the stream. From a hydrology standpoint, the bridge would also be a better option than a five-chambered culvert. The existing culvert is falling apart on its top and bottom sides with concrete crumbling.
  - ◇ *US 84 MP 254 New Wildlife Overpass:* Second choice overpass tied with MP 253.4. The road is narrow here. Significant fill would probably be needed.
  - ◇ *US 84 MP 253.4 New Wildlife Overpass:* Second-choice location, tied with MP 254. One of these two locations should be where an overpass is built. The slope is steep to the west, and there are good road cuts. The steep slope on the west side has a ridge coming up to it. The slopes are a bit offset. The east side might need some fill. Trails left by animals were observed on the west side, showing that the local wildlife is used to the surrounding steep terrain. The land is private in this section, but most of the properties appear to be larger ranches.
  - ◇ *US 84 MP 249.7 New Wildlife Overpass:* The top location for overpass in this segment. Telemetry data show mule deer migratory movements occurring at this location, which is suitable for building an overpass, as it has cuts on both sides of the road. There is private land on both sides. Work with landowners to initiate planning for this overpass.
  - ◇ MP 249.4 New Wildlife Underpass Bridge: There is a lot of overburden and tie fence end to the future arch culvert or bridge. Elk and mule deer present. Tie fence end to the future arch culvert or bridge.

6.5.6.6 *Benefit-Cost Analysis*

There are several types of benefit-cost analyses. However, they all share the same basic premise, which is to use a benefit-cost ratio with the benefit in the numerator and the cost in the denominator. The cost is associated with the construction and maintenance of the proposed mitigation infrastructure. The estimated monetary benefit is derived from the reduction in the number of crashes over the lifetime of the mitigation.

The unique approach here is based on the Colorado DOT's new method of including the economic value of elk and mule deer not killed in crashes as a result of the mitigation among the benefits (Kintsch et al., 2019).

6.5.6.6.1 *Ballpark Estimates for Costs of Infrastructure*

Table 6-29 presents the costs per unit for overpasses, bridges, and culverts placed on a four-lane highway as estimated by the Action Plan development team's engineers, based on NMDOT 2019 cost estimates. The price of 8-foot wildlife exclusion fence per mile for both sides of the highway, double cattle guards, also known as game guards, and escape ramps are all taken from Colorado DOT estimates in the West Slope Study (Kintsch et al., 2019).

Table 6-29. Chama wildlife corridor project wildlife mitigation rough cost estimates.

Infrastructure	Cost per unit	Cost for Infrastructure	Total for Segment
US 84 Colorado to US 64 Junction			
One overpass (2-lane): MP 284	$4,460,000	$4,460,000	
One single span bridge (2-lane) MP 284.9	$1,070,000	$1,070,000	
Fence MP 287.4 to 282.8 = 4.6 miles	$100,000	$460,000	
Approximate 4 double cattle guards	$ 60,000	$240,000	
Escape ramps @ 4/mile = 4.6 x 4 =18	$14,000	$252,000	
Total for segment			$6,482,000
US 64/US 84 Junction East to Chama			
One overpass (2-lane): MP 151.8	$4,460,000	$4,460,000	
One overpass (2-lane): MP 150.6	$4,460,000	$4,460,000	
One overpass (2-lane): MP 154.6	$4,460,000	$4,460,000	
One span bridge (2-lane): MP 149.5	$1,070,000	$1,070,000	
One span bridge (2-lane): MP 156.2	$1,070,000	$1,070,000	
One span bridge (2-lane): MP 157.2	$1,070,000	$1,070,000	
Fence MP 149–140 = 11 miles	$100,000	$1,100,000	
Escape ramps @ 4/mile = 11 x 4 = 44	$14,000	$616,000	
Double cattle guards approximately 4 sets	$60,000	$240,000	
Total for segment			$18,546,000
US 64/84 South of Chama to the Tierra Amarilla US 64/84 junction			
One overpass (2-lane): MP 166.6	$4,460,000	$4,460,000	
One span bridge (2-lane): MP 165.9	$1,070,000	$1,070,000	
One span bridge (2-lane): MP 168.2	$1,070,000	$1,070,000	
Fence MP 161–171 = 10 miles	$100,000	$1,000,000	
Escape ramps 10 miles @ 4/mile = 10 x 4 = 40	$14,000	$560,000	
Double cattle guards approximate 15 sets	$60,000	$900,000	
Total for segment			$9,060,000

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Table 6-29 (cont.)

Infrastructure	Cost per unit	Cost for Infrastructure	Total for Segment
US 84 South of Tierra Amarilla			
One overpass (2-lane): MP 249.7	$4,460,000	$4,460,000	
One overpass (2-lane): MP 253.4 or MP 254	$4,460,000	$4,460,000	
One single span bridge (2-lane): US 64 MP 174.5	$1,070,000	$1,070,000	
One single span bridge (2-lane): US 84 MP 252.8	$1,070,000	$1,070,000	
One single span bridge (2-lane): US 84 MP 250	$1,070,000	$1,070,000	
One single span bridge (2-lane): US 84 MP 249.4	$1,070,000	$1,070,000	
One box culvert (2-lane): US 84 MP 250.5	$1,430,000	$1,430,000	
Fence US 64 MP 174.5 to US 84 MP 249: ~6 miles	$100,000	$600,000	
Escape ramps 6 miles @ 4/mile = 6 x 4 = 24	$14,000	$336,000	
Double cattle guards approximate 15 sets	$60,000	$900,000	
Total for segment			$16,466,000
Total for Entire Corridor			$50,554,000

6.5.6.6.2 Animal-Vehicle Crash Costs

From 2009 to 2018, there were 270 crashes in this hotspot that included all animals. All categories of crash severity were represented: 257 crashes that resulted only in property damage, 7 Class C injury crashes, 4 Class B injury crashes, 1 Class A injury crash, and 1 fatal crash.

The NMDOT 2019 and FHWA 2018 (Harmon et al., 2018) crash cost values for these crashes are presented in Table 6-5. Based on these values, the costs associated with all the animal crashes in this hotspot were calculated (Table 6-30).

Table 6-30. Calculation of wildlife-vehicle crash costs in Chama wildlife corridor using NMDOT and FHWA crash values.

Crash Type	NMDOT-Estimated Individual Crash Costs to Society	Total NMDOT Value of Crashes	FHWA-Estimated Individual Crash Costs to Society Based on Harmon et al. (2018)	Total FHWA Value of Crashes
257 property damage only	$7,400	$1,901,800	$ 11,900	$3,058,300
7 possible injury (Type C)	$44,900	$314,300	$125,600	$879,200
4 minor injury (Type B)	$79,000	$316,000	$198,500	$794,000
1 incapacitating/serious injury (Type A)	$216,000	$216,000	$655,000	$655,000
1 fatality	$4,008,900	$4,008,900	$11,295,400	$11,295,400
Total		$6,757,000		$16,681,900

The benefits portion of the ratio is estimated by examining the expected reduction in crash costs. These benefits are estimated by taking the crash costs and multiplying by 90 percent reduction of crashes the mitigation can be expected to provide, expected mitigation lifespan of 75 years, and economic value of mule deer and elk saved by the mitigation over 75 years (Table 6-31).

Table 6-31. Estimating the benefit of mitigation in the Chama wildlife corridor.

	NMDOT Crash Values	FHWA Crash Values
Total value of crash costs over 10 years	$6,757,000	$16,681,900
Crash cost per mile per year	$17,782	$43,900
Crash cost for 38 miles of project over 75 years of infrastructure (Cost/mile/year x 38 x 75)	$50,678,700	$125,115,000
If mitigation reduced crashes by 90%, over 75 years, that value would be:	$45,610,830	$112,603,500
Wildlife Lost and Saved Values		Estimated Value of Elk and Mule Deer Saved over 75 years of Mitigation
If 28% of animal crashes were with elk (75 of 270 animal crashes), and 57% were with deer (154 of 270 animal crashes), and there have been 27 crashes with animals per year, and the number prevented would be 90% of 27 there would be 24 animal crashes prevented per year. This would roughly equate to 6.7 elk and 13.7 mule deer saved each year. At a value of $2,392 for each elk and $2,061 for each mule deer, the value of animals saved each year x 75 years of mitigation= Elk ($2,392 x 6.7 x 75 years) + Mule deer ($2,061 x 13.7 x 75 years) = Elk - $1,201,980 + Deer - $2,117,678 = 3,319,658.		$3,319,658

6.5.6.6.3 Benefit-Cost Ratio

- NMDOT values for crashes:
  Benefit/Cost Equation = $45,610,830+ $3,319,658/$50,554,000 = 0.97
- FHWA Values for Crashes
  Benefit/Cost Equation = $112,603,500+ $3,319,658/$50,554,000 = 2.29

When NMDOT crash values were used in the benefit-cost equation, the proposed mitigation was just short of the ratio of 1, meaning that it would not be expected to quite pay for itself in 75 years. When the FHWA crash values were used in the benefit-cost ratio, the proposed $50.5 million recommended project would more than pay for itself over 75 years. The discrepancy is linked to the fact that the FHWA estimates the costs of the more severe and deadly crashes higher than NMDOT. If the full list of mitigation measures equaled approximately $48.93 million, the project would be expected to possibly pay for itself over the same time period based on NMDOT crash costs.

6.5.7 US 285 Rio Grande Del Norte National Monument Wildlife Corridor Recommendations for Wildlife Mitigation Projects

- *US 285 MP 383–408*
- *25-mile corridor, 14.8 miles of mitigation*
- *Taos and Rio Arriba Counties*
- *NMDOT District 5*

6.5.7.1 Project Area Overview

This corridor (the Del Norte wildlife corridor) is approximately 25 miles long, and straddles the boundary of Taos and Rio Arriba Counties between the Colorado border and Tres Piedras, New Mexico. This north-south stretch of US 285 bisects a major winter range and migration corridor for mule deer, elk, and pronghorn within the Taos Plateau (Figure 6-35).

Figure 6-35. Pronghorn, elk, and mule deer live in and move through the Del Norte wildlife corridor and would benefit from wildlife mitigation (photo credit: NMDGF).

The Taos Plateau provides winter range for a unique, high-elevation pronghorn population, with some individuals that summer at elevations over 10,000 feet (NMDGF 2020). The project area traverses the Colorado Plateau ecoregion with large sections of the Southern Rocky Mountains ecoregion on the eastern and western edges. Habitat in the area consists of sagebrush steppe dominated by four-wing saltbush (*Atriplex canescens*), grama grasses (*Bouteloua* spp.), rubber rabbitbrush (*Ericameria nauseosa*), and big sagebrush (*Artemisia tridentata*).

Multiple miles of right-of-way laydown fence replaced standard NMDOT right-of-way fence along portions of BLM - Rio Grande del Norte National Monument lands east and west of US 285, near San Antonio Mountain (Figure 6-36). During anticipated migration periods, laydown fence is dropped by NMDOT maintenance personnel. This allows animals to pass across the road more easily without having to jump over or crawl under the right-of-way fence. In addition to the large swath of Rio Grande Del Norte National Monument, private land, SLO land, and USFS (Carson National Forest) land also abut US 285 within the project area. Some commercial and residential development is present near Tres Piedras at the southern end of the project area, but most of the corridor lies in a rural setting.

Figure 6-36. Rio Grande Del Norte National Monument and US 285 looking north (top) and Del Norte laydown fence in upright position (bottom) (photo credit: P. Cramer).

The corridor is also within the S.O. 3362 Action Plan for New Mexico's high priority Northcentral Landscape. This corridor is also supported by Presidential Proclamation 8946 declaring the establishment of the Rio Grande del Norte National Monument, which recognized the importance of the area on both sides of US 285 to big game migration and habitat connectivity (Figure 6-37).

Figure 6-37. Elk move across the Taos Plateau. The top recommended overpass location lies just behind the wooded ridge (photo credit: M. Watson).

US 285 has relatively low traffic volumes (less than 2,000 vehicles per day) along this segment, but the highway nonetheless fragments the migration corridor, as evidenced by the wildlife-vehicle crash data. Two short WVC hotspots occur within the Del Norte wildlife corridor: the 43rd ranked WVC hotspot at MP 386.5 to MP 389.5 and the 57th ranked WVC hotspot at MP 393.5 to MP 394.5. The traffic volume of less than 1,600 vehicles per day currently allows for movement of wildlife across the road (Charry and Jones, 2009; Gagnon et al., 2013) without an exceptionally high incidence of WVCs. However, wildlife-vehicle crashes, changing landscapes due to climate change, and the importance of this area for three focal ungulate species make this an important project for the Action Plan. Figure 6-38 presents wildlife-vehicle crashes in this corridor.

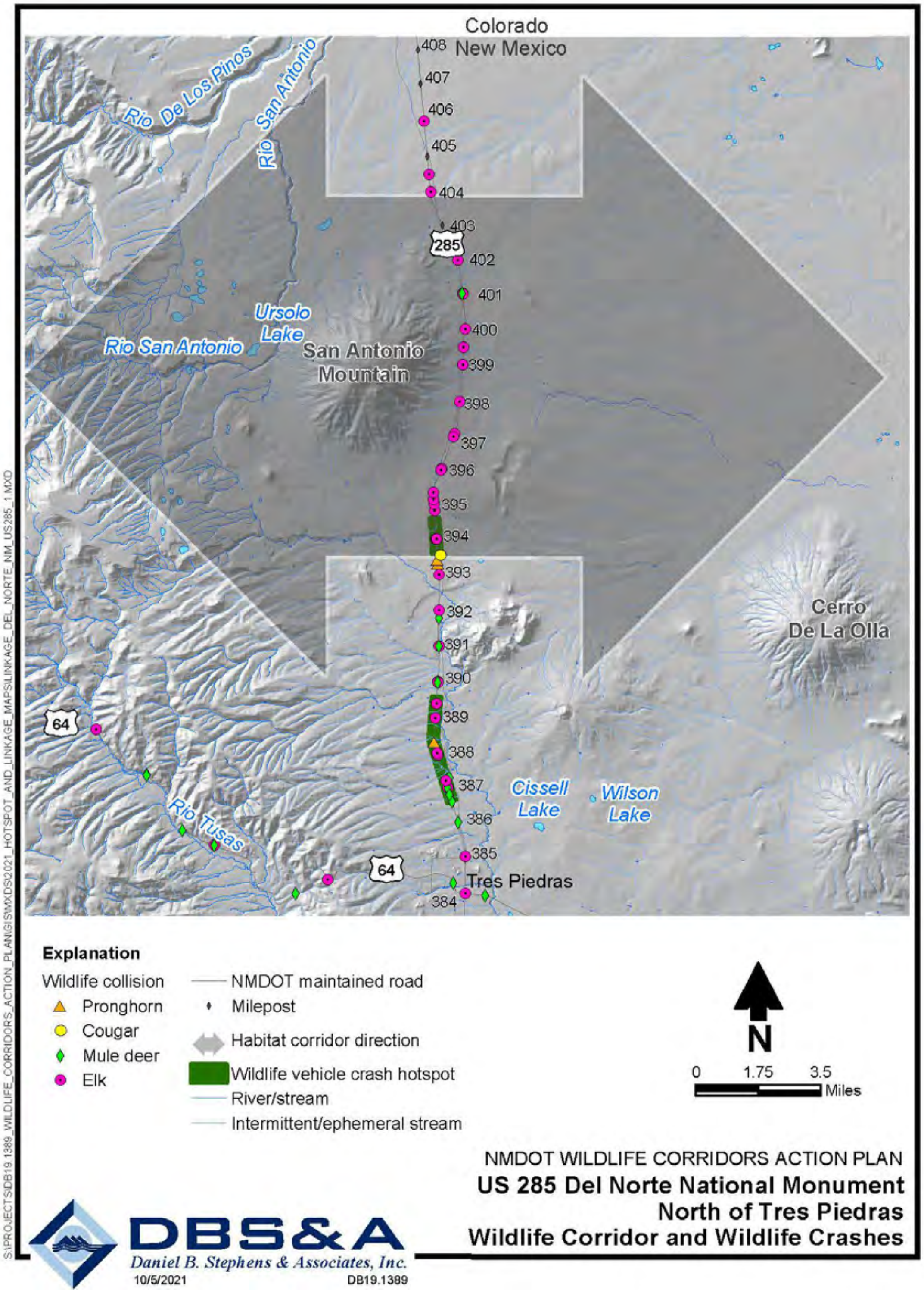

Figure 6-38. Wildlife-vehicle crashes and wildlife movement in the Del Norte wildlife corridor.

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6.5.7.2 Transportation – Safety Statistics

The crash data reported in the following subsections include both animal-vehicle crashes and wildlife-vehicle crashes to better reflect the impact of collisions with all animals. Animal-vehicle crashes include wild and domestic animals and livestock. Using all animal statistics to evaluate the situation helps the reader to differentiate where there are strictly wildlife problem areas, and where these domesticated animals may also be involved. The recommended wildlife mitigation that includes wildlife exclusion fences would be expected to reduce all these crashes, not just those with wildlife. Therefore, the total animal crashes are reported and then used in the benefit-cost analyses of the value of the recommended infrastructure. The reported wildlife crashes are those strictly with the six focal species: mule deer, elk, pronghorn, bighorn, black bear, and cougar.

6.5.7.2.1 Wildlife-Vehicle Crashes per Mile per Year

NMDOT 2009-2018 data documented 80 reported crashes with all animals and 72 reported crashes with the focal species in this hotspot (Table 6-32).

Table 6-32. Del Norte wildlife corridor, NMDOT crashes with all animals and with the six focal species, 2009-2018.

Length (miles)	Total Crashes with All Animals	Total Crashes with Focal Species	Wildlife Crashes per mile per year	Crashes with Six Focal Species					
				Deer	Elk	Black Bear	Cougar	Pronghorn	Bighorn Sheep
25	80	72	0.29	13	55	0	1	3	0

6.5.7.2.2 Seasonality of Wildlife-Vehicle Crashes

It appears that wildlife crashes occur more frequently during the winter and spring seasons (Figure 6-39). This seasonal distribution of WVCs coincides with the expected timing of ungulate movement between summer and winter ranges.

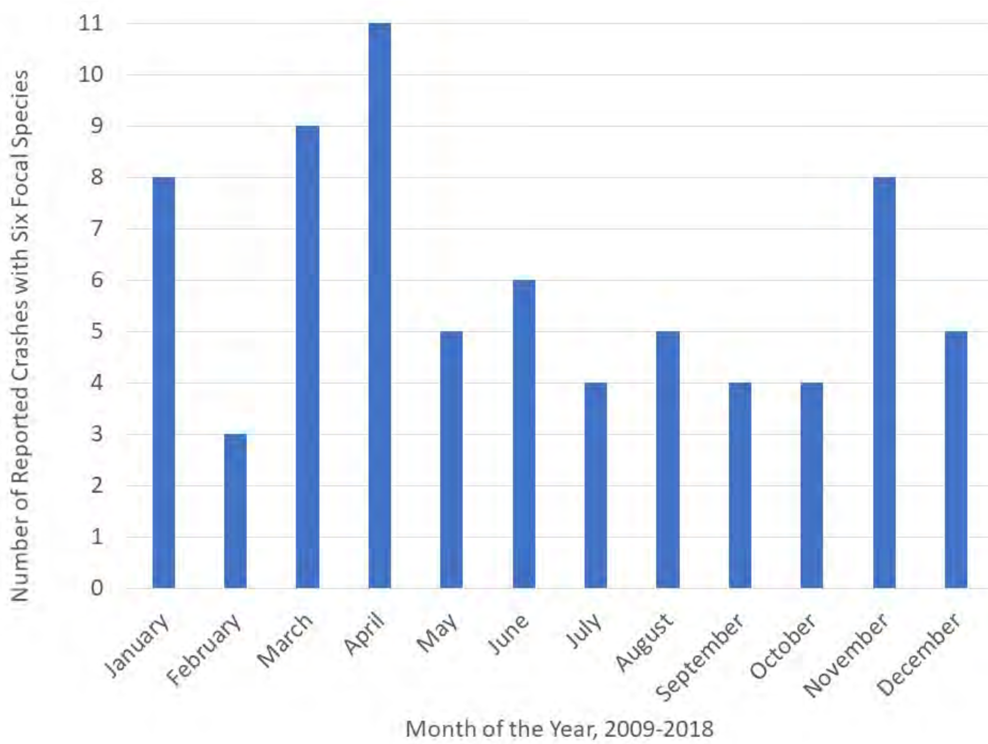

Figure 6-39. Wildlife-vehicle crashes by month in the Del Norte wildlife corridor.

6.5.7.2.3 WVC Species Percentages

Of the WVCs in this wildlife corridor, 18 percent were with mule deer, 76 percent involved elk, 4 percent involved pronghorn, and 1 percent involved cougar.

6.5.7.2.4 Wildlife-Vehicle Crashes as Percentage of All Crashes

There were 138 total crashes in the corridor from 2009 to 2018. Of these, 80 crashes involved animals. There were 72 reported crashes with the focal species, representing 52 percent of all crashes.

6.5.7.2.5 Average Annual Daily Traffic (AADT)

AADT is important in estimating if large wild animals such as the six focal species have opportunities to cross the roads under scrutiny. Traffic volumes can form a complete barrier to wildlife movement all day and into the night once AADT reaches well above 20,000 vehicles per day. At 10,000 vehicles per day there is still a barrier, with some opportunity for nocturnal movements across roads. Wildlife can find limited opportunities to cross roads with AADT between 2,000 and 10,000 vehicles per day. However, at AADT of 2,000 and 10,000 per day, wildlife will try to cross roads, and will have greater mortality in some areas because of the lower perceived risk by wild animals but the continued presence of vehicles (Charry and Jones, 2009; Ng et al., 2004; Seiler, 2005).

AADT in the corridor is 1,585 vehicles per day (2018) and 2,039 vehicles per day (estimated 2038).

6.5.7.2.6 Number of Lanes

The road has two lanes through this corridor.

6.5.7.2.7 STIP Possibility

- STIP Control Number 5101441, US 285 Tres Piedras, Road – Minor Rehabilitation. MP 384-392.56. District 5, 2021 start. Total Programmed = $25,946,892.

6.5.7.3 Ecological and Feasibility Considerations

6.5.7.3.1 Species of Concern

There are eight species of concern in this corridor: black bear, cougar, mule deer, elk, pronghorn, American badger, red fox, and white-tailed jackrabbit. Mule deer, elk, cougar, and pronghorn have all been recorded in relation to WVCs in the corridor.

6.5.7.3.2 Data

NMDGF elk and pronghorn GPS collar data from this area were provided to the Action Plan development team. When mapped, the data demonstrated animals of both species crossing US 285 to the north and south of San Antonio Mountain. NMDOT crash data and bear and cougar mortality data from NMDGF were also used to pinpoint problem areas. Habitat linkage modeling performed for the Action Plan also shows this as a priority linkage for pronghorn and elk.

6.5.7.3.3 Public Land

There is 0.8 mile of SLO land on both sides of the road, 0.5 mile of USFS land on both sides of the road, 0.8 mile of USFS land on one side of the road, 15.6 miles of BLM land on both sides of the road, and 0.5 mile of BLM land on one side of the road.

6.5.7.3.4 Support

The NMDGF has identified the Northcentral Landscape, including the Del Norte Corridor project area, as their top priority landscape for winter range and big-game movement for the S.O. 3362 New Mexico Action Plan. The BLM, along with several non-profit organizations, has been actively removing interior fencing within the Rio Grande Del Norte National Monument to enhance wildlife movement in the area, as well as working with NMDOT in constructing and laying down the right-of-way fence along US 285.

NMDGF Big Game Program Manager Nicole Tatman sent a letter stating that the area where the lay-down fence is on the Rio Grande Del Norte National Monument is being used by GPS-collared elk and pronghorn.

6.5.7.4 Recommendations Overview

The Del Norte wildlife corridor occurs along a relatively flat section of roadway with a limited number of existing structures that could be used or retrofitted for wildlife passage. Because the project area is 25 miles long and has limited mitigation opportunities, the team decided it would be best to create multiple smaller projects within the Del Norte area that could be prioritized and constructed in phases. Using preliminary GPS collar movement data for pronghorn and elk, habitat linkage modeling results, wildlife-vehicle crash data, and field reconnaissance results, three segments of US 285 were identified as most feasible for effective mitigation projects, to be carried out in separate phases. An animal detection driver warning system is recommended for a stretch between the mitigation in Phase I and Phase II. Gagnon et al. (2019) found that animal detection systems have the potential to reduce WVCs and allow wildlife to cross the road.

Wild animals need structures placed at intervals that match the scale of their daily movement (Bissonette and Adair, 2008), or within the distance that they are willing to move along a fence line to find crossing structures. Mule deer in southern Utah were documented to change their migration movements by moving 1 mile in either direction along a new wildlife exclusion fence (Cramer and Hamlin, 2019a). This should be considered the maximum distance the project would allow for mule deer to move toward a crossing structure when encountering a fence. Dodd et al. (2007a) found that 2 miles between crossing structures was acceptable for elk in Arizona. Herds of elk are very reluctant to use most underpass structures (Cramer, 2014; Cramer and Hamlin, 2017 and 2019; Gagnon et al., 2015; Kintsch et al., 2021) unless they are span bridges (Gagnon et al., 2015 and 2017) or overpasses (Kintsch et al., 2021) or an elk herd adapts over time to the underpass (Kintsch et al., 2021; Sawyer and LeBeau, 2011). Overpasses are necessary to accommodate pronghorn due to general herd avoidance of underpasses (Sawyer et al., 2016; Simpson et al., 2016). Gagnon et al. (2021) found that pronghorn road avoidance and lack of movement over roads began at AADT of approximately 3,000 vehicles per day. This corridor has traffic volumes only half as high, so that pronghorn movements have not been disrupted compared to higher-traffic roads. However, once a fence is placed along the road to guide wildlife to road-crossing structures, pronghorn herds need wildlife overpasses. One goal of the Action Plan is to allow herds of mule deer, elk, and pronghorn to move beneath or above the highway in their daily and migration movements. The recommendations here are prescribed specifically for the species of concern along various segments of US 285.

Phase I was given highest priority based on its position just south of San Antonio Mountain from MP 392.1 to MP 396.6, where NMDGF GPS collar data show the highest concentration of movement. This area also encompasses the 57th ranked WVC hotspot in the state. Recommendations for a comprehensive mitigation project include two overpasses and one bridge.

Phase II is considered a second top priority for the Del Norte wildlife corridor. This segment is located just north of San Antonio Mountain from MP 401 to MP 405. GPS collar data show this area to also be used by elk and pronghorn, but to a lesser extent than the south side of the mountain. Recommendations for a comprehensive mitigation project include two overpasses and two bridges.

There is an approximately 4.5-mile gap between Phases I and II, directly east of San Antonio Mountain. This stretch of roadway falls within the known ungulate movement corridor around San Antonio Mountain, but the lack of existing structures and relatively flat terrain provide little opportunity for wildlife crossing mitigation. The potential exists for end run events at the fence ends of the Phase I and Phase II projects. To address this flat, straight, 4.5-mile stretch of US 285, Phase II would also include the installation of multiple animal detection systems between the Phase I and II projects. Animal detection systems that can detect animals over large areas (e.g., Doppler radar) are still in the early stages of research and development, but preliminary results examining their effectiveness are encouraging (Gagnon et al., 2019).

Phase III is located from MP 386.4 to 389.8, between No Agua Peaks and Tres Piedras. This area encompasses the 43rd ranked WVC hotspot in the state. Recommendations for a comprehensive mitigation project include one bridge, one arch culvert, and the retrofitting of two concrete box culverts with wildlife exclusion fence in this entire stretch.

There are eight potential species of concern in the area that could all benefit from the proposed project recommendations. The overpasses should be readily used by pronghorn, elk, and mule deer. Black bear and cougar have been documented using underpass structures more readily than overpasses in Colorado (Kintsch et al., 2021), Arizona (Gagnon et al., 2011), and Utah (Cramer, 2012). These two carnivores may be best accommodated if the culverts are along arroyos, canyons, and drainages. American badger and red fox will also benefit. Both of these carnivores have been recorded using overpasses in Colorado (Kintsch et al., 2021) and underpasses in New Mexico (Loberger et al., 2021), Colorado (Kintsch et al., 2021; Cramer and Hamlin, 2021), and Utah (Cramer and Hamlin, 2019). The white-tailed jackrabbit is not known to have used wildlife crossing structures; however, the black-tailed jackrabbit has been shown to use wildlife crossing underpasses thousands of times on the Utah-Arizona border and the New Mexico-Colorado border (Cramer and Hamlin, 2019 and 2021), in Arizona (Gagnon et al., 2020a and 2020b), and in Colorado (Kintsch et al., 2021).

Figure 6-40 shows the priority mitigation actions along with land ownership information. The full complement of mitigation recommendations is provided in Table E-7 (Appendix E).

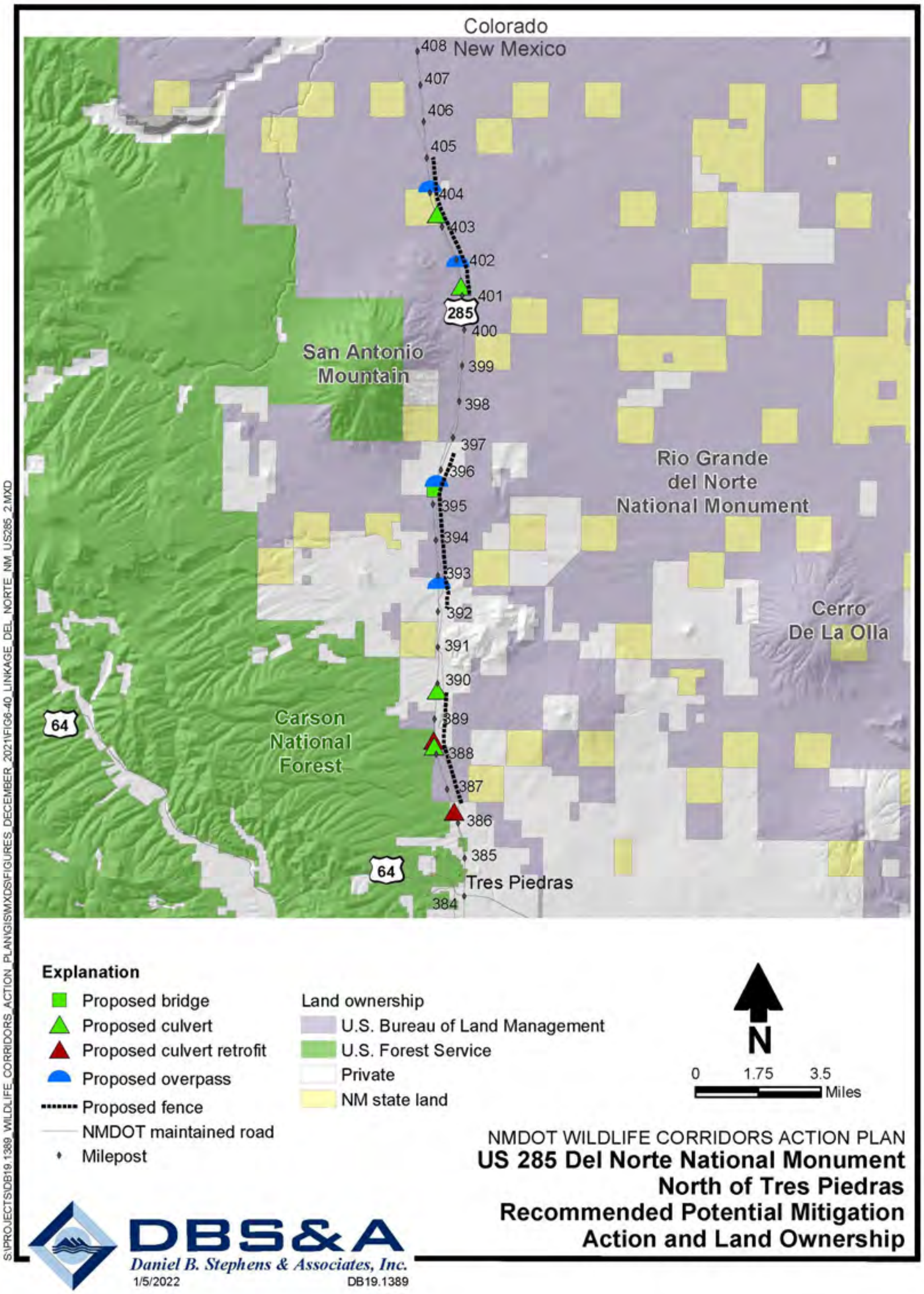

Figure 6-40. Land ownership and recommended project mitigation actions in the Del Norte wildlife corridor.

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The priority recommendations are presented in Figure 6-41.

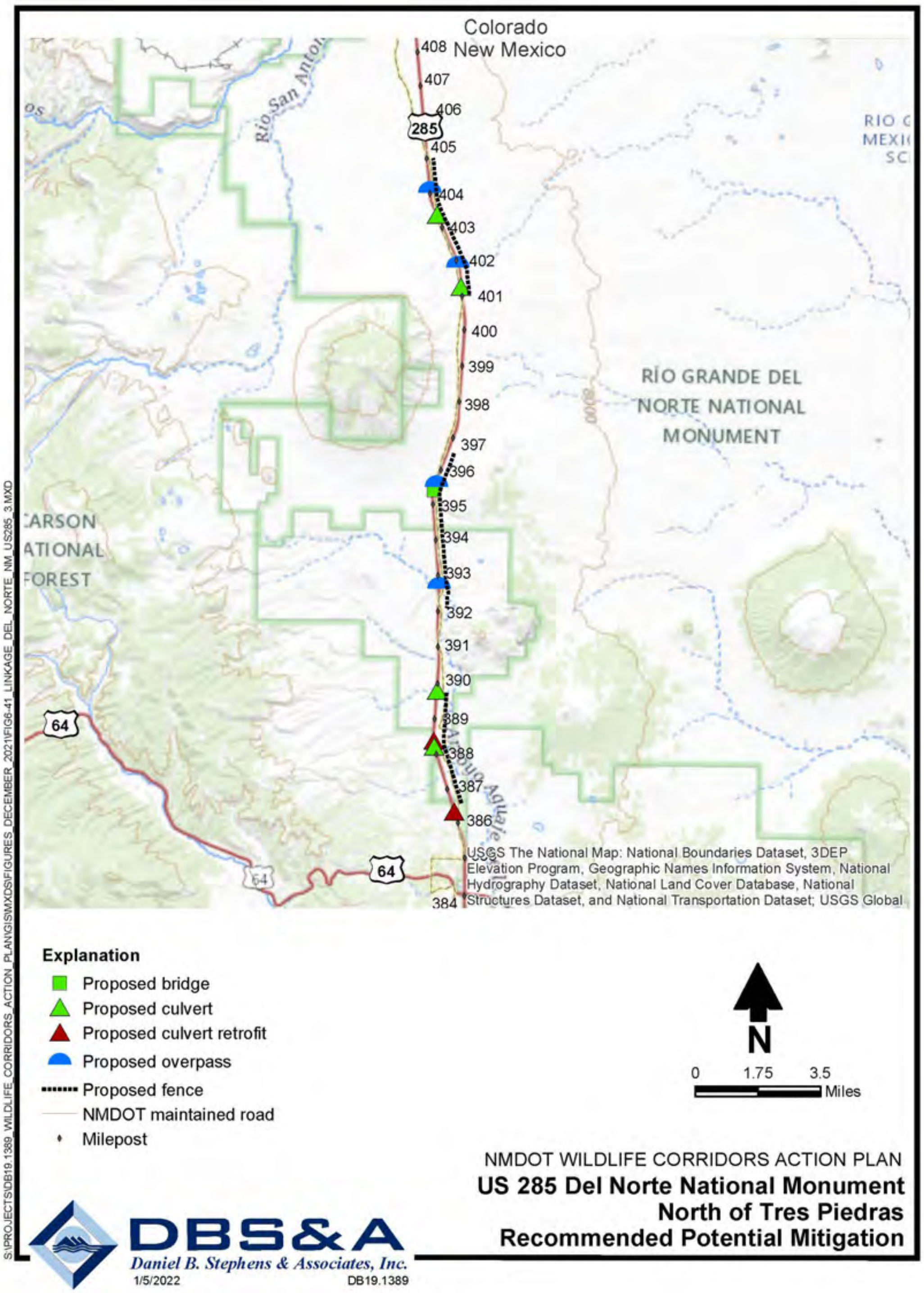

Figure 6-41. Top priority mitigation recommendations for the Del Norte wildlife corridor.

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6.5.7.5 Specific Wildlife-Highway Mitigation Recommendations

The recommendations give an overview estimate of what can be done for wildlife mitigation. Many of the existing culverts and bridges are presented in Table E-7 (Appendix E) to provide evidence of opportunities to replace them with more wildlife-friendly structures—for example, when the infrastructure is replaced or when there is a transportation project nearby. The Action Plan team is not presenting these recommendations as the final and only opportunities for enhancing wildlife movement below and above the roads. Rather, these are the top recommendations based on a one-day field reconnaissance of each project area, existing road conditions, 2021 costs, and the current state of the science and practice of transportation ecology.

6.5.7.5.1 Cost-Effective Short-Term Solutions

Short-term solutions that could be addressed for this wildlife corridor include removing fence blocking existing culverts and replacing them with wildlife-friendly right-of-way fence farther away from the culvert entrance.

Additionally, sections of laydown fence could be added along both sides of the road to fill in gaps between existing sections of laydown fence. With the current low AADT, this would be the most cost-effective solution until higher traffic volumes threaten to increase the number of WVCs. The priority should be on fence sections within and between MP 396 and MP 401. Cooperation with the BLM Rio Grande Del Norte National Monument and SLO would be required.

6.5.7.5.2 Retrofit Existing Infrastructure

As previously discussed, the Del Norte corridor project area would best be addressed using a three-phased approach, and any structure retrofits should focus on the priority phases. However, very few existing structures are suitable for large mammal passage; therefore, retrofitting individual structures is not recommended.

6.5.7.5.3 Intermediate Solutions - New Structures

Several of the existing culverts along US 285 in the Del Norte corridor project area appear dilapidated and in poor condition, or potentially too small for existing hydrologic conditions. An opportunity to address needs at these locations may arise when NMDOT implements a road-improvement project that includes replacing or repairing drainage structures in the general area, particularly within the three phases. Intradepartmental communications and cooperation could ensure that new structures are well-suited for wildlife passage while meeting hydrologic needs.

Structures in greatest need of replacement to provide effective wildlife passage are as follows:

- Phase II
  - *MP 401.2 – New Wildlife Underpass Bridge:* Elk presence was detected here; therefore, a bridge is a better structure to accommodate elk herds than any type of culvert. The road is about 10 feet above the landscape, so a bridge would be erected about 10 feet above the ground, with enough room for elk herds. The area is entirely managed by the BLM.
  - *MP 403.4 – New Wildlife Underpass Bridge:* The existing culvert has a fence blocking the entrances. This can immediately be removed to facilitate wildlife movement. When this culvert is replaced, a bridge is most suitable to facilitate the movement of elk herds. The area is completely managed by the BLM.
- Phase III
  - *MP 388.2 – New Wildlife Underpass Arch Culvert:* There is evidence of elk in the area, based on elk droppings, tracks, and a carcass found nearby. The existing culvert is in bad shape and will probably be replaced in the near future. The arch culvert is not the preferred structure for elk, but it should accommodate mule deer. GPS data demonstrate greater prevalence of elk farther north. The area has both private properties and public land under BLM management. Private landowners will need to be consulted.
  - *MP 389.7 – New Wildlife Underpass Bridge:* The existing four-cell box culvert is used by livestock at this location. There is fence blocking the entrance of the culvert cells that should immediately be removed. The bridge would better accommodate elk than an arch culvert, such as the one recommended at MP 388.2. This would need to be a bridge to give a location for elk herds to move safely beneath the road. Private landowners will need to be consulted.

6.5.7.5.4 Solutions Based on Best Management Practices

Elk and pronghorn GPS collar data indicate that movement is most common around San Antonio Mountain. To cover the 25-mile wildlife habitat corridor in an effective and efficient manner, mitigation projects were divided into three phases, in order of priority. Each phase can be constructed as a standalone project. Construction of Phase II is not recommended without the addition of an animal activated detection system between MP 396.6 and MP 401.0, to be completed in Phase I and Phase II. Two driver warning animal detection systems are

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recommended to fill this gap, but this is subject to change based on consultation with an experienced installer. An additional driver warning animal detection system can be placed at the terminal fence ends for any of the three projects lacking suitable crossing structures to tie the fence end into. Fence end locations, as well as all project recommendations, are subject to change upon further investigation, research, and planning. For now, the addition of the following crossing structures and driver warning animal detection system would maximize the mitigation project effectiveness for the Del Norte wildlife corridor:

- Phase I
  - *MP 392.8 New Wildlife Overpass:* Elk tracks and droppings were present during the field reconnaissance. There is a basalt substrate. This location is along private land. The landowners would need to be consulted to find out whether they would be willing to protect an overpass and wildlife movements in the long term through implementation of conservation easements.
  - *MP 395.4 New Wildlife Underpass Bridge:* An immediate action should be to remove the fence blocking the entrance to the existing five-cell concrete box culvert. An elk carcass was found. The construction of a span bridge may require raising the road. The area is completely managed by the BLM.
  - *MP 395.6 New Wildlife Overpass:* This should be the priority overpass location. It is just south of San Antonio Mountain. Telemetry data for elk and pronghorn identify animal crossings in the area. A natural ridge comes down to the road on the east side; the topography is flat to the west. Both sides of the road are managed by the BLM.
- Phase II
  - *MP 398.0–400.2 Animal Detection System (estimated location):* Milepost location estimated based on an initial assessment of the gap separating Phase I and II sections of US 285. A doppler radar-type animal detection system can cover a large distance. Its placement will need reevaluation by the installer. The area is completely managed by the BLM. Type and location of animal detection system to be determined.
  - *MP 401.9 – Overpass:* This is in an important wildlife migration area. It would need additional fill on the east side, possibly both sides. The area is completely managed by the BLM.

- *MP 404.2 – Overpass:* This is a good location for a pronghorn overpass. It will need substantial fill on both sides. The area is completely managed by the BLM.

6.5.7.6 Benefit-Cost Analysis

There are several types of benefit-cost analyses. However, they all share the same basic premise, which is to use a benefit-cost ratio with the benefit in the numerator and the cost in the denominator. The cost is associated with the construction and maintenance of the proposed mitigation infrastructure. The estimated monetary benefit is derived from the reduction in the number of crashes over the lifetime of the mitigation.

The unique approach here is based on the Colorado DOT's new method of including the economic value of elk and mule deer not killed in crashes as a result of the mitigation among the benefits (Kintsch et al., 2019).

6.5.7.6.1 Ballpark Estimates for Costs of Infrastructure

Table 6-33 presents the costs per unit for overpasses, span bridges, arch culverts made of pipe, and concrete box culverts as estimated by the Action Plan development team's engineers based on NMDOT 2019 cost estimates and a private animal activated detection system contractor based on recent cost estimates. The structure cost estimates are identified as being applicable to two-lane highways. The price of 8-foot wildlife exclusion fencing per mile for both sides of the highway, double cattle guards, also known as game guards, and escape ramps are all taken from Colorado DOT estimates in the West Slope Study (Kintsch et al., 2019).

Table 6-33. Del Norte wildlife corridor project wildlife mitigation rough cost estimates.

Infrastructure	Cost per unit	Cost for Infrastructure	Total for Segment
Phase I (MP 392.1-396.6)			
One overpass (2-lane): MP 392.8	$4,460,000	$4,460,000	
One overpass (2-lane): MP 395.6	$4,460,000	$4,460,000	
One span bridge (2-lane): MP 395.4	$1,070,000	$1,070,000	
Fence: MP 392.1-396.6 = 4.5 miles	$100,000	$450,000	
Approximately 5 double cattle guards	$60,000	$300,000	
Escape ramps @ 4/mile = 18	$14,000	$252,000	
Total for Phase I			$10,992,000
Phase II (MP 398.0-405.0)			
One overpass (2-lane): MP 401.9	$4,460,000	$4,460,000	
One overpass (2-lane): MP 404.2	$4,460,000	$4,460,000	
One bridge (2-lane): MP 401.2	$1,070,000	$1,070,000	
One bridge (2-lane): MP 403.4	$1,070,000	$1,070,000	
Two ADS: MP 398.0 and 400.2	$655,000	$1,310,000	
Approximately 6 double cattle guards	$60,000	$360,000	
Fence: MP 401.0-405.0 = 4 miles	$100,000	$400,000	
Escape ramps @ 4/mile = 16	$14,000	$224,000	
Total for Phase II			$13,354,000
Phase III (MP 386.4-389.7)			
One arch culvert (2-lane): MP 388.2	$1,840,000	$1,840,000	
One bridge (2-lane): MP 389.7	$1,070,000	$1,070,000	
Approximately 14 double cattle guards	$60,000	$840,000	
Fence: MP 386.4-389.7 = 3.3 miles	$100,000	$330,000	
Escape ramps @ 4/mile = 14	$ 14,000	$ 196,000	
Total for Phase III			$4,276,000
Total for entire corridor			$28,622,000

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6.5.7.6.2 Animal-Vehicle Crash Costs

From 2009 to 2018, there were 80 crashes along this corridor caused by collisions with animals. Crash severity varied. A total of 73 crashes resulted in just property damage, with also 4 Class C injury crashes, 2 Class B injury crashes, 0 Class A injury crashes, and 1 fatal crash.

The NMDOT 2019 and FHWA 2018 (Harmon et al., 2018) cost values for these crashes are presented in Table 6-5. Based on these values, the costs of the animal-vehicle crashes in this wildlife corridor were calculated (Table 6-34).

Table 6-34. Calculation of wildlife-vehicle crash costs in Del Norte wildlife corridor using NMDOT and FHWA crash values.

Crash Type	NMDOT-Estimated Individual Crash Costs to Society	Total NMDOT Value of Crashes	FHWA-Estimated Individual Crash Costs to Society Based on Harmon et al. (2018)	Total FHWA Value of Crashes
73 property damage only	$7,400	$540,200	$11,900	$868,700
4 possible injury (Type C)	$44,900	$179,600	$125,600	$502,400
2 minor injury (Type B)	$79,000	$158,000	$198,500	$397,000
0 incapacitating/serious injury (Type A)	$216,000	$0	$655,000	$0
1 fatality	$4,008,900	$4,008,900	$11,295,400	$11,295,400
Total		$4,886,700		$13,063,500

The mitigation recommendations cover 14.8 of the total 25 miles of this corridor. The mitigation, fence, and animal detection-driver warning systems were recommended to be placed strategically where the greater concentrations of WVCs occurred and where GPS locations of collared animals indicate the heaviest movements. The full three-phase system would be expected to reduce wildlife crashes less than 90 percent because the fence and animal detection-driver warning system cover 14.8 miles of the 25 miles (59 percent). The researchers estimate that the full three-phased system will decrease wildlife crashes by approximately 75 percent, based on the strategic locations of the system components.

The benefits portion of the ratio is estimated by examining the expected reduction in crash costs. These benefits are estimated by taking the crash costs and multiplying by the 75 percent reduction of crashes the mitigation can be expected to provide, expected 75-year lifespan of the mitigation structures, and economic values of mule deer and elk saved by the mitigation over 75 years (Table 6-35).

Table 6-35. Estimating the benefit of proposed mitigation in the Del Norte wildlife corridor.

	NMDOT Crash Values	FHWA Crash Values
Total value of crash costs over 10 years	$4,886,700	$13,063,500
Crash cost per mile per year	$19,547	$52,254
Crash cost for 25 miles of project over 75 years of infrastructure (Cost/mile/year x 25 x 75)	$36,650,625	$97,976,250
If mitigation reduced crashes by 75%, over 75 years, that value would be:	$27,487,969	$73,482,188
Wildlife Lost and Saved Values		Estimated Value of Elk and Mule Deer Saved over 75 years of Mitigation
If 69% of animal crashes were with elk (55 of 80 animal crashes), and 16% were with deer (13 of 80 animal crashes), and there have been 8.0 crashes with animals per year, and the number prevented would be 75% of 8.0 there would be 6 animal crashes prevented per year. This would roughly equate to 4.1 elk and 1 mule deer saved each year. At a value of $2,392 for each elk and $2,061 for each mule deer, the value of animals saved each year x 75 years of mitigation= Elk ($2,392 x 6 x 75 years) + Mule deer ($2,061 x 1 x 75 years) = Elk - $735,540 + Deer - $154,575 = $890,115.		$890,115

6.5.7.6.3 Benefit-Cost Ratio

- NMDOT values for crashes:
  Benefit/Cost Equation = $27,487,969+ $890,115/$28,622,000 = 0.99
- FHWA Values for Crashes
  Benefit/Cost Equation = $73,482,188 + $890,115/$28,622,000 = 2.60

Using either the NMDOT or FHWA crash values, the mitigation would be expected to pay for itself over 75 years, with a benefit-cost ratio between 0.99 and 2.60. Though some cost savings could be incurred through reducing the amount of fencing and game guards needed, the full project including all sections of roadway and all recommended structures is expected to cost less than the economic benefits gained from the mitigation.

6.5.8 I-25 South Raton to Maxwell–Pronghorn Triangle Wildlife Corridor Recommendations for Wildlife Mitigation Projects

- *I-25 Mile Post 427–449, NM 505 MP 0–12, NM 445 MP 0–12, US 64 MP 321–344*
- *69-mile corridor, 19 miles of mitigation*
- *Colfax County*
- *NMDOT District 4*

6.5.8.1 Project Area Overview

The Pronghorn Triangle wildlife corridor is bordered by four roads that total approximately 69 miles in length. This wildlife corridor primarily focuses on pronghorn (Figure 6-40), but mule deer, elk, and black bear have also been involved in WVCs in this area.

Figure 6-42. Pronghorn are the focus of the Pronghorn Triangle wildlife corridor, but all wildlife should similarly benefit with enhanced movement across the landscape (photo credit: NMDGF).

The Sangre de Cristo Mountains and the Carson National Forest lie to the northwest of this "triangle" formed by I-25, US 64, NM 505, and NM 445, and the project area is primarily short grass prairie within the High Plains and Tablelands ecoregion (Figure 6-43).

Figure 6-43. Pronghorn move across the Pronghorn Triangle wildlife corridor (photo credit: M.Watson).

The Burlington Northern Santa Fe (BNSF) rail line runs parallel to I-25 to the east and then west (moving south to north), and along the Canadian River to the east. The Maxwell National Wildlife Refuge (NWR) is the main public land along this corridor, with some U.S. Bureau of Reclamation (USBR) land near Stubblefield Reservoir; therefore, private landowners will have to play an important role in any mitigation actions for wildlife. The corridor also includes the 26th and 35th ranked WVC hotspots and a portion of the 12th ranked WVC hotspot.

NMDGF identified this area as one of primary importance for pronghorn conservation within their S.O. 3362 Action Plan (NMDGF, 2020). This core habitat area represents year-round pronghorn habitat, with mule deer, elk, and black bear occupying habitats here both year-round and seasonally, using short grass prairie for moving into and out of the Sangre de Cristo Mountains.

Similar to findings in other western states, I-25 and its associated traffic volume and right-of-way fences represent the greatest movement barriers to pronghorn in this corridor (Dodd et al., 2011; Seidler et al., 2015; NMDGF, 2020). Aside from the need to provide connectivity across the pronghorn's range, long-term habitat fragmentation by fenced roads can lead to genetic consequences that can further reduce pronghorn population viability (Theimer et al., 2012). The S.O. 3362 Action Plan (NMDGF, 2020) states that "[l]inkage of animal movements east and west of the interstate would be improved with the construction of several wildlife crossing structures

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across/under I-25 between Las Vegas, NM and the Colorado border, along with fencing to make these structures effective."

Previous mitigation actions have addressed WVCs within the town of Raton. The previous project, completed in 2017, spanned approximately 4.5 miles of wildlife exclusion fence along I-25 from MP 450.5 to MP 455. Another mitigation project is currently under construction north of Raton to the Colorado border. However, on the southern end of the Raton project area, mule deer routinely move around the end of the fence, entering the right-of-way and causing collisions. Extending the fence further south is a high priority.

Mule deer and elk are involved in crashes in almost equal numbers in this corridor. More crashes have been reported with pronghorn in this area (22) than in any other WVC hotspot or wildlife corridor identified in the Action Plan. These crashes are plotted on the map of the corridor in Figure 6-44.

This wildlife corridor contains the 26th ranked WVC hotspot located on I-25 from MP 429 to MP 431, the 35th ranked WVC hotspot located on I-25 from MP 434 to MP 441, and a portion of the 12th ranked WVC hotspot located at the intersection of US 64 and I-25 (US 64 from MP 341 to MP 344 and I-25 from MP 445 through Raton).

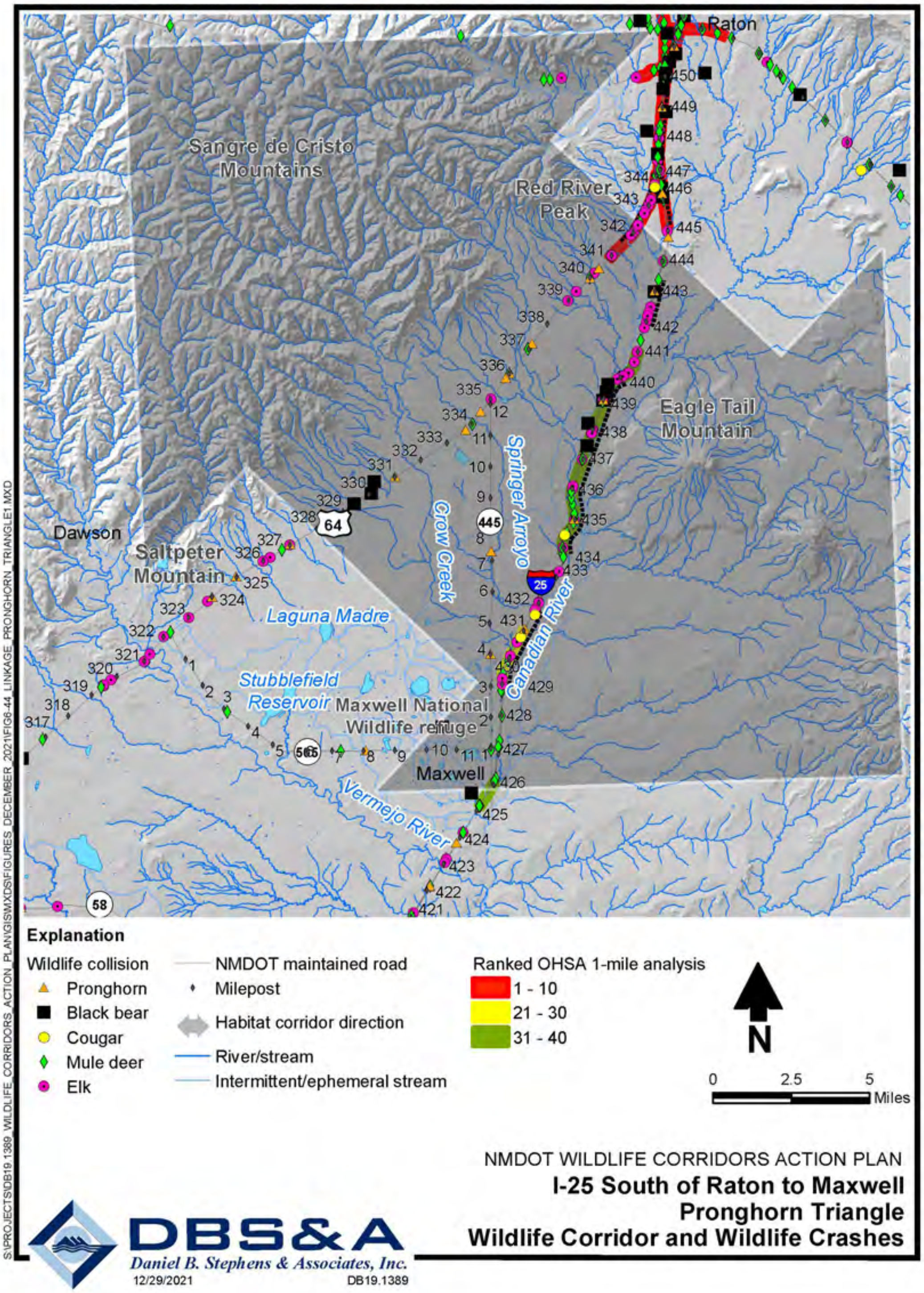

Figure 6-44. Wildlife-vehicle crashes and wildlife movement in the Pronghorn Triangle wildlife corridor.

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The Maxwell NWR is on the north side of NM 505, just west of I-25 in the southern portion of this wildlife corridor. There are, however, several large private ranches in the area that are crucial for protecting wildlife here (Figure 6-45).

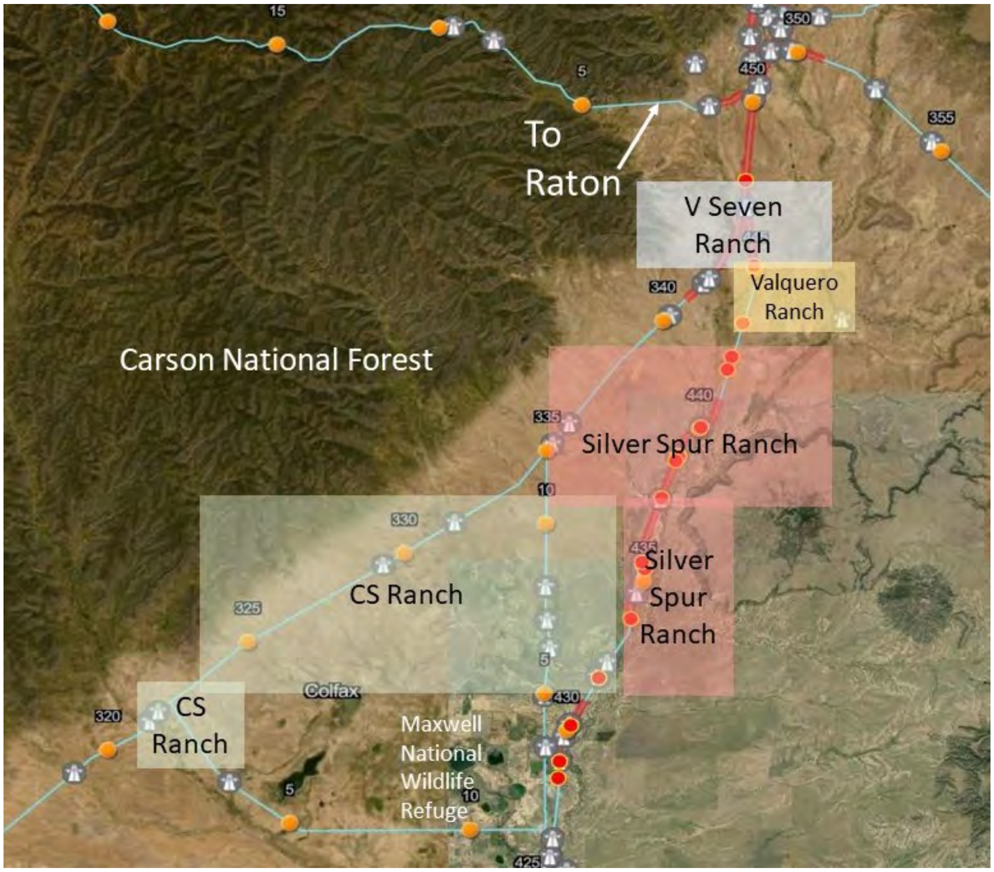

Figure 6-45. Approximate locations of large private ranches and public land in the Pronghorn Triangle wildlife corridor in northern New Mexico.

6.5.8.2 *Transportation – Safety Statistics*

The crash data reported in the following subsections include both animal-vehicle crashes and wildlife-vehicle crashes to better reflect the impact of collisions with all animals. Animal-vehicle crashes include wild and domestic animals and livestock. Using all animal statistics to evaluate the situation helps the reader to differentiate where there are strictly wildlife problem areas, and where these domesticated animals may also be involved. The recommended wildlife mitigation that includes wildlife exclusion fences would be expected to reduce all these crashes, not just those with wildlife. Therefore, the total animal crashes are reported and then used in the benefit-cost analyses of the value of the recommended infrastructure. The reported wildlife crashes are those strictly with the six focal species: mule deer, elk, pronghorn, bighorn, black bear, and cougar.

6.5.8.2.1 Wildlife-Vehicle Crashes per Mile per Year

According to NMDOT data (2009-2018), there were 231 reported crashes resulting from collisions with animals and 202 reported crashes with the focal species in this wildlife corridor between 2009 and 2018 (Table 6-36).

Table 6-36. Pronghorn Triangle wildlife corridor, NMDOT crashes involving all animals and just the six focal species, 2009-2018.

Length (miles)	Total Crashes with All Animals	Total Crashes with Focal Species	Wildlife Crashes per mile per year	Crashes with Six Focal Species					
				Deer	Elk	Black Bear	Cougar	Pronghorn	Bighorn Sheep
69	231	202	0.29	81	79	16	4	22	0

6.5.8.2.2 Seasonality of Wildlife-Vehicle Crashes

It appears that wildlife-vehicle crashes occur more frequently during late spring and early summer in this wildlife corridor (Figure 6-46). This trend may represent daily movements of ungulates looking for water during the summer months of dry years, but the exact cause is unconfirmed.

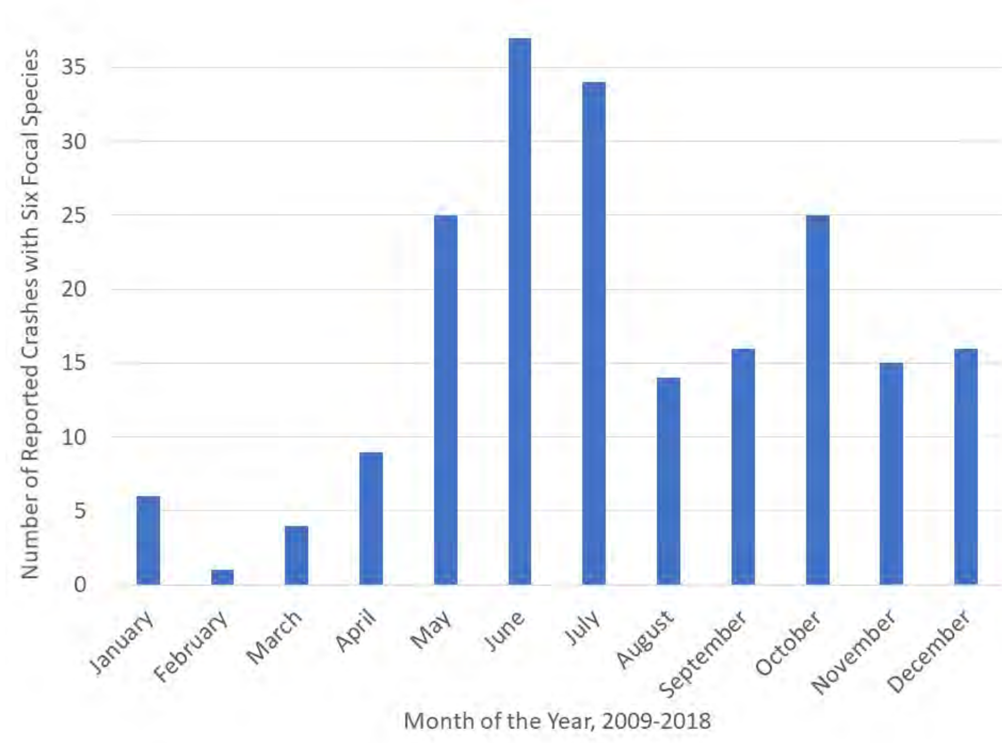

Figure 6-46. Wildlife-vehicle crashes by month in the Pronghorn Triangle wildlife corridor.

6.5.8.2.3 WVC Species Percentages

Of the WVCs in this wildlife corridor, 40 percent involved mule deer, 39 percent involved elk, 8 percent involved black bear, 11 percent involved pronghorn, and 2 percent involved cougar.

6.5.8.2.4 Wildlife-Vehicle Crashes as Percentage of All Crashes

There were 376 total crashes in the corridor from 2009 to 2018. Of these, 231 crashes were with animals. There were 202 reported crashes involving the focal species, representing 54 percent of all crashes.

6.5.8.2.5 Average Annual Daily Traffic (AADT)

AADT is important in estimating if large wild animals such as the six focal species have opportunities to cross the roads under scrutiny. Traffic volumes can form a complete barrier to wildlife movement all day and into the night once AADT reaches well above 20,000 vehicles per day. At 10,000 vehicles per day there is still a barrier, with some opportunity for nocturnal movements across roads. Wildlife can find limited opportunities to cross roads with AADT between 2,000 and 10,000 vehicles per day. However, at AADT of 2,000 and 10,000 per day, wildlife will try to cross roads, and will have greater mortality in some areas because of the lower perceived risk by wild animals but the continued presence of vehicles (Charry and Jones, 2009; Ng et al., 2004; Seiler, 2005).

AADT in the corridor is as follows:

- I-25, MP 427 to 435: Current = 6,428 (2018), Future = 9,552 (estimated 2038)
- I-25, MP 435 to 447: Current = 6,070 (2018), Future = 9,020 (estimated 2038)
- I-25, MP 447 to 450: Current = 4,541 (2018), Future = 6,748 (estimated 2038)
- NM 505, MP 0 to 12: Current = 44 (2018), Future = 57 (estimated 2038)
- NM 445, MP 0 to 12: Current = 101 (2018), Future = 131 (estimated 2038)
- US 64, MP 320 to 335: Current = 731 (2018), Future = 675 (estimated 2038)
- US 64, MP 335 to 344: Current = 670 (2018), Future = 618 (estimated 2038)

6.5.8.2.6 Number of Lanes

I-25 has four lanes (divided) throughout the corridor. The other roads in the corridor have two lanes.

6.5.8.2.7 STIP Possibility

- STIP Control Number 4101270, US 64 (Colfax), Major Road Rehabilitation. MP 322.5-330. District 4, 2023 start. Total Programmed = $10,600,000
- STIP Control Number 4101380, I-25 (Tinaja) - Informational, Minor Road Rehabilitation. MP 435-442. District 4, 2024 start. Total Programmed = $7,000,000
- STIP Control Number 4101360, US 64 (Hoxie Jct) - Informational, Major Road Rehabilitation. MP 335.5-344. District 4, 2024 start. Total Programmed = $7,000,000

6.5.8.3 Ecological and Feasibility Considerations

6.5.8.3.1 Species of Concern

There are nine species of concern that are known or could potentially be found in this corridor: black bear, mule deer, elk, cougar, pronghorn, American badger, red fox, swift fox, and ornate box turtle. Mule deer, elk, black bear, pronghorn, and cougar have been recorded in relation to WVCs in the corridor.

6.5.8.3.2 Data

NMDOT crash data and black bear and cougar mortality data from NMDGF were used to support the project recommendations.

6.5.8.3.3 Public Land

There is 1.5 miles of U.S. Fish and Wildlife Service (USFWS land (Maxwell NWR) and 0.8 mile of USBR, each on one side of NM 505.

6.5.8.3.4 Support

The NMDGF has identified the I-25 corridor from Las Vegas, New Mexico to the Colorado border, including the Pronghorn Triangle project area, as its 4th ranked priority landscape for winter range and big-game movement as part of the S.O. 3362 Action Plan (NMDGF, 2020).

NMDGF Raton District Corporal Matt Ordonez sent a letter to NMDGF detailing the high number of deer that enter I-25 south of the existing fence in southern Raton. He recounted deer caught in the fenced right-of-way. He suggested the Raton wildlife exclusion fence extend along I-25 southward to MP 446.

The NMDGF Action Plan representative, Mark Watson, wrote a letter to fellow NMDGF personnel that he has observed a herd of approximately 400 elk cross US 64 between Cimarron in the south and Raton in the north.

NMDGF's Nicole Tatman, Big Game Program Manager, wrote a letter stating how the I-25 highway severs pronghorn and probably also mule deer movement.

6.5.8.4 Recommendations Overview

The Pronghorn Triangle wildlife corridor occurs along four roadways with little topographic variation. Additionally, there are only a limited number of existing structures that could be used for wildlife passage. Because the project area is approximately 69 miles long and has limited mitigation opportunities, the team decided it would be best to create multiple smaller projects within the Pronghorn Triangle corridor that could be mitigated separately. Using wildlife-vehicle crash data and field reconnaissance results, up to six projects in the Pronghorn Triangle wildlife corridor were identified for potential mitigation efforts. These projects are not necessarily listed in order of priority, but are broken down to be more manageable for construction purposes.

The previous wildlife mitigation project in Raton has a south terminus at a vehicle overpass where Hereford Avenue crosses I-25, at MP 450.5. This area currently falls within the 12th ranked WVC hotspot in the state. NMDGF and NMDOT Raton patrol yard personnel have also identified mule deer entering the right-of-way around the southern terminus of the fence and getting struck by vehicles. Attempts to dissuade these end-run events by installing flagging on the fence failed. Therefore, it is recommended that future mitigation efforts extend from the southern fence terminus of the previous project to further reduce WVCs in the area. Based on funding availability, the project extension could terminate at the junction of US 64 and I-25 in the short-term, but extending the project farther south along I-25 and US 64 is recommended to create a more effective mitigation project. Therefore, mitigation at this location could be implemented as a single project or broken into two or three projects. The complete project would encompass I-25 from MP 445.1 to the southern terminus of the previous Raton project at MP 450.5 and US 64 from MP 341.5 northward to the intersection of I-25 at MP 344.1. Recommendations for a comprehensive mitigation project include structure retrofits and one arch culvert for deer and other species, along with one overpass to accommodate pronghorn due to their avoidance of underpasses (Sawyer et al., 2016).

Another project along I-25 that can be constructed independently from other projects would stretch from MP 441.9 northward to MP 443.3. Recommendations for a comprehensive mitigation project include structure retrofits and one overpass.

The 35th ranked WVC hotspot along I-25 extends from MP 433.7 in the south to MP 441 in the north. This WVC hotspot would be addressed by a project between MP 433.7 and MP 440. Recommendations for a comprehensive mitigation project include structure retrofits, one arch culvert, and two bridges.

The last proposed project for this wildlife corridor stretches along the southern portion of I-25 from MP 428.9 to MP 431.8, and encompasses the 26th ranked WVC hotspot. Recommendations for a comprehensive mitigation project include retrofitting a culvert and two large bridges over Curtis Creek and Crow Creek.

The lack of existing usable structures, potential areas for new structures, low traffic volumes, and lower WVCs along NM 505, NM 445, and US 64 led to the conclusion that large-scale mitigation projects along these roadways may not be justified at this time. However, with the high prevalence of pronghorn in the area, targeted modification of existing five-strand right-of-way fence to be more wildlife-friendly may reduce pronghorn WVCs by allowing the animals to cross the roadway more quickly and preventing them from becoming trapped within the right-of-way (Sprague et al., 2013) (Figure 6-47).

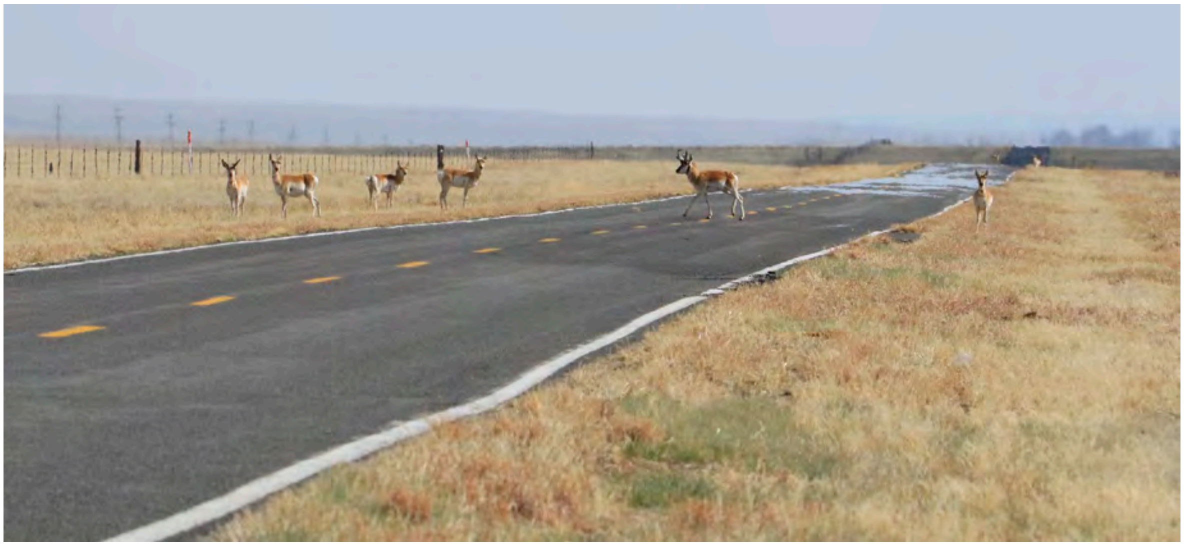

Figure 6-47. Pronghorn herd on the road in the Pronghorn Triangle wildlife corridor (photo credit: Mark Watson).

These modifications will provide pronghorn access across NM 505, NM 445, and US 64 until traffic volumes exceed impassable levels at AADT of approximately 3,000 vehicles per day, at which point overpasses will likely be required (Gagnon et al., 2021). These modifications can benefit all ungulates, but especially pronghorn given their inclination to crawl under or through fences rather than jump over them (Schmidly, 1994). Wildlife-friendly fences typically consist of four strands of wire with the bottom wire raised to a height of 16 inches above the ground and with top and bottom smooth wire. Exact locations of fence modifications are not known at this time, but may become more apparent with additional research and collaboration with private landowners.

There are nine potential species of concern in the area that could all benefit from the proposed project recommendations. The overpasses should be readily used by pronghorn, elk, and mule deer. Black bear and cougar have been documented using underpasses more readily than overpasses in Colorado (Kintsch et al., 2021), Arizona (Gagnon et al., 2011), and Utah (Cramer, 2012). The needs of these two carnivores may be best accommodated if the culverts are along drainages. American badger and red fox will also benefit. Both of these carnivores have been recorded using overpass structures in Colorado (Kintsch et al., 2021) and Utah (Cramer and Hamlin, 2019), and underpass structures in New Mexico (Loberger et al., 2021) and Colorado (Kintsch et al., 2021; Cramer and Hamlin, 2021), and would therefore be expected to use future wildlife crossing structures and retrofitted structures with wildlife exclusion fence. Kit fox have been documented using wildlife crossing structures including overpasses (Gagnon et al., 2017) and may be expected to use underpasses in manners similar to red fox. The ornate box turtle has not been documented using road-crossing structures, but as mentioned earlier would be expected to more readily use the overpasses and underpasses if they contained logs, tree stumps, large rocks and boulders, and native vegetation.

Figure 6-48 shows the priority mitigation actions along with land ownership information. The full complement of mitigation recommendations is provided in Table E-8 (Appendix E).

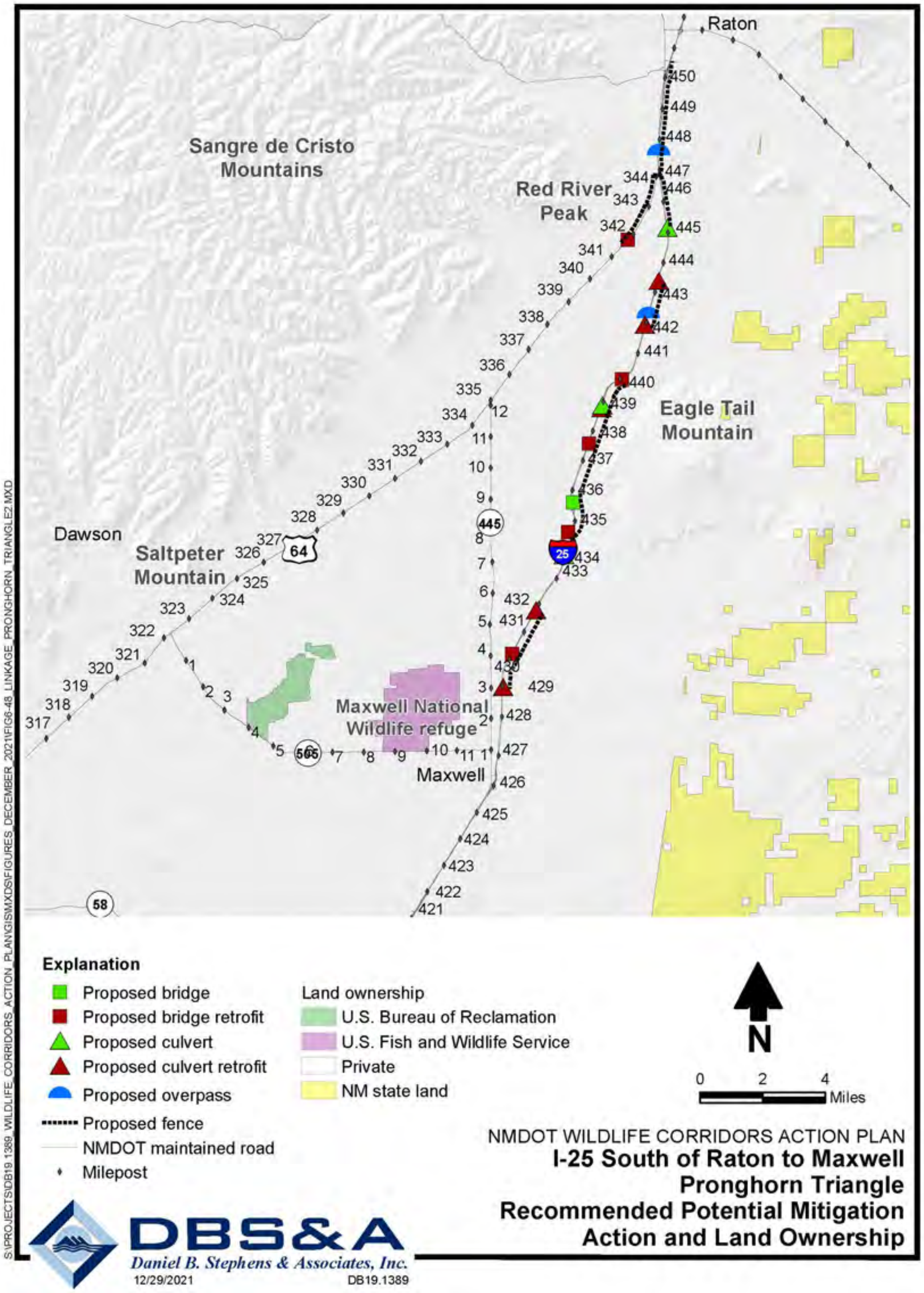

Figure 6-48. Land ownership and recommended project mitigation actions in the Pronghorn Triangle wildlife corridor.

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The priority recommendations are presented in Figure 6-49.

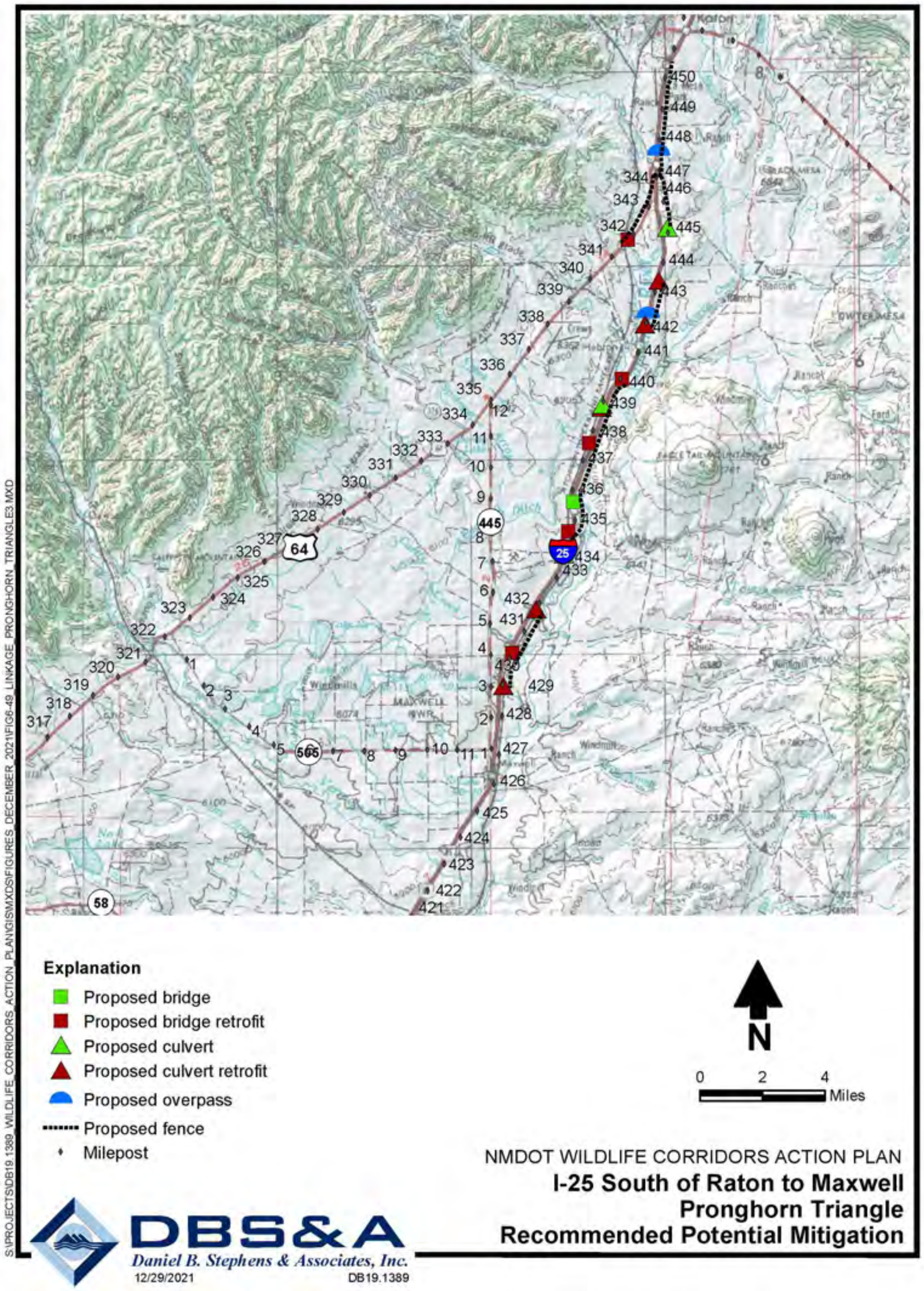

Figure 6-49. Top priority mitigation recommendations for the Pronghorn Triangle wildlife corridor.

6.5.8.5 Specific Wildlife-Highway Mitigation Recommendations

The recommendations give an overview estimate of what can be done for wildlife mitigation. Many of the existing culverts and bridges are presented in Table E-1 (Appendix E) to provide evidence of opportunities to replace them with more wildlife-friendly structures—for example, when the infrastructure is replaced or when there is a transportation project nearby. The Action Plan team is not presenting these recommendations as the final and only opportunities for enhancing wildlife movement below and above the roads. Rather, these are the top recommendations based on a one-day field reconnaissance of each project area, existing road conditions, 2021 costs, and the current state of the science and practice of transportation ecology.

6.5.8.5.1 Cost-Effective Short-Term Solutions

Easy short-term solutions that could be implemented for this wildlife corridor include removing fences blocking culverts and replacing them with wildlife-friendly fencing farther away from the culvert entrance at the right-of-way boundary. In addition, fence modifications converting standard right-of-way fence to wildlife-friendly fence along NM 445, NM 505, and US 64 could be constructed incrementally based on available funding and partnership opportunities with private landowners.

Another short-term solution would be to place variable message boards along I-25 warning drivers of the danger of wildlife on the road, starting in late April and into August. The northbound message board should be placed near MP 428, and the southbound message board should be placed near MP 450.5, where the existing Raton mitigation project ends. The boards should state the length of the I-25 segment associated with an elevated danger of wildlife on the road. This would be a temporary mitigation measure until a more permanent solution is implemented.

6.5.8.5.2 Retrofit Existing Infrastructure

Few possibilities exist to implement effective mitigation projects without constructing new structures. However, two smaller projects that would not require new structures include adding wildlife exclusion fence to US 64 from MP 341.5 to MP 344.1 and to I-25 from MP 428.9 to MP 431.8. The addition of fence would enhance the use of existing structures without additional construction required for many local species, although this is not likely to work for pronghorn. The structures below have been identified as potential retrofits for these locations:

- US 64
    - *MP 341.7 – 344.1 Add Wildlife Exclusion Fence:* This 2.6-mile fence would help keep wildlife off of US 64 and tie into fence on I-25.
- I-25
    - *MP 428.9 – 431.8 Add Wildlife Exclusion Fence:* There are two bridges and one culvert along this stretch of I-25. The bridges are 25 feet high and could accommodate ungulates, carnivores, and other wildlife. The culvert is 14 feet high and could also accommodate wildlife, possibly mule deer, black bear, and cougar. Consult with private landowners on measures to protect wildlife approaching these structures.

6.5.8.5.3 Intermediate Solutions - New Structures

One of the top recommended projects for the Pronghorn Triangle wildlife corridor would be the extension of the existing Raton project to the south. Part of the 12th ranked WVC hotspot encompasses the northern portion of the corridor from US 64 MP 341 to the I-25 interchange and from I-25 MP 445.1 through Raton. Mitigation in this area could build upon the previous Raton project and further reduce WVCs. Structures needed to provide effective wildlife passage in this area are as follow:

- *I-25, MP 445.1 New Wildlife Underpass Arch Culvert:* Any action would need to involve a partnership with private landowners in the area.
- *I-25, MP 447.6 New Wildlife Overpass:* Any action would need to involve working with private landowners in the area.

6.5.8.5.4 Solutions Based on Best Management Practices

To address the remainder of the wildlife corridor, as well as the 35th ranked WVC hotspot, large scale construction would be needed on I-25 from MP 433.7 to MP 440. Another I-25 overpass project between MP 441.9 and MP 443.3 could further enhance landscape-scale movement of ungulates through the area; overpasses are particularly critical for pronghorn movements across high traffic volume roads, as they will rarely use underpasses (Sawyer et al., 2016; Simpson et al., 2016). The addition of the following crossing structures would maximize mitigation project effectiveness for the Pronghorn Triangle wildlife corridor:

- I-25
    - MP 433.7 New Wildlife Underpass Arch Culvert

- MP 435.6 New Wildlife Underpass Bridge
- MP 438.8 New Wildlife Underpass Bridge
- MP 442.3 New Wildlife Overpass

6.5.8.6 *Benefit-Cost Analysis*

There are several types of benefit-cost analyses. However, they all share the same basic premise, which is to use a benefit-cost ratio with the benefit in the numerator and the cost in the denominator. The cost is associated with the construction and maintenance of the proposed mitigation infrastructure. The estimated monetary benefit is derived from the reduction in the number of crashes over the lifetime of the mitigation.

The unique approach here is based on the Colorado DOT's new method of including the economic value of elk and mule deer not killed in crashes as a result of the mitigation among the benefits (Kintsch et al., 2019).

6.5.8.6.1 *Ballpark Estimates for Costs of Infrastructure*

Table 6-37 presents the costs per unit for overpasses, span bridges, and arch culverts made of pipe as estimated by the Action Plan development team's engineers based on NMDOT 2019 cost estimates. The structure cost estimates are identified as being applicable to two-lane or four-lane highways. The price of 8-foot wildlife exclusion fence per mile for both sides of the highway, double cattle guards, also known as game guards, and escape ramps are all taken from Colorado DOT estimates in the West Slope Study (Kintsch et al., 2019). Costs for fence modifications were not estimated due to uncertainty regarding both quantity and location.

Table 6-37. Pronghorn Triangle wildlife corridor project wildlife mitigation rough cost estimates.

Infrastructure	Cost per unit	Cost for Infrastructure	Total for Segment
US 64 (MP 341.5-344.1)			
Fence: MP 341.5-344.1 = 2.6 miles	$100,000	$260,000	
Approximately 13 double cattle guards	$60,000	$780,000	
Escape ramps @ 4/mile = 11	$14,000	$154,000	
Total for US 64 (MP 341.5-344.1)			$1,194,000

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Table 6-37 (cont.)

Infrastructure	Cost per unit	Cost for Infrastructure	Total for Segment
I-25 (MP 428.9-431.8)			
Fence MP 428.9-431.8 = 2.9 miles	$100,000	$290,000	
Escape ramps @ 4/mile = 12	$14,000	$168,000	
Total for I-25 (MP 428.9-431.8)			$458,000
I-25 (MP 433.7-440)			
Pair of arch culverts (2-lane): MP 433.7, one for each direction of travel lane pair	$1,840,000	$3,680,000	
One span bridge (4-lanes): MP 435.6	$2,520,000	$2,520,000	
One span bridge (4-lane): MP 438.8	$2,520,000	$2,520,000	
Fence MP 433.7-440 = 6.3 miles	$100,000	$630,000	
Approximately 4 double cattle guards	$60,000	$240,000	
Escape ramps @ 4/mile = 26	$14,000	$364,000	
Total for I-25 (MP 433.7- 440)			$9,954,000
I-25 (MP 441.9-443.3)			
One overpass (4-lane with median): MP 442.3	$7,280,000	$7,280,000	
Fence MP 441.9-443.3 = 1.4 miles	$100,000	$140,000	
Approximately 2 double cattle guards	$60,000	$120,000	
Escape ramps @ 4/mile = 6	$14,000	$84,000	
Total for I-25 (MP 441.9-443.3)			$7,624,000
I-25 (MP 445.1-450.5)			
One overpass (4-lane): MP 447.6	$7,280,000	$7,280,000	
Pair of arch culverts (2-lane): MP 445.1, each for opposing lanes of I-25	$1,840,000	$3,680,000	
Fence MP 445.1-450.5 = 5.4 miles	$100,000	$540,000	
Approximately 7 double cattle guards	$60,000	$420,000	
Escape ramps @ 4/mile = 22	$14,000	$308,000	
Total for I-25 (MP 445.1-450.5)			$12,228,000
Total for entire corridor			$31,458,000

6.5.8.6.2 Animal-Vehicle Crash Costs

From 2009 to 2018, a total of 231 crashes involved collisions with animals along this wildlife corridor. A total of 201 property damage only crashes were recorded, 17 Class C injury crashes, 11 Class B injury crashes, 2 Class A injury crashes, and 0 fatal crashes.

The NMDOT 2019 and FHWA 2018 (Harmon et al., 2018) costs for these crashes are presented in Table 6-5. Based on these values, the costs associated with animal crashes in this wildlife corridor were calculated (Table 6-38).

Table 6-38. Calculation of wildlife-vehicle crash costs in the Pronghorn Triangle wildlife corridor using NMDOT and FHWA crash cost values.

Crash Type	NMDOT-Estimated Individual Crash Costs to Society	Total NMDOT Value of Crashes	FHWA-Estimated Individual Crash Costs to Society Based on Harmon et al. (2018)	Total FHWA Value of Crashes
201 property damage only	$7,400	$1,487,400	$ 11,900	$2,391,900
17 possible injury (Type C)	$44,900	$763,300	$125,600	$2,135,200
11 minor injury (Type B)	$79,000	$869,000	$198,500	$2,183,500
2 incapacitating/serious injury (Type A)	$216,000	$432,000	$655,000	$1,310,000
0 fatality	$4,008,900	0	$11,295,400	$0
Total		$3,551,700		$8,020,600

The full recommended mitigation along I-25 represents 16.1 miles of fence and structures. By comparison, the I-25 road segment in this corridor is 22 miles long. The recommended mitigation would cover 73 percent of the total length. The US 64 segment is 23 miles long. The recommended fence is 2.6 miles long, making it approximately 10 percent of the US 64 stretch in this corridor. All the recommended fences and structures are located where approximately 75 percent of the wildlife-vehicle crashes occur. The expected crash reduction is roughly estimated to be 90 percent of the crashes in the mitigation areas, which are located where approximately 75 percent of the past crashes occurred. On this basis, the expected crash reduction is roughly estimated to be 75 percent of 90 percent in the Pronghorn Triangle wildlife corridor, or 67.5 percent.

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The benefits portion of the ratio is estimated by examining the expected reduction in crash costs. These benefits are estimated by taking the crash costs, multiplying by the 67.5 percent reduction of crashes the mitigation can be expected to provide, expected 75-year lifespan of the proposed mitigation, and economic value of mule deer and elk saved by the mitigation over 75 years (Table 6-39).

Table 6-39. Estimating the benefit of mitigation in the Pronghorn Triangle wildlife corridor.

	NMDOT Crash Values	FHWA Crash Values
Total value of crash costs over 10 years	$3,551,700	$8,020,600
Crash cost per mile per year	$5,147	$11,624
Crash cost for 69 miles of project over 75 years of infrastructure (Cost/mile/year x 69 x 75)	$26,637,750	$60,154,500
If mitigation reduced crashes by 67.5%, over 75 years, that value would be:	$17,980,481	$40,604,288
Wildlife Lost and Saved Values		Estimated Value of Elk and Mule Deer Saved over 75 years of Mitigation
If 34% of animal crashes were with elk (79 elk/231 all animal crashes), and 35% were with deer (81 deer/231), and there have been 23.1 crashes with animals per year, and the number prevented would be 67.5% of 23.1, there would be 15.6 animal crashes prevented per year. This would roughly equate to 5.3 elk and 5.5 mule deer saved each year. At a value of $2,392 for each elk and $2,061 for each mule deer, the value of animals saved each year x 75 years of mitigation= Elk ($2,392 x 5.3 x 75 years) + Mule deer ($2,061 x 5.5 x 75 years) = Elk - $950,820 + Deer - $850,162 = $1,800,983		$1,800,983

6.5.8.6.3 Benefit-Cost Ratio

- NMDOT values for crashes:
  Benefit/Cost Equation = $17,980,481 + $1,800,983/$31,458,000 = 0.63
- FHWA Values for Crashes
  Benefit/Cost Equation = $40,604,288 + $1,800,983/$31,458,000 = 1.35

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If the NMDOT crash values are used, the mitigation would not be expected to pay for itself over 75 years, with a benefit-cost ratio of 0.63. A ratio of 1 would mean the mitigation would be expected to pay for itself. However, when the FHWA crash cost values are used, the benefit-cost ratio is 1.39 and the mitigation is expected to pay for itself over 75 years. If the full list of mitigation measures equaled approximately $29.78 million, the project would be expected to possibly pay for itself over the same time period based on NMDOT crash costs.

6.5.9 I-10 Peloncillo Mountains and Steins Wildlife Corridor Recommendations for Wildlife Mitigation Projects

- *5-mile corridor, 3.3 miles of mitigation*
- *NMDOT District 1*
- *Hidalgo County*

6.5.9.1 Project Area Overview

The Peloncillo Mountains are a north-south linkage for wildlife movement in the southwestern corner of New Mexico. They extend from the New Mexico-Mexico border in the south to southeastern Arizona north of I-10 in the north. They are an important mountain range for wildlife movement from Mexico into southwestern New Mexico and southeastern Arizona. Desert bighorn sheep (*Ovis canadensis mexicana*) (Figure 6-50) are especially vulnerable to habitat fragmentation caused by the highway running across this mountain range. This bootheel region is characterized by very high biodiversity (e.g., Bailey, 1931; Ligon, 1961; Cartron, 2010; Cartron and Frey, in press).

Figure 6-50. The Peloncillo Mountains wildlife corridor was identified to help reconnect mountain habitat for desert bighorn sheep and other wildlife (photo credit: AZGFD).

The range is bisected by I-10 near the town of Steins, just east of the Arizona-New Mexico border. The Burlington Northern Santa Fe (BNSF) rail line also bisects the corridor just north of I-10. The Peloncillo Mountains wildlife corridor is bisected by I-10 for 5 miles, from MP 0 at the Arizona border to MP 5.

Government agencies, non-profit organizations, and landowner groups are interested in facilitating a wildlife overpass and other mitigation for wildlife in this area. These entities include the SLO, which owns land on both sides of I-10 within the corridor, and the Malpais Borderlands Group, which is an organization of private ranch owners in southwestern New Mexico and southeastern Arizona. NMDGF recommended one or more overpasses for this corridor to reconnect disjunct desert bighorn sheep populations on both sides of I-10. The interstate and rail line are major barriers to New Mexico and Arizona desert bighorn sheep populations and other terrestrial species. The land ownership along I-10 is predominantly BLM. There is a section of SLO land on the west side of the corridor between MP 2 and MP 3 that occurs on both sides of I-10. The locations of the few wildlife-vehicle crashes recorded in this corridor are shown in Figure 6-51.

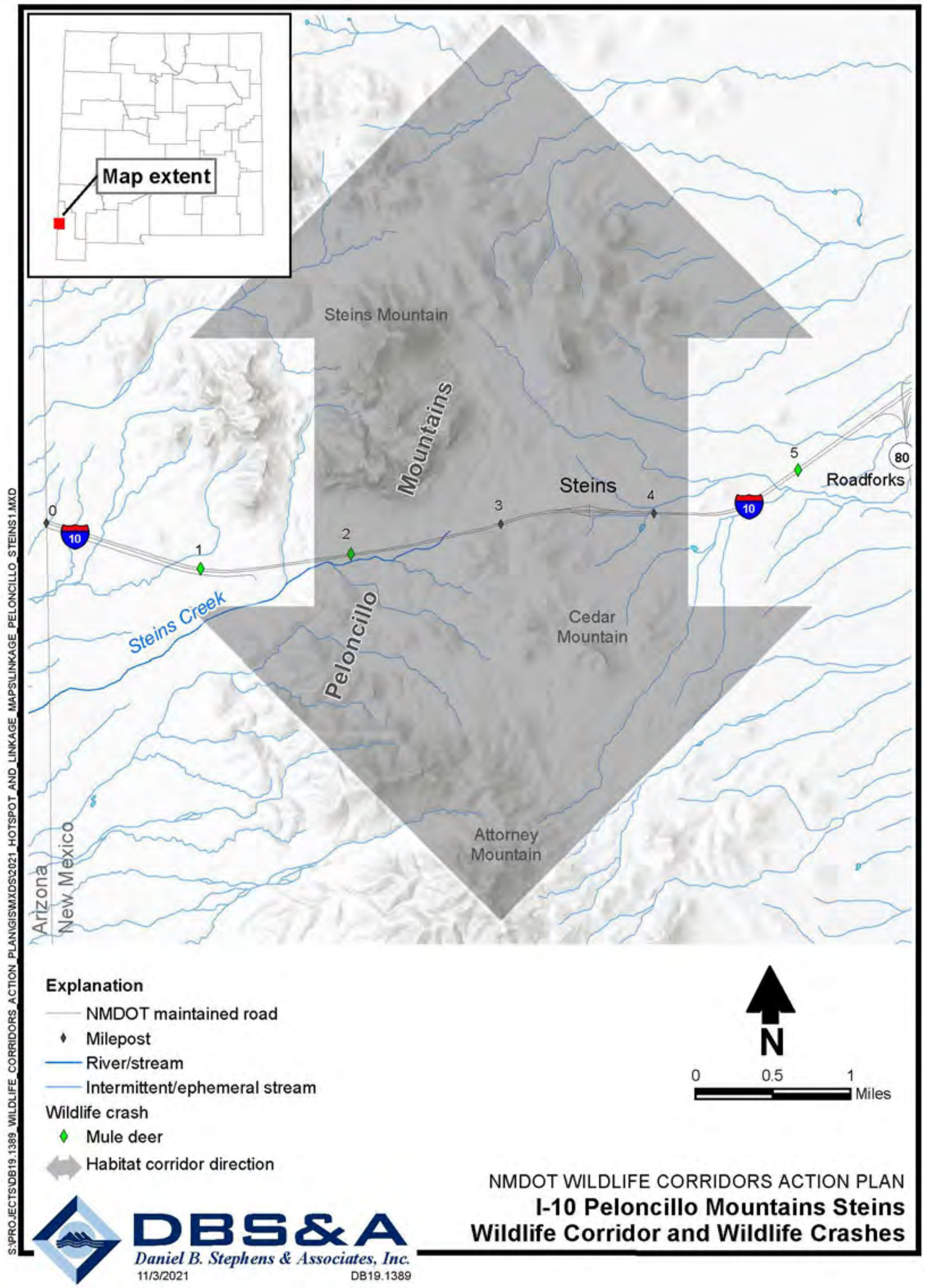

Figure 6-51. Wildlife-vehicle crashes and wildlife movement in the Peloncillo Mountains wildlife corridor.

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6.5.9.2 *Transportation – Safety Statistics*

The crash data reported in the following subsections include both animal-vehicle crashes and wildlife-vehicle crashes to better reflect the impact of collisions with all animals. Animal-vehicle crashes include wild and domestic animals and livestock. Using all animal statistics to evaluate the situation helps the reader to differentiate where there are strictly wildlife problem areas, and where these domesticated animals may also be involved. The recommended wildlife mitigation that includes wildlife exclusion fences would be expected to reduce all these crashes, not just those with wildlife. Therefore, the total animal crashes are reported and then used in the benefit-cost analyses of the value of the recommended infrastructure. The reported wildlife crashes are those strictly with the six focal species: mule deer, elk, pronghorn, bighorn, black bear, and cougar.

6.5.9.2.1 *Wildlife-Vehicle Crashes per Mile per Year*

According to NMDOT data from 2008-2019, there were 4 reported crashes involving animals. All 3 wildlife crashes were with mule deer. Also, 1 desert bighorn sheep carcass was documented by NMDGF along this section of I-10 (Table 6-40).

Table 6-40. Peloncillo Mountains wildlife corridor, NMDOT crashes with all animals and six focal wildlife species of interest, 2009-2018.

Length (miles)	Total Crashes with All Animals	Total Crashes with Focal Species	Wildlife Crashes per mile per year	Crashes with Six Focal Species					
				Deer	Elk	Black Bear	Cougar	Pronghorn	Bighorn Sheep
5	4	3	0.06	3	0	0	0	0	0

6.5.9.2.2 *Seasonality of Wildlife-Vehicle Crashes*

The 3 reported crashes with wildlife occurred at two different times of year: July and December-January.

6.5.9.2.3 *WVC Species Percentages*

Of the WVCs in this wildlife corridor, 100 percent involved deer.

6.5.9.2.4 *Wildlife-Vehicle Crashes as Percentage of All Crashes*

There were 87 total crashes in the corridor from 2009 to 2018. Of these, 4 crashes were with animals. There were 3 reported crashes with the focal species, representing 3.4 percent of all crashes.

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6.5.9.2.5 Average Annual Daily Traffic (AADT)

AADT is important in estimating if large wild animals such as the six focal species have opportunities to cross the roads under scrutiny. Traffic volumes can form a complete barrier to wildlife movement all day and into the night once AADT reaches well above 20,000 vehicles per day. At 10,000 vehicles per day there is still a barrier, with some opportunity for nocturnal movements across roads. Wildlife can find limited opportunities to cross roads with AADT between 2,000 and 10,000 vehicles per day. However, at AADT of 2,000 and 10,000 per day, wildlife will try to cross roads, and will have greater mortality in some areas because of the lower perceived risk by wild animals but the continued presence of vehicles (Charry and Jones, 2009; Ng et al., 2004; Seiler, 2005).

AADT in the corridor is 12,440 vehicles per day, with an estimated future value of 18,433 vehicles per day by 2038.

6.5.9.2.6 Number of Lanes

The road is a four-lane divided highway throughout the corridor.

6.5.9.2.7 STIP Possibility

- STIP Control Number 1101470. I-10 Corridor Preliminary Engineering, $2 million, future years.

6.5.9.3 Ecological and Feasibility Considerations

6.5.9.3.1 Species of Concern

There are 11 species of concern that could potentially be found in this corridor: black bear, cougar, mule deer, desert bighorn sheep, American badger, white-nosed coati, kit fox, hog-nosed skunk, javelina, Gila monster, and ornate box turtle.

6.5.9.3.2 Data

AZGFD monitored nine desert bighorn sheep in the Peloncillo Mountains. These animals move east and south to the New Mexico portion of the mountain range, but do not cross I-10 and remain on the north side of the interstate. The animal movements southward toward I-10 can help elucidate where the most important areas could be for an overpass. The majority of data points occurred between MP 1 and MP 3.5 (Figure 6-52). NMDGF monitors 30 bighorn sheep in this area; all animals remained on the south side of I-10.

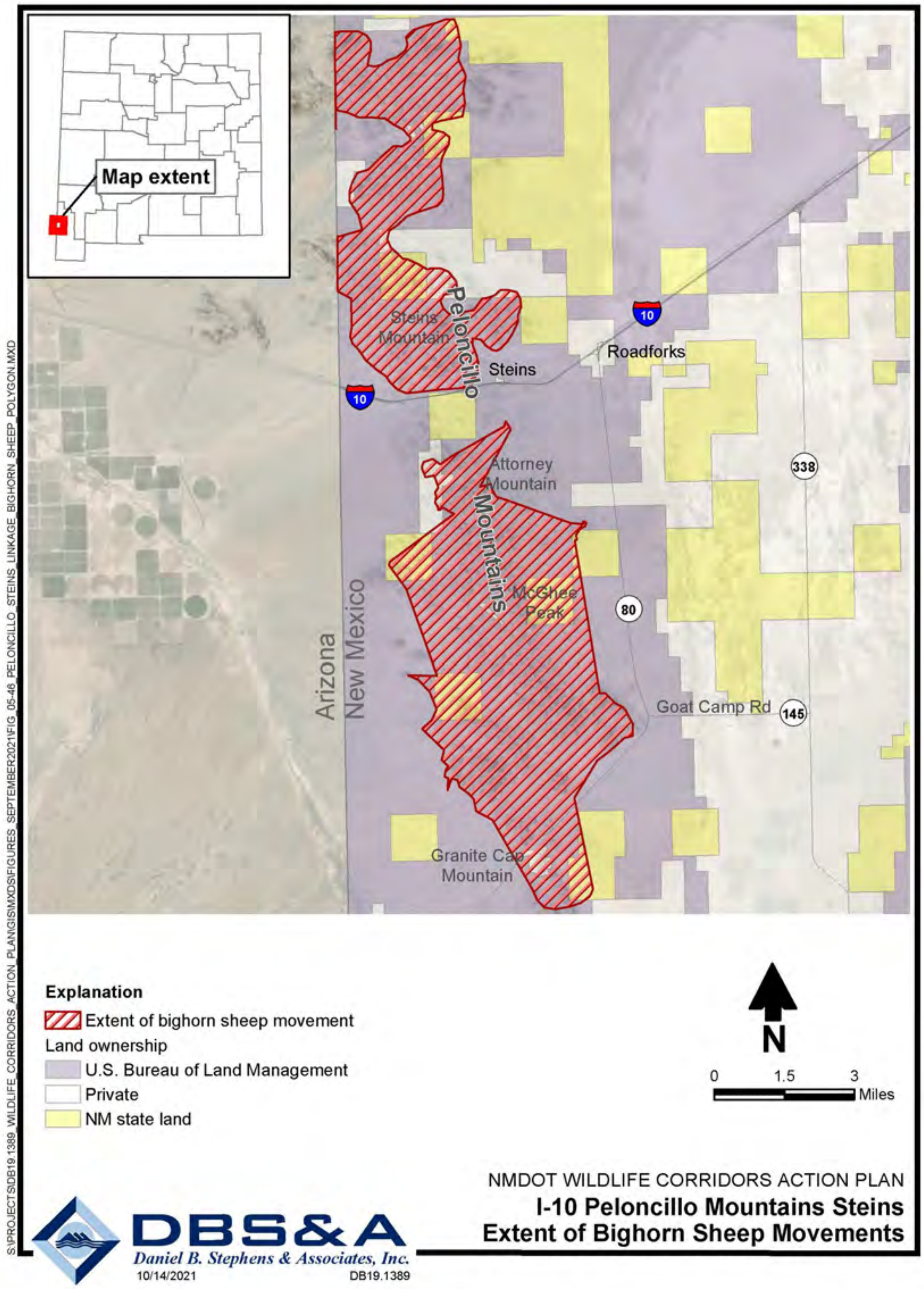

Figure 6-52. AZGFD and NMDGF GPS data points for desert bighorn sheep in the Peloncillo Mountains in New Mexico.

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The Wildlands Network has placed approximately 16 cameras along points under and near I-10 in this area (Traphagen, 2021) and photographed the presence of 24 species of birds and mammals, including bighorn sheep, mule deer, bobcat, javelina (Figure 6-53), and black-tailed jackrabbit.

Figure 6-53. Javelina in foreground of rail line and I-10 in the Peloncillo Mountains (photo credit: M. Traphagen, Wildlands Network).

Jaguars were historically found in Arizona and New Mexico, and the Peloncillo Mountains are part of the proposed Jaguar Management Units 2 and 3 (Sanderson et al., 2021). A jaguar was photographed in the Peloncillo Mountains south of I-10 in 1996, and another was photographed in the Animas Mountains (east of the Peloncillo Mountains) in 2006. Over the last three decades, camera traps have photographed a handful of male jaguars in the mountains south of I-10 in southeast Arizona, including photographs taken as recently as January 2021.

As of the end of 2020, there were a minimum of 114 Mexican wolves in New Mexico (Mexican Wolf Interagency Field Team, 2021). The Peloncillo Mountains lie between these New Mexico Mexican wolves and the packs in Mexico (Figure 6-54). In early 2021, a Mexican wolf dispersed from Mexico and came up into the Peloncillo Mountains headed north, but was killed on I-10 in Arizona (Mexican Wolf Interagency Field Team, 2021). These recorded movements of individual animals belonging to these two species help to demonstrate the importance of this habitat linkage.

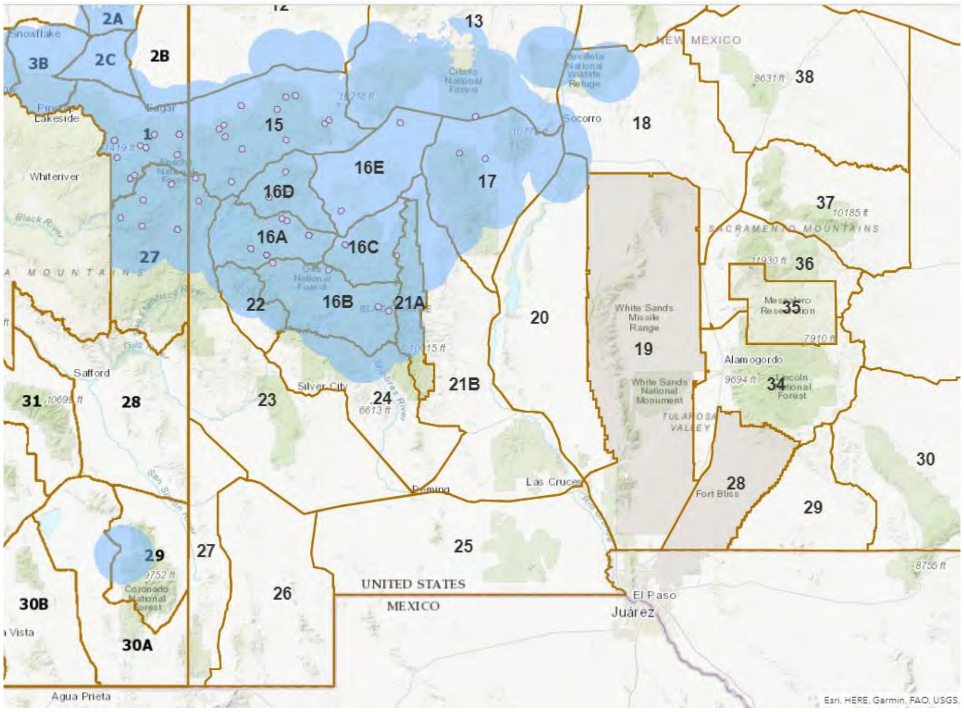

Figure 6-54. Mexican wolf pack ranges in southern New Mexico and eastern Arizona (blue shading) (source: Mexican Wolf Interagency Team, 2021).

6.5.9.3.3 Modeling

Linkage modeling conducted prior to this Wildlife Corridors Action Plan found two important corridors within this linkage for desert bighorn. The bighorn sheep populations in the Peloncillo Mountains occupy a core habitat of medium importance for its contribution to bighorn connectivity across New Mexico, as modeled by Wan et al. (2018).

Menke's 2008 modeling of cougar potential corridors in New Mexico identified this possible corridor for cougar and other species, with three core areas within it that had the highest potential for cougar movement across I-25 (Figure 6-55).

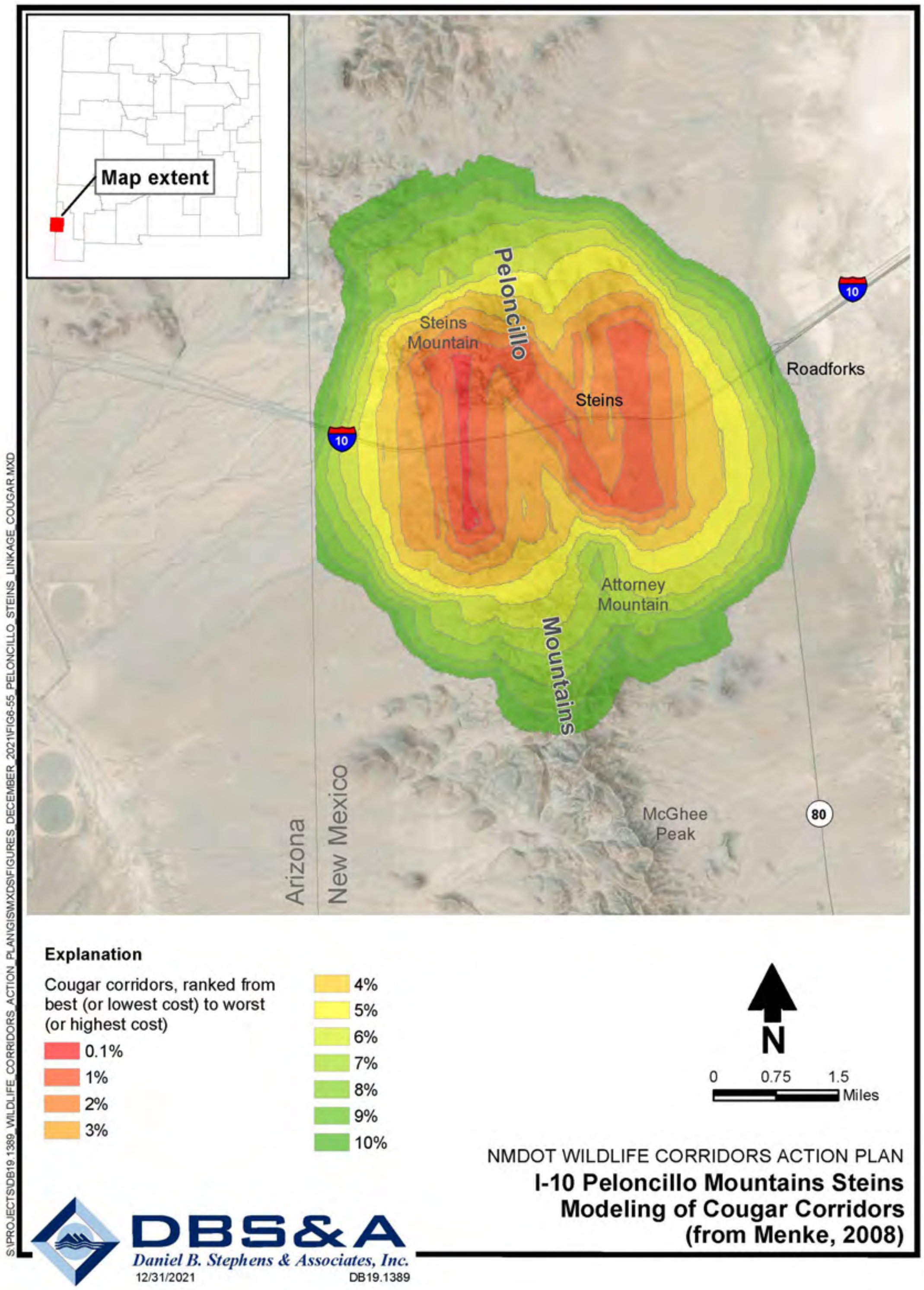

Figure 6-55. Menke's 2008 modeled cougar corridors across I-10 in the Peloncillo Mountains.

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6.5.9.3.4 Public Land

Public land managed by BLM occurs along this stretch of I-10 for over 5 miles. There is 1 mile of SLO land that is bisected by I-10, between MP 2 and MP 3.

The NMDGF recommended this corridor primarily for desert bighorn sheep, but for other species as well. NMDGF also mentioned that the Malpais Borderlands Group, consisting of local ranchers, may be willing to work with NMDOT on an overpass for bighorn sheep.

There is also potential for AZDOT, AZGFD, NMDGF, and NMDOT to partner for completing a bighorn sheep overpass.

The SLO, which owns land on both sides of the interstate, may be interested in supporting an overpass on their land. Their commissioner wrote a letter in support of the Action Plan.

Defenders of Wildlife mentioned this corridor as an important one for the Action Plan, and mentioned that wildlife are not killed as often on I-10 simply because they are blocked by traffic; WVC hotspots would not show this.

Wildlands Network supports this area as a top wildlife corridor, and has received funding from Patagonia, Inc. to monitor existing culverts and bridges, as well as select points along I-10 in the Peloncillo Mountains (Traphagen, 2021).

The Malpais Borderlands Group may also be willing to work with NMDOT along I-10 to secure a conservation easement for an overpass (NMDGF personal communication), and the Wildlands Network can assist with securing funding for a future overpass (M. Traphagen, personal communication).

6.5.9.4 Recommendations Overview

The recommendations include overpass locations for desert bighorn sheep and underpass arch culverts and bridges to accommodate other mammals such as black bear, javelina, coyote, bobcat, Mexican wolf, and jaguar.

The field reconnaissance team documented nine potential overpass locations along this wildlife corridor. All but one of them, possibly two, had a cut above the highway on only one side. The Action Plan team would like for the overpasses to be 150 feet wide because desert bighorn sheep in this area may not be as acclimated to people as other bighorn sheep populations, and these animals are documented as avoiding highways. For these reasons, safe passages are required for desert bighorn sheep that buffer them from traffic noise as they pass over the road.

The Action Plan development team would like to make it clear that if the goal is to facilitate all genders and age groups across I-10, one or several overpass structures are the only option. Along SR 68 in Arizona, AZGFD monitored underpasses built for bighorn sheep, and over a two-year period only documented a few dozen ram crossings and no ewe or lamb crossings (Bristow and Crabb, 2008). Data collected from SR 68 led to the addition of three overpasses for bighorn sheep along US 93 in the same mountain range as SR 68, and researchers have documented more than 6,000 bighorn sheep successful movements over the overpasses of all gender and age classes (Gagnon et al., 2017).

The top overpass location is from MP 2.25 to MP 2.3. This is because the land on both sides is owned by the SLO, which is a proponent of an overpass. Fill would be needed on the north side or the bridge would need to be angled to join the offset cut on the north side of I-10. The location is near Steins Mountain, where bighorn sheep are known to reside.

The second top overpass location, based on topography and the rail line, is at MP 4.5. The height of the rock above I-10 is about 20 feet; however, fill would be needed on the south side. Beneficially, the railroad track is relatively far away from I-10 at this point, and looking closely at the railroad tracks just to the northeast of the potential overpass location, there is a dirt road that goes under the tracks at an apparent train trestle and another dirt road just east of this one and north of the proposed eastern fence end at MP 4.8. This location is approximately 2 miles east of Steins Mountain, which presumably corresponds to the best desert bighorn habitat, but there are hills and ridges at this site on both sides of I-10. BLM manages the land on both sides.

There were eight recommendations for new wildlife underpasses for this wildlife corridor, either as arch culverts or bridges. These would benefit many other species of mammals, reptiles, and birds.

The rail line runs parallel to the highway through the mountains here, and it is not clear how desert bighorn sheep will behave when confronted with an active railway near an overpass. NMDOT would not be able to place an overpass over the rail line in typical road mitigation fashion because the rail cars stack cargo containers up to three high. There may be an opportunity to place a double overpass where the railroad and highway are close together just east of the Arizona border. Trains come through once every 30 minutes or so, as observed by field crews during daylight hours. The steep gradients caused the trains to travel relatively slowly, potentially facilitating desert bighorn sheep passage over or under the tracks.

The team also recommends replacing certain culverts with arch culverts and single span bridges to accommodate the many other mammals and smaller species that are known to move through this mountain range.

Widespread support from government agencies, non-profit groups, and landowner organizations can help make these recommended overpasses a reality.

There are 11 potential species of concern in the area that could all benefit from the proposed project recommendations. The overpasses should be readily used by desert bighorn and mule deer. In fact, the overpass is the only recommended structure for providing connectivity for populations of desert bighorn. Black bear and cougar have been documented using underpass structures more readily than overpasses in Colorado (Kintsch et al., 2021) and Utah (Cramer, 2014), and underpasses in Arizona (Gagnon et al., 2011) and New Mexico (Loberger et al., 2021). Hog-nosed skunks have been documented using culverts in Arizona (Grandmaison et al., 2021), and can be expected to use structures in ways similar to striped skunks, which have been documented using culverts in Arizona (Gagnon et al., 2011), New Mexico (Loberger et al., 2021), Utah (Cramer, 2012), and Colorado (Kintsch et al., 2021). American badger will also benefit. This carnivore has been recorded using overpasses in Colorado (Kintsch et al., 2021) and underpasses in New Mexico (Loberger et al., 2021), Colorado (Kintsch et al., 2021; Cramer and Hamlin, 2021), and Utah (Cramer and Hamlin, 2019 and 2021). Kit fox have been documented using wildlife crossing structures including overpasses (Gagnon et al., 2017), and may be expected to use underpasses in manners similar to red fox. As a surrogate for kit fox, red fox have been recorded using overpasses in Colorado (Kintsch et al., 2021) and underpasses in New Mexico (Loberger et al., 2021), Colorado (Kintsch et al., 2021; Cramer and Hamlin, 2021), and Utah (Cramer and Hamlin, 2019 and 2021). Javelina are expected to use the culverts, and even overpasses, as documented in Arizona (AZGFD, 2021). The ornate box turtle has not yet been documented using road-crossing structures, but would be expected to more readily use road-crossing structures that contain logs, tree stumps, large rocks and boulders, and native vegetation.

Figure 6-56 shows the priority mitigation actions along with land ownership information. The full complement of mitigation recommendations is provided in Table E-9 (Appendix E).

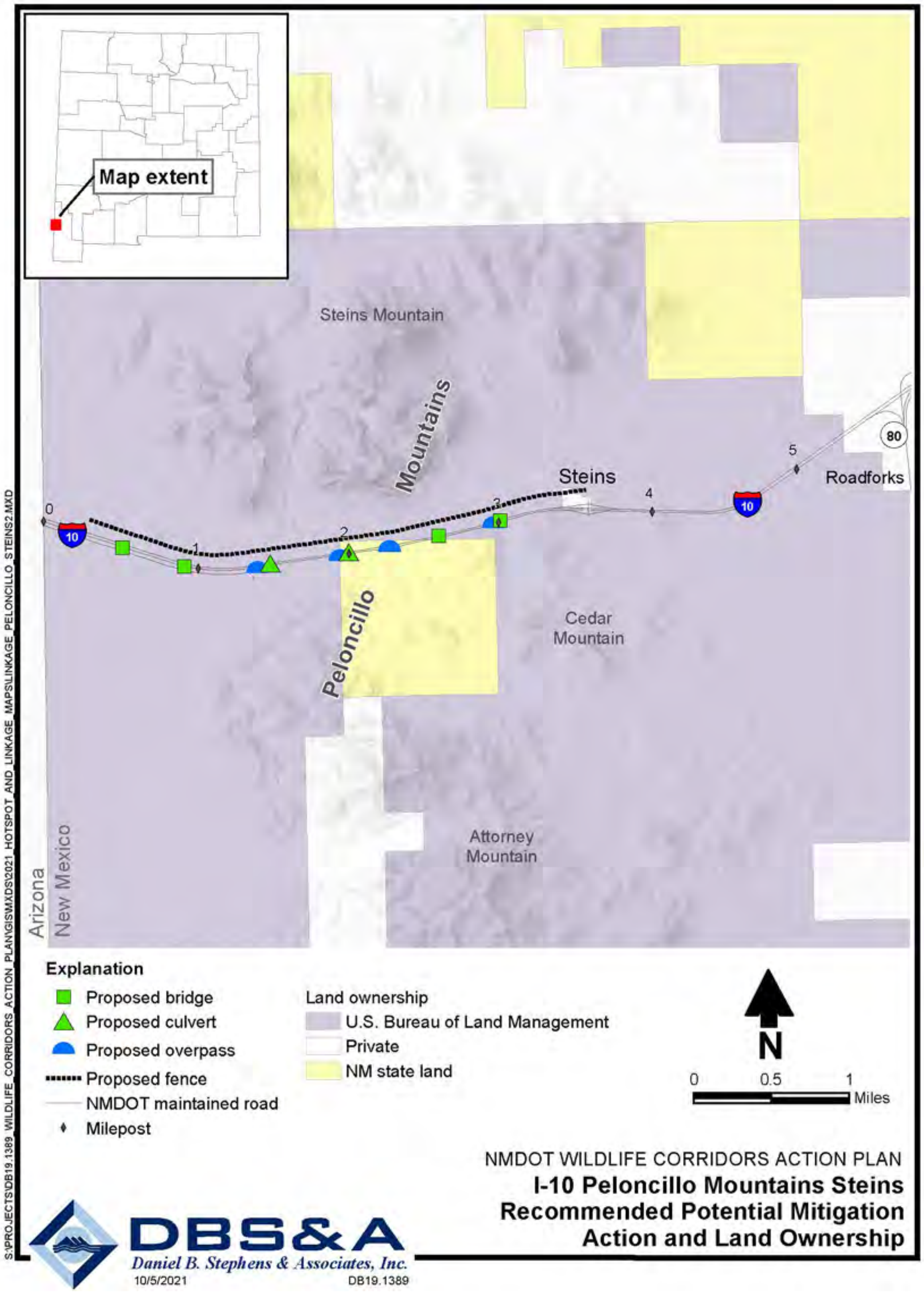

Figure 6-56. Land ownership and recommended project mitigation actions in the Peloncillo Mountains wildlife corridor.

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The priority recommendations are presented in Figure 6-57.

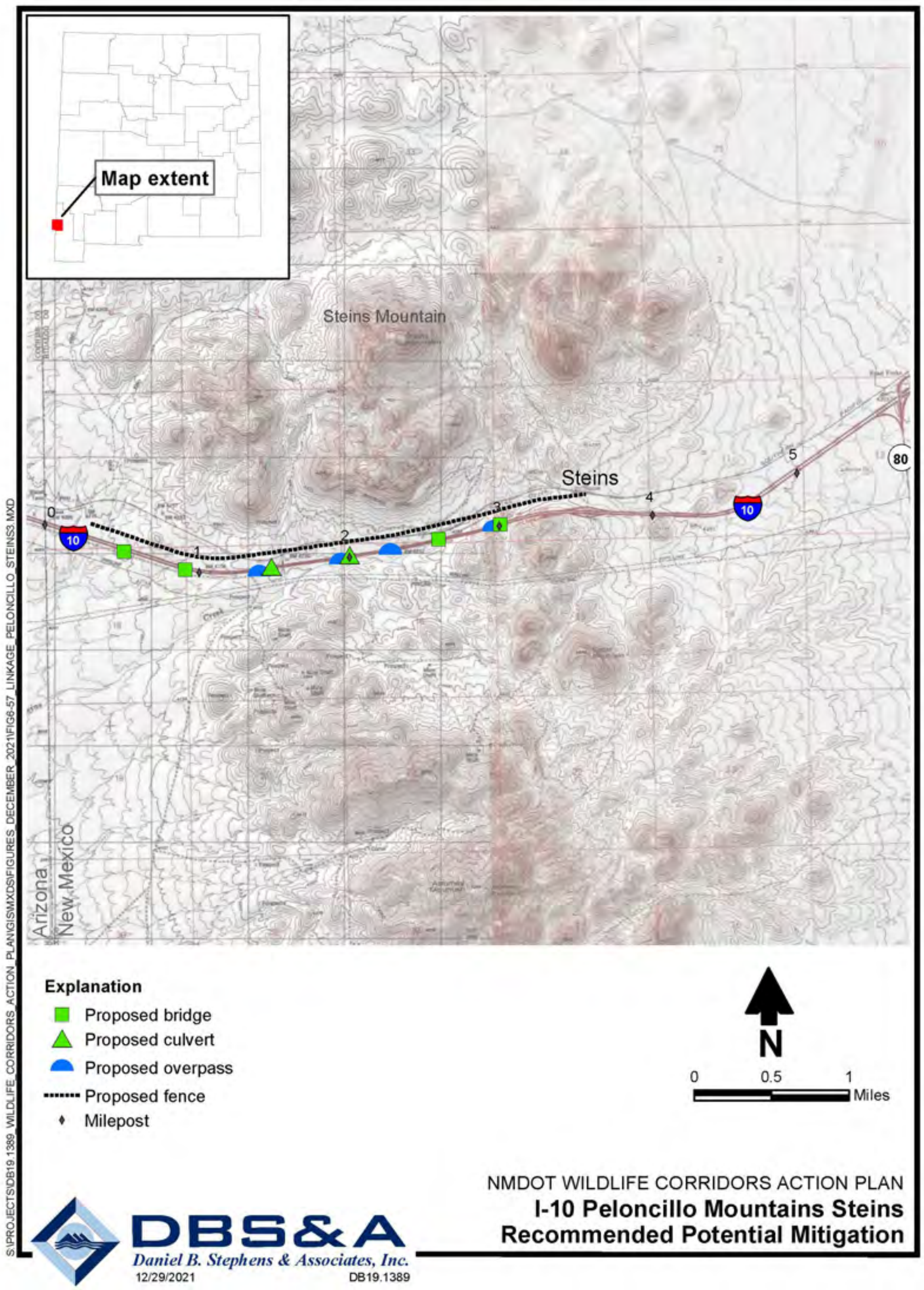

Figure 6-57. Top priority mitigation recommendations for the Peloncillo Mountains wildlife corridor.

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6.5.9.5 Specific Wildlife-Highway Mitigation Recommendations

The recommendations give an overview estimate of what can be done for wildlife mitigation. Many of the existing culverts and bridges are presented in Table E-9 (Appendix E) to provide evidence of opportunities to replace them with more wildlife-friendly structures—for example, when the infrastructure is replaced or when there is a transportation project nearby. The Action Plan team is not presenting these recommendations as the final and only opportunities for enhancing wildlife movement below and above the roads. Rather, these are the top recommendations based on a one-day field reconnaissance of each project area, existing road conditions, 2021 costs, and the current state of the science and practice of transportation ecology.

6.5.9.5.1 Cost-Effective Short-Term Solutions

Clear brush/trees/tumbleweed from entrances to all existing culverts to promote wildlife movement. This applies to both the MP 0.4 concrete box culvert and the MP 4.0 culvert.

6.5.9.5.2 Retrofit Existing Infrastructure

There were no retrofit recommendations other than clearing existing culverts of brush and sediment.

6.5.9.5.3 Intermediate Solutions - New Structures

- *MP 0.4 Wildlife Underpass Bridge or Arch Culvert:* This bridge or culvert would be for wildlife other than bighorn sheep.
- *MP 0.9 Wildlife Underpass bridge or Arch Culvert:* Place a single span bridge or arch culvert for carnivores.
- *MP 1.5 Wildlife Underpass Arch Culvert:* For carnivore use. The existing culvert has a lot of fill in it, and it needs to be cleared. There is a culvert beneath the rail road near this location, making it a potentially good place for wildlife to pass beneath both transportation corridors.
- *MP 2.0 Wildlife Underpass Arch Culvert:* For carnivores and other wildlife other than desert bighorn sheep.
- *MP 3.0 Wildlife Underpass Bridge or Arch Culvert:* This culvert or bridge would help carnivores, such as Mexican wolves, move under the highway. Medium-sized mammals such as coyote and javelina are already using the existing culvert.

6.5.9.5.4 Solutions Based on Best Management Practices

The following recommended structures provide more guarantee of success than culverts and bridges for providing passage for desert bighorn sheep:

- *MP 1.4 Wildlife Overpass:* Third best possible overpass location.
- *MP 1.9 Wildlife Overpass:* Second best possible overpass location. Fill needed on the south. The railroad is father away from the highway here than at Steins Mountain, which helps bighorn sheep and other species take on one obstacle at a time rather than be overwhelmed by two transportation corridors.
- *MP 2.25 or MP 2.3 Wildlife Overpass:* This is the most important overpass site. It matches bighorn sheep movements north and south. The state owns the land on both sides of I-10. This possible location for an overpass is near Steins Mountain. The cut bank on the north side is more to the east here, and the cut bank on the south is more to the west, so it may need an angle. There is a drainage right next to this area on the south side that parallels I-10. It would likely bring in wildlife to the site.
- *MP 2.6 Wildlife Underpass Bridge:* Create an underpass here. There is a box culvert here at an angle. This would accommodate wildlife except for desert bighorn sheep.
- *MP 2.9 Wildlife Overpass:* This is the boldest overpass recommendation. Create a double overpass over the rail lines as well. The railroad is approximately 500 feet from I-10 at this location. This could be implemented jointly with any of the above overpasses.

6.5.9.6 Benefit-Cost Analysis

There are several types of benefit-cost analyses. However, they all share the same basic premise, which is to use a benefit-cost ratio with the benefit in the numerator and the cost in the denominator. The cost is associated with the construction and maintenance of the proposed mitigation infrastructure. The estimated monetary benefit is derived from the reduction in the number of crashes over the lifetime of the mitigation.

The unique approach here is based on the Colorado DOT's new method of including the economic value of elk and mule deer not killed in crashes as a result of the mitigation among the benefits (Kintsch et al., 2019).

6.5.9.6.1 *Ballpark Estimates for Costs of Infrastructure*

Table 6-41 presents the costs per unit for overpasses, bridges, and culverts placed on a four-lane highway as estimated by the Action Plan development team's engineers based on NMDOT 2019 cost estimates. The price of 8-foot wildlife exclusion fence per mile for both sides of the highway, double cattle guards, also known as game guards, and escape ramps are all taken from Colorado DOT estimates in the West Slope Study (Kintsch et al., 2019).

Table 6-41. Peloncillo Mountains wildlife corridor project wildlife mitigation rough cost estimates.

Infrastructure	Cost per unit	Cost for Infrastructure
Overpass (4-lane): MP 1.4	$7,280,000	$7,280,000
Overpass (4-lane): MP 1.9	$7,280,000	$7,280,000
Overpass (4-lane): MP 2.3	$7,280,000	$7,280,000
Overpass (4-lane): MP 2.9	$7,280,000	$7,280,000
Span bridge (4-lane): MP 0.9	$2,520,000	$2,520,000
Span bridge (4-lane): MP 2.6	$2,520,000	$2,520,000
Span bridge (4-lane): MP 3.0	$2,520,000	$2,520,000
Pipe Arch culvert (4-lane): MP 0.4	$3,230,000	$3,230,000
Pipe Arch culvert (4-lane): MP 1.5	$3,230,000	$3,230,000
Concrete box culvert (4-lane): MP 2.0	$2,280,000	$2,280,000
3.3 Miles of fence = 3.3 x $100,000 = $330,000	$100,000/mile	$330,000
Double cattle guards, estimate 4 guards at Steins interchange 4 x $60,000	$60,000	$240,000
Escape ramps, 4 per mile x 3.3 = 13.2	$14,000	$184,800
Total		$46,174,800

6.5.9.6.2 *Animal-Vehicle Crash Costs*

From 2009 to 2018, there were 4 crashes that included all animals in this wildlife corridor. The crash severity of these included 3 property damage only crashes, 1 Class C injury crashes, 0 Class B injury crashes, 0 Class A injury crashes, and 0 fatal crashes.

The NMDOT 2019 and FHWA 2018 (Harmon et al., 2018) crash values for these crashes are presented in Table 6-5. Based on these values, the costs of the animal crashes in this wildlife corridor were calculated (Table 6-42).

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Table 6-42. Calculation of wildlife-vehicle crash costs in Peloncillo Mountains wildlife corridor using NMDOT and FHWA crash values.

Crash Type	NMDOT-Estimated Individual Crash Costs to Society	Total NMDOT Value of Crashes	FHWA-Estimated Individual Crash Costs to Society Based on Harmon et al. (2018)	Total FHWA Value of Crashes
3 property damage only	$7,400	$22,200	$ 11,900	$ 35,700
1 possible injury (Type C)	$44,900	$44,900	$125,600	$125,600
0 minor injury (Type B)	$79,000	$0	$198,500	$0
0 incapacitating/serious injury (Type A)	$216,000	$0	$655,000	$0
0 fatality	$4,008,900	$0	$11,295,400	$0
Total		$67,100		$161,300

The benefits portion of the ratio is estimated by examining the expected reduction in crash costs. These benefits are estimated by taking the crash costs and multiplying by 90 percent reduction of crashes the mitigation can be expected to provide, expected 75-year lifespan of the mitigation, and economic values of mule deer saved by the mitigation over 75 years (Table 6-43). The cost of all animal crashes was estimated from 5 miles of I-10 through the Peloncillo Mountains. The mitigation recommended was for only 3.3 miles of this stretch. However, these calculations continued with the estimates of the original 5 miles.

Table 6-43. Estimating the benefits expected from the proposed mitigation, Peloncillo Mountains wildlife corridor.

	NMDOT Crash Values	FHWA Crash Values
Total value of crash costs over 10 years	$67,100	$161,300
Crash cost per mile per year	$1,342	$3,226
Crash cost for 5 miles of project over 75 years of infrastructure (Cost/mile/year x 5 x 75)	$503,250	$1,209,750
If mitigation reduced crashes by 90%, over 75 years, that value would be:	$452,925	$1,088,775
Wildlife Lost and Saved Values		Estimated Value of Mule Deer Saved over 75 years of Mitigation
If 100% of wildlife crashes were deer, and there were 3/10 years = 0.3 deer crashes/year, over 75 years that would equate to 22.5 deer. If the mitigation prevents 90 percent of those deer killed, it would equate to 20 deer saved. At a value of $2,061 for each mule deer, the value of animals saved over 75 years of mitigation= 20 per 75 years x $2,061 each = $46,373		$46,373

6.5.9.6.3 Benefit-Cost Ratio

- NMDOT values for crashes:
  Benefit/Cost Equation = $452,925+ $46,373/$46,174,800= 0.01
- FHWA Values for Crashes
  Benefit/Cost Equation = $1,088,775+ $46,373/$46,174,800= 0.02

The recommended wildlife mitigation would not be expected to pay for itself over the course of 75 years. If the full list of mitigation measures equaled approximately $0.5 million, the project would be expected to possibly pay for itself over the same time period based on NMDOT crash costs.

6.5.10 I-25 US 550 Sandia–Jemez Mountains Bernalillo Wildlife Corridor Recommendations for Wildlife Mitigation Projects

- *I-25 MP 242–263, US 550 MP 0–15*
- *36-mile corridor, 26 miles of mitigation*
- *Sandoval County*
- *NMDOT Districts 3 and 6*

6.5.10.1 *Project Area Overview*

The Sandia-Jemez Mountains corridor is located between the Sandia Mountains on the east and south side of I-25 and the Jemez Mountains north of I-25. Within this corridor, wildlife captured and GPS collared on the Pueblo of Santa Ana west of I-25 moved south and north of US 550 on the southwest side of the Pueblo, thus, the linkage also occurs across the north and south sides of US 550 to the west of the I-25 corridor. Mule deer, elk, pronghorn, black bear, and cougar move through this wildlife corridor (Figure 6-58).

Figure 6-58. Five of the six focal species have been documented trying to move through the Sandia-Jemez Mountains corridor and as victims of vehicle collisions (photo credit: NMDGF and AZGFD).

There is substantial development in many of the nearby areas, as the corridor begins just 17 miles north of Albuquerque and encompasses the Santa Ana, San Felipe, Cochiti, and Kewa (Santo Domingo) Pueblos along I-25, and the Jemez, Zia, and Santa Ana Pueblos in the lands between US 550 and the Jemez Mountains. It will take precisely focused efforts to protect the wildlife movement corridors within this linkage amid the rapidly expanding urban development and roads.

Wildlife movement data collected by the Department of Natural Resources of the Pueblo of Santa Ana were extremely helpful in demonstrating where mule deer, elk, pronghorn, black bear, and cougar move or cannot move in this corridor. It was the Pueblo's GPS location data and wildlife roadkill dataset that elevated this potential linkage to the status of a top wildlife corridor in the Action Plan.

The AADT for I-25 ranges from 40,000 to 58,000 vehicles per day. These numbers form a virtual wall of vehicles during daylight hours, and still pose barriers at night, and most wild animals do not attempt to cross the highway (Charry and Jones, 2009). Consequently, there are few reported wildlife crashes. This area was therefore not ranked as a WVC hotspot based on wildlife crashes per mile. The wildlife GPS collar movement data and corridor models were the most decisive factors in identifying this area as a major wildlife corridor in need of wildlife mitigation across I-25 and US 550. The majority of the roads in this area are in NMDOT District 3. North of the Pueblo of Santa Ana on US 550, the district changes to NMDOT District 6.

NMDOT wildlife crash data are shown on a map of the corridor in Figure 6-59.

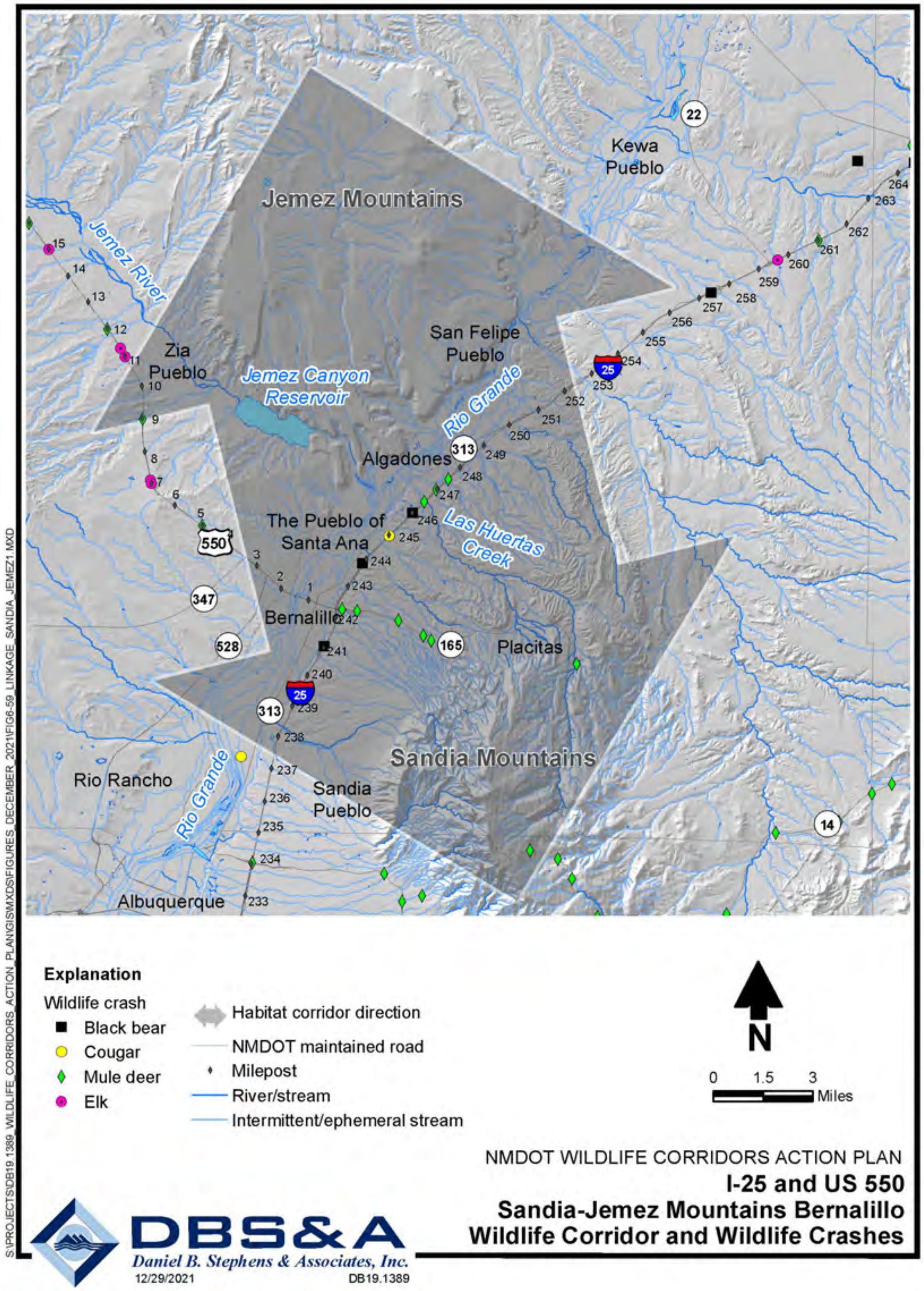

Figure 6-59. Wildlife-vehicle crashes and wildlife movement in the Sandia-Jemez Mountains wildlife corridor.

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There is also high public support and some agency support for the Crest of Montezuma wildlife corridor southeast of I-25 on the north end of the Sandia Mountains (Figure 6-60).

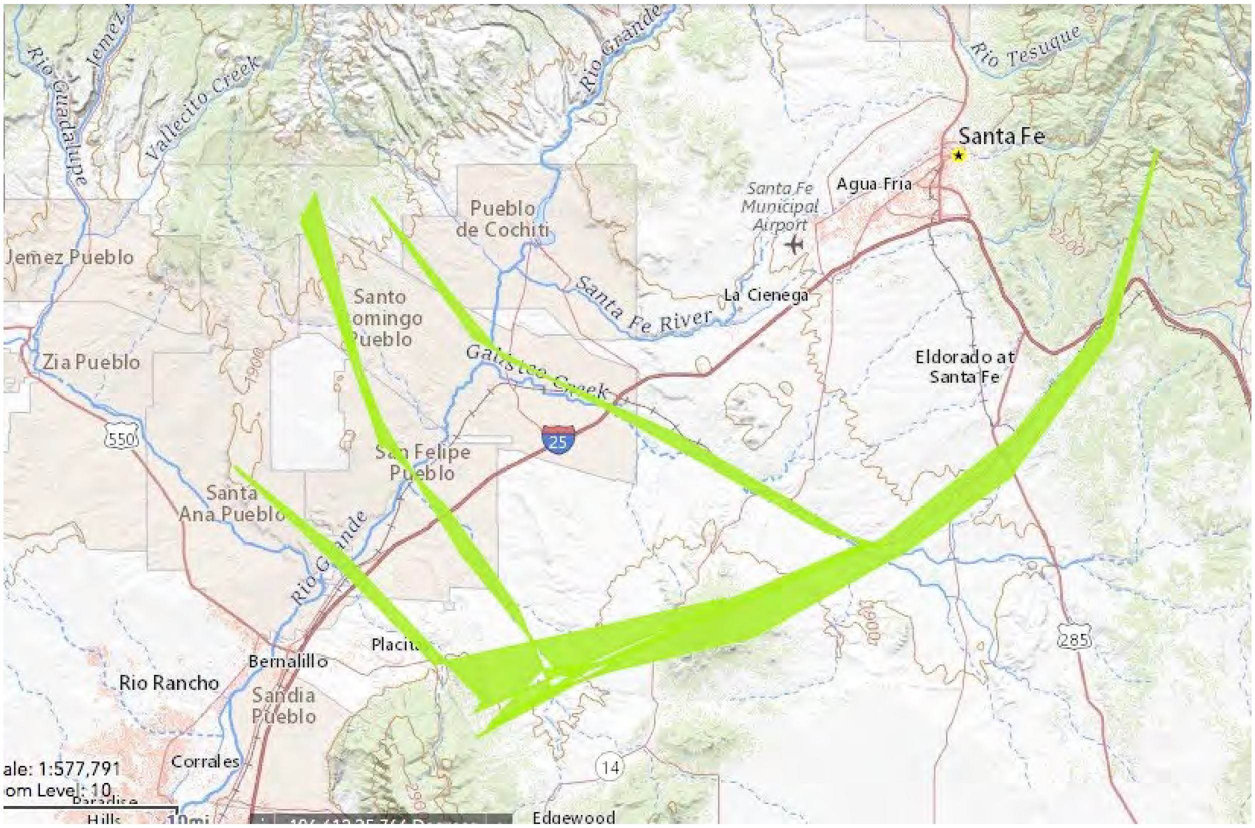

Figure 6-60. Crest of Montezuma potential linkage from the northern end of the Sandia Mountains west to the Jemez Mountains and northeast to the Sangre de Cristo Mountains, with reference to Tribal lands (courtesy of Peter Callan).

6.5.10.2 Transportation – Safety Statistics

The crash data reported in the following subsections include both animal-vehicle crashes and wildlife-vehicle crashes to better reflect the impact of collisions with all animals. Animal-vehicle crashes include wild and domestic animals and livestock. Using all animal statistics to evaluate the situation helps the reader to differentiate where there are strictly wildlife problem areas, and where these domesticated animals may also be involved. The recommended wildlife mitigation that includes wildlife exclusion fences would be expected to reduce all these crashes, not just those with wildlife. Therefore, the total animal crashes are reported and then used in the benefit-cost analyses of the value of the recommended infrastructure. The reported wildlife crashes are those strictly with the six focal species: mule deer, elk, pronghorn, bighorn, black bear, and cougar.

6.5.10.2.1 Wildlife-Vehicle Crashes per Mile per Year

According to the NMDOT 2009-2018 crash data, there were 57 reported crashes with all animals and 20 reported crashes with the focal species (Table 6-44).

Table 6-44. Sandia-Jemez Mountains wildlife corridor, NMDOT crashes with all animals and six focal wildlife species of interest, 2009-2018.

Length (miles)	Total Crashes with All Animals	Total Crashes with Focal Species	Wildlife Crashes per mile per year	Crashes with Six Focal Species					
				Deer	Elk	Black Bear	Cougar	Pronghorn	Bighorn Sheep
36.3	57	0.055	10	10	6	3	1	0	0

6.5.10.2.2 Seasonality of Wildlife-Vehicle Crashes

NMDOT crash data for I-25 and US 550 for the six focal species by month are provided in Figure 6-61.

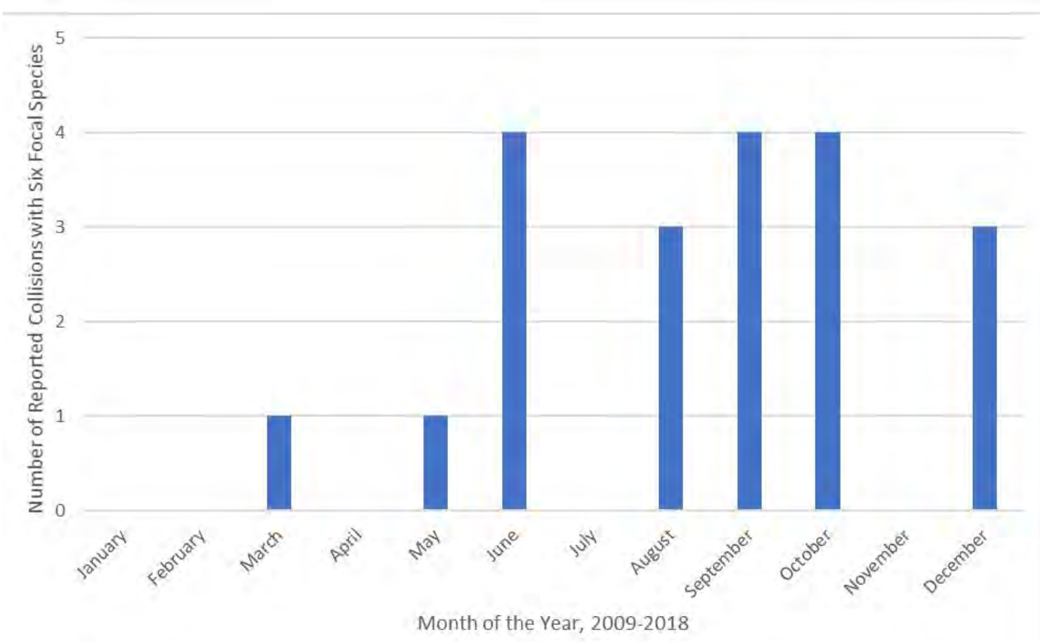

Figure 6-61. NMDOT wildlife-vehicle crash data by month in Sandia-Jemez Mountains wildlife corridor.

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The Pueblo of Santa Ana's Department of Natural Resources tracks wildlife carcasses along US 550 and I-25 on the Pueblo. Data on 29 carcasses were shared with the Action Plan development team. The number of carcasses of black bear, cougar, mule deer, and elk on US 550 and I-25 by MP are shown in Figures 6-62 and 6-63.

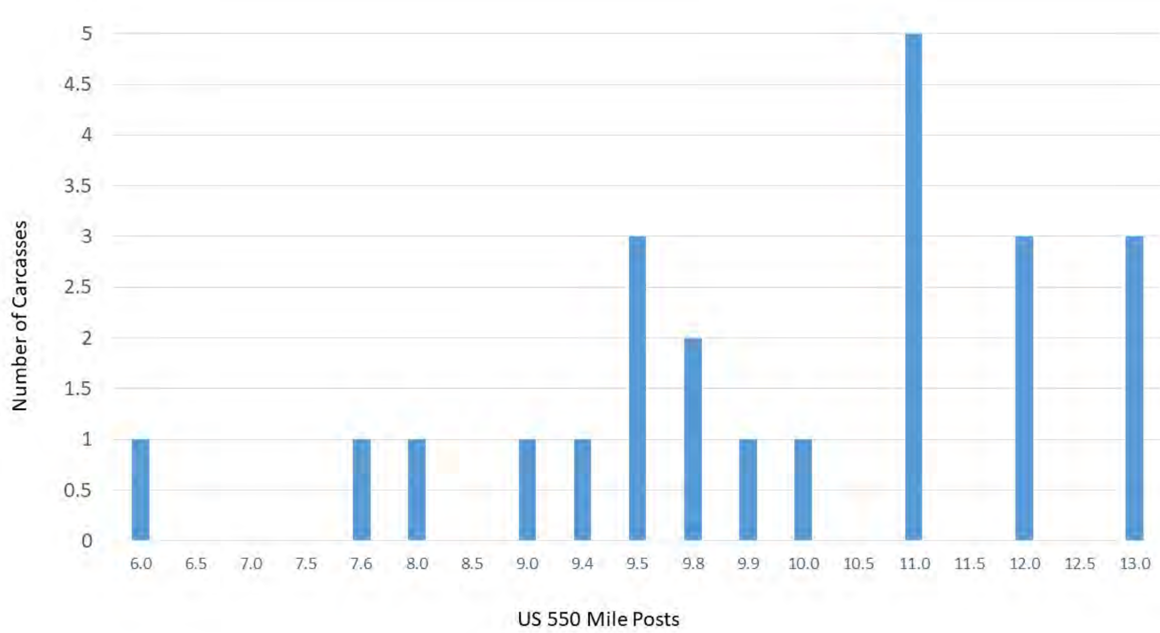

Figure 6-62. Pueblo of Santa Ana carcass data for US 550 by milepost (shared by Pueblo of Santa Ana).

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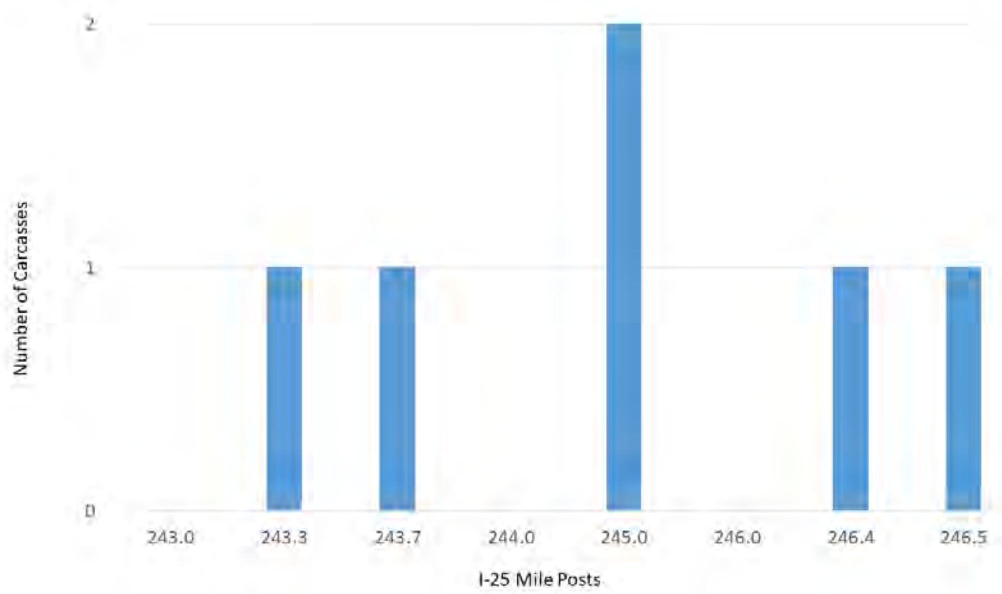

Figure 6-63. Pueblo of Santa Ana carcass data for I-25 by milepost (shared by Pueblo of Santa Ana).

The Pueblo of Santa Ana carcass data for I-25 and US 550 by month are provided in Figure 6-64.

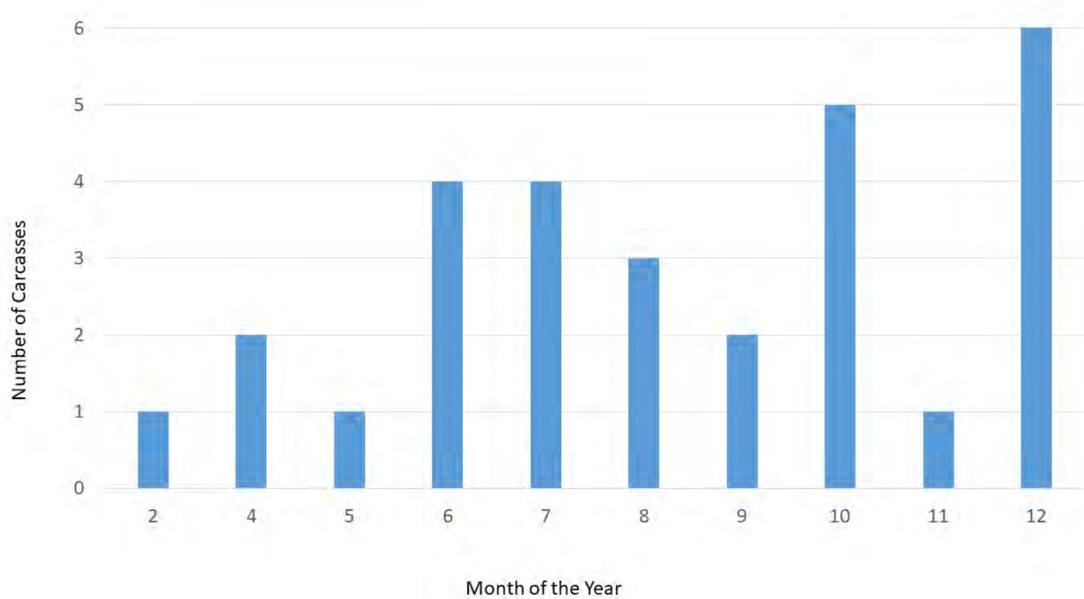

Figure 6-64. Pueblo of Santa Ana carcass data by month in Sandia-Jemez Mountains wildlife corridor.

6.5.10.2.3 WVC Species Percentages

Of the WVCs in this wildlife corridor, 50 percent involved mule deer, 30 percent involved elk, 15 percent involved black bear, and 5 percent involved cougar.

Of the Pueblo of Santa Ana carcass data for 29 animals, 38 percent were mule deer, 52 percent were elk, 3 percent were black bear, and 7 percent were cougar.

Figure 6-65 shows NMDOT reported crashes and Pueblo of Santa Ana reported carcasses in the corridor.

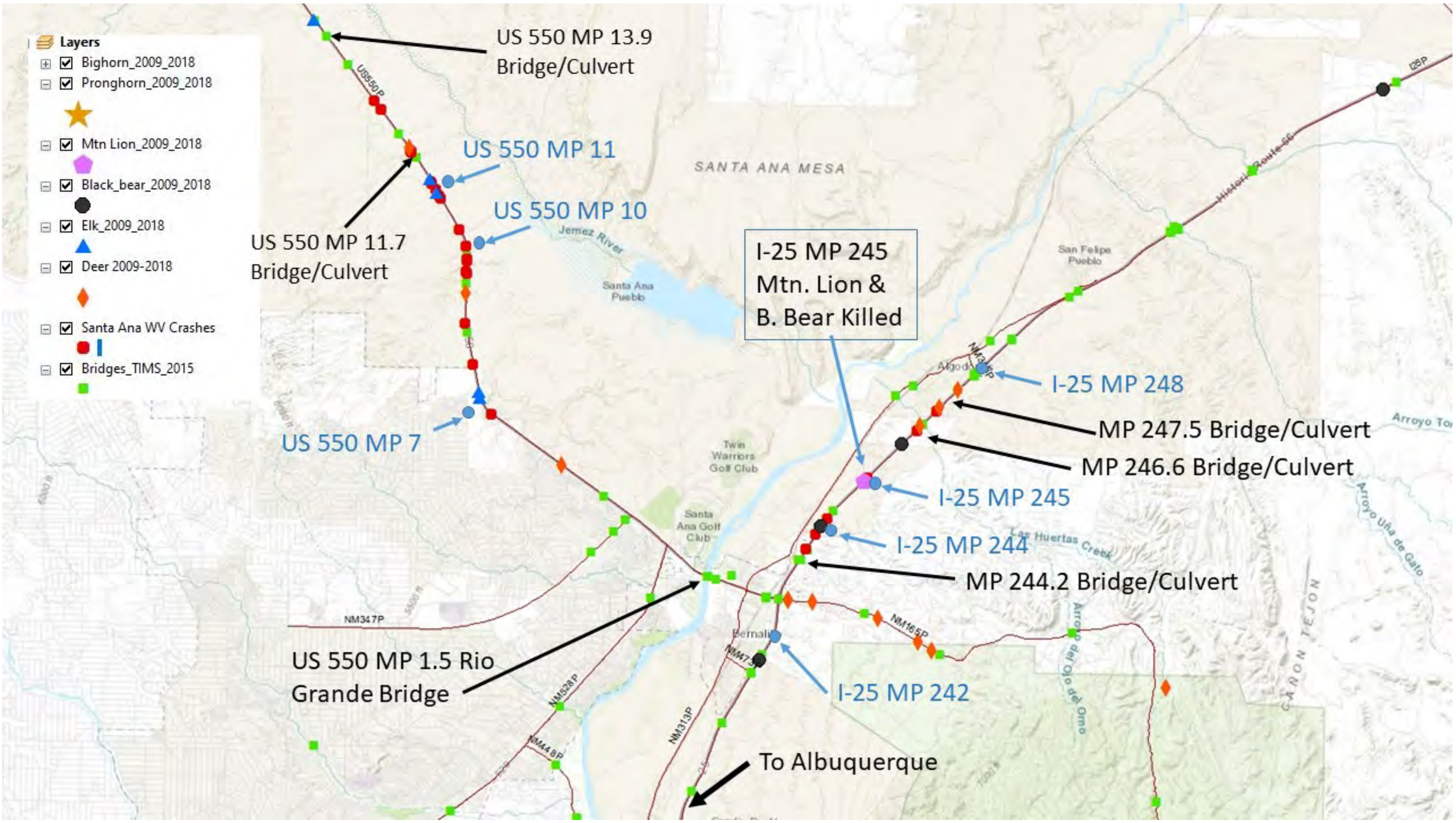

Figure 6-65. NMDOT WVC data and Pueblo of Santa Ana carcass and crash data in the Sandia-Jemez Mountains wildlife corridor.

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6.5.10.2.4 Wildlife-Vehicle Crashes as Percentage of All Crashes

There were 2,238 total crashes in this corridor from 2009 to 2018. Of these, 57 crashes were with animals. There were 20 reported crashes with the focal species, representing 0.9 percent of all crashes.

6.5.10.2.5 Average Annual Daily Traffic (AADT)

AADT is important in estimating if large wild animals such as the six focal species have opportunities to cross the roads under scrutiny. Traffic volumes can form a complete barrier to wildlife movement all day and into the night once AADT reaches well above 20,000 vehicles per day. At 10,000 vehicles per day there is still a barrier, with some opportunity for nocturnal movements across roads. Wildlife can find limited opportunities to cross roads with AADT between 2,000 and 10,000 vehicles per day. However, at AADT of 2,000 and 10,000 per day, wildlife will try to cross roads, and will have greater mortality in some areas because of the lower perceived risk by wild animals but the continued presence of vehicles (Charry and Jones, 2009; Ng et al., 2004; Seiler, 2005).

All sections of I-25 and US 550 have current AADT over 10,000 vehicles per day (Table 6-45):

- US 550: Current (2018) = 21,821, Future = 18,583 (estimated 2038)
- I-25: Current (2018) = 33,211, Future = 48,177 (estimated 2038)

Table 6-45. Average annual daily traffic on I-25 and US 550 in Sandia-Jemez Mountains wildlife corridor.

Road	Mileposts	Mile Markers (GPS)	AAADT (2018)	Future AADT (2038)	Notes
I-25	259.5–264.25	260.7–265.7	31,814	47,274	Left out very short segments at highway interchanges. That is why there are a few short gaps in MPs.
I-25	257.5–259.1	258.8–260.23	27,459	40,803	
I-25	252.8–257.3	253–258.4	31,844	47,319	
I-25	248–252.2	249.1–253.3	39,475	58,658	
I-25	242.5–248	243.7–249.1	35,464	46,832	
US 550	0–2.6	0–2.5	33,590	28,605	Average of four segments.
US 550	2.6–18	2.5–18.1	10,052	8,560	Mix of Pueblo of Santa Ana and Zia Pueblo lands.

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6.5.10.2.6 Number of Lanes

Both highways are four lanes throughout the corridor.

6.5.10.2.7 STIP Possibility

- STIP Control Number M300812: Minor preservation (I-25 MP 243-257); 2021 Start.
- STIP Control Number A302103: Pavement preservation, informational (I-25 North of Algodones Bridge); 2024 Start.
- STIP Control Number 5101340: Preliminary engineering, slope mitigation and roadway improvements (I-25 MP 263-283); Start data N/A.

6.5.10.3 Ecological and Feasibility Considerations

6.5.10.3.1 Species of Concern

The following species are or may be present in the wildlife corridor based on species occurrence maps and crash and carcass data: black bear, cougar, mule deer, elk, pronghorn, American badger, hog-nosed skunk, kit fox, red fox (in the northern part of the corridor), javelina, and ornate box turtle.

6.5.10.3.2 Data

Data used included the NMDOT crash data. NMDGF provided black bear and cougar mortality data, which included locations where these species were killed by vehicles on roads, and additional locations where mortality was related to other causes.

Pueblo of Santa Ana Range and Wildlife Division Manager, Glenn Harper, placed GPS collars on five of the six focal species in the Action Plan: mule deer, elk, pronghorn, cougar, and black bear. Sawyer and Telander (2020) summarized the data with Brownian Bridge analyses of the movements of each species. The data ranged from collars placed between 2009 to 2020. The Action Plan development team digitized all polygons of the Santa Ana collared animals and combined them into one map (Figure 6-68). The following species accounts are from the Pueblo of Santa Ana research program.

- Pronghorn: A total of 4 pronghorn were tracked from 2009 to 2012, with over 11,000 GPS locations included in the mapping. The animals all stayed on the north side of both I-25 and US 550, and no locations were detected on the opposite side of each highway.
- Elk: A year-round heat map was created based on GPS collar data on 9 elk from 2010 to 2017. No GPS data points were detected on the southeast side of I-25. Several of the elk

spent time on the south end of the Jemez Mountains. Elk did cross US 550 on Pueblo of Santa Ana lands.

- Mule deer: A total of 29 mule deer were tracked with GPS collars from 2010 to 2020. All movements were north of I-25; no deer were detected southeast of the highway. Mule deer did move across US 550, mainly on Pueblo of Santa Ana lands.
- Black bear: A total of 2 black bears were collared, and their movements were followed from 2017 to 2020. These animals largely used the Pueblo of Santa Ana lands all northwest of the Rio Grande and north of the Jemez River.
- Cougar: A total of 6 cougars were tracked across the landscape. No cougar GPS locations were detected across I-25; the animals all stayed northwest of the interstate, but they did cross US 550.

Dr. Travis Perry of Furman University placed GPS collars on cougars in the Sandia Mountains on Kirtland Air Force Base. A polygon of cougar movements was created by the Action Plan development team for this report based on the GPS locations of three cougars. The map polygon focused on cougar movements in the Sandia Mountains. This polygon was combined with the Santa Ana GPS collar data polygons of other wildlife species for a master map of collared animal data in the Sandia and Jemez Mountains wildlife corridor (Figure 6-66).

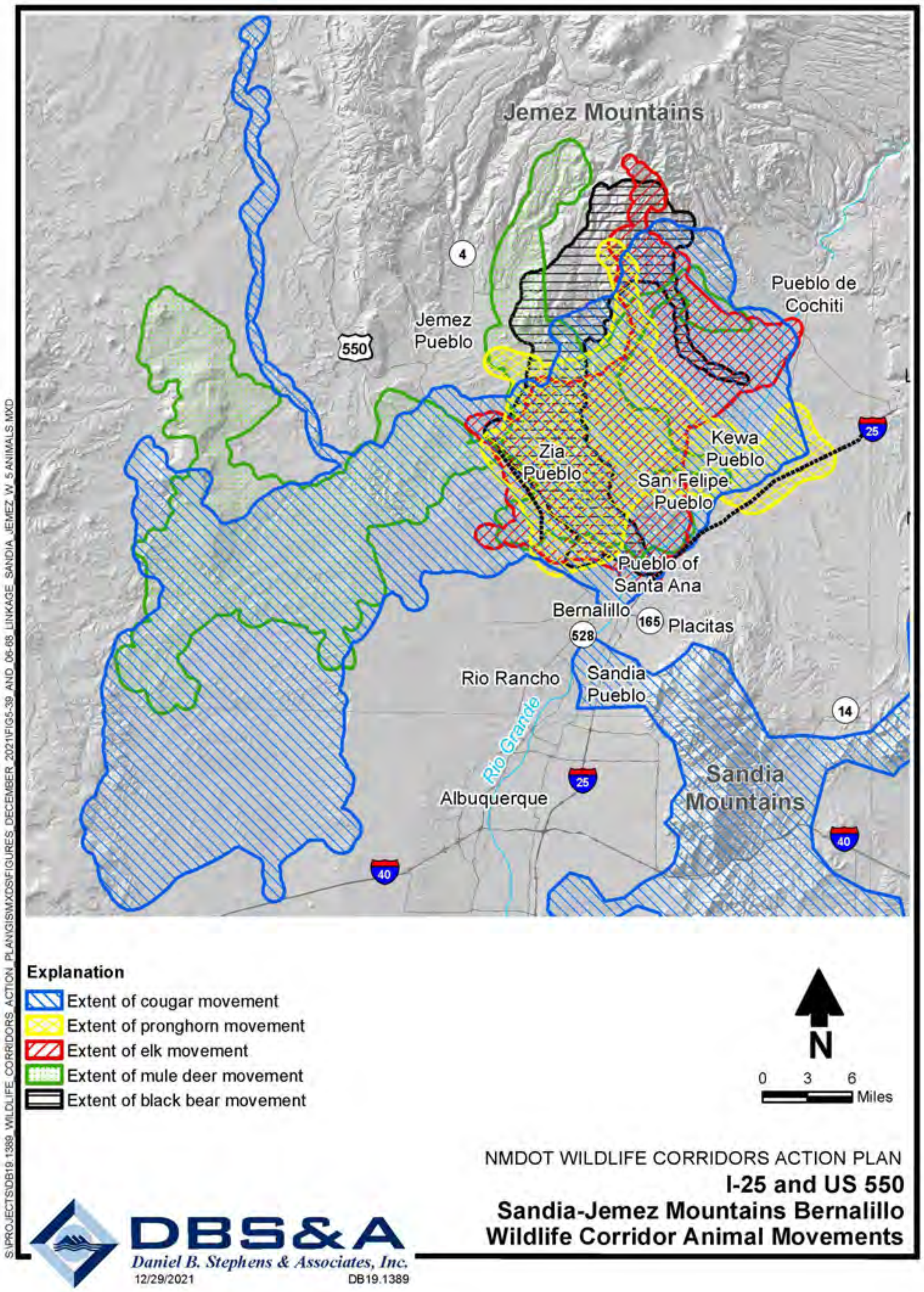

Figure 6-66. Pronghorn, cougar, elk, mule deer, and black bear movements from Pueblo of Santa Ana GPS collar data and Kirtland Airforce Base in conjunction with Travis Perry at Furman University collared cougar movements in the Sandia Mountains. Polygons based on Sawyer and Telander (2020) heat maps and UNM GPS data shared for development of the Action Plan.

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6.5.10.3.3 Modeling

Menke (2008) modeled cougar potential movement corridors and pathways in New Mexico. There is a linkage between the Sandia Mountains and the Jemez Mountains that cougars would be expected to use in crossing I-25 (Figure 6-67).

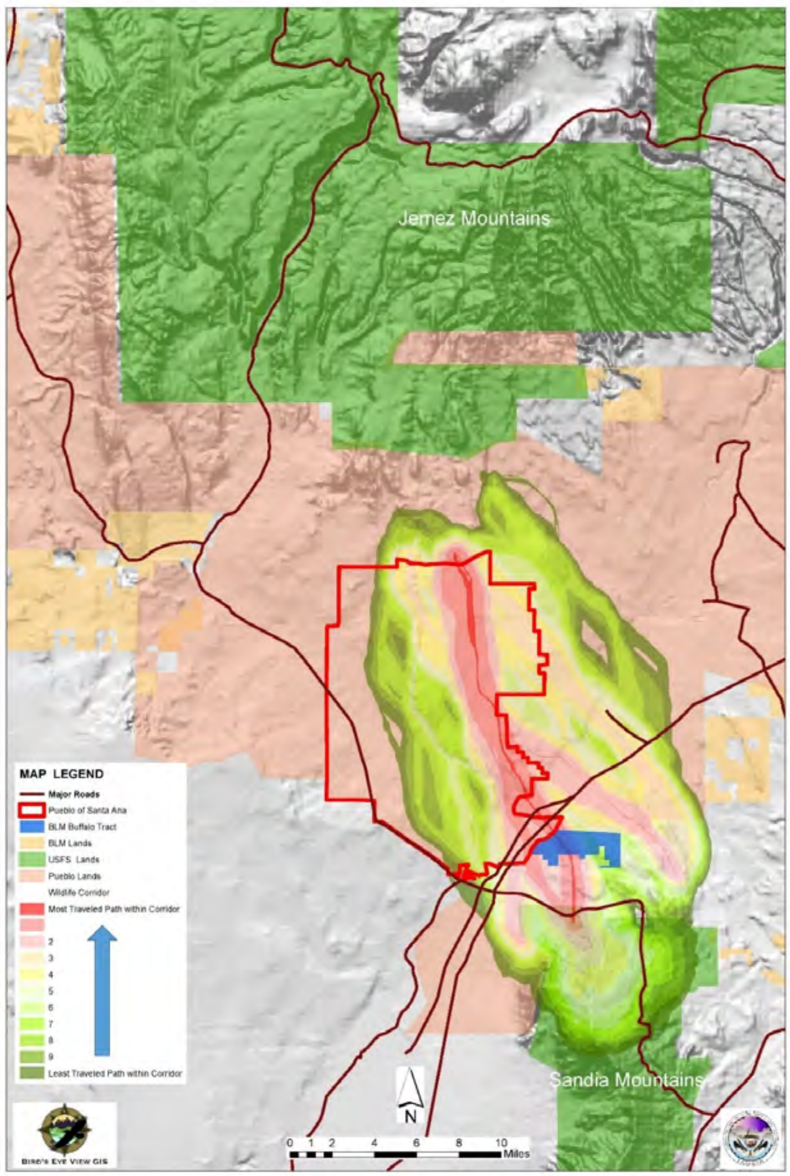

Figure 6-67. Potential cougar linkage from Sandia to Jemez Mountains, as developed in Menke (2008).

6.5.10.3.4 Public Land

There is no public land adjacent to US 550 or I-25 in this corridor. The Sandia and Jemez mountains and the foothills are primarily USFS lands, although Tribal and private lands are interspersed. Lower elevational lands between the two mountain ranges are primarily Tribal, BLM, and private. The Pueblo of Santa Ana largely lies west of I-25, and is bisected by US 550 in this corridor. The Zia Pueblo borders US 550 at the north end. The Jemez Pueblo lies north of the Zia and Santa Ana Pueblos, and is partially within the corridor. The Sandia Pueblo is bisected by I-25 in the southern portion of the corridor. The San Felipe Pueblo lies between the Santa Ana and Kewa Pueblos and is bisected by I-25. The Kewa Pueblo is generally north of I-25.

6.5.10.3.5 Support

The Pueblo of Santa Ana supports designation of this wildlife corridor and NMDOT actions to retrofit existing structures with fences and place new wildlife crossing structures on I-25 and US 550. The San Felipe Pueblo is also in support of creating wildlife crossing structures on roads across their lands. Natural resource professionals from both Pueblos helped in the field reconnaissance of this corridor.

The New Mexico Commissioner of Public Lands, Ms. Stephanie Garcia Richard, sent NMDOT a copy of a letter to the Cibola National Forest in support of the effort to protect the Crest of Montezuma Wildlife Corridor. A letter from NMDGF dated in 2007 to the Cibola National Forest Sandia Ranger District and Forest Supervisor gave support to protecting the area of the Crest of Montezuma and concern for wildlife connectivity in this corridor and the Sandia and Manzano Mountains, and Tijeras Canyon that connects them. Several other letters in support of protecting wildlife habitat connectivity in the Crest of Montezuma Corridor, dated 2007 and 2008, were also submitted. These letters demonstrated additional support from individuals, a state representative from New Mexico District 22 in Sandoval and Santa Fe Counties, and a Sandoval County Resolution, Number 3-20-08.6, to increase open space lands contiguous to the Crest of Montezuma. Mr. P. Callen of the non-profit Pathways: Wildlife Corridors of New Mexico sent a letter and provided data, maps, and photographs of wildlife in the northern Sandia Mountains and areas north and northwest of Placitas. Members of the Action Plan development team met with Mr. Callen and Mr. Johnson to review the important areas for wildlife to cross roads in this corridor. Their research and advocacy helped select this as an important wildlife corridor for the Action Plan.

Mr. David Reynolds of Kirtland Air Force Base in Albuquerque sent a letter stating that 10 years of cougar research originating on the base had GPS collar data showing locations of where cougar crossed I-25 and I-40 in the Albuquerque area. These data were used in helping to delineate the corridor.

The national non-profit organization Defenders of Wildlife sent a letter in support of this corridor stating that the area north of Placitas on I-25 has proven to be a barrier that prevents movement of cougar, deer, and elk.

Private citizens from Albuquerque, Bernalillo, and Placitas also wrote to NMDOT with letters of support for this corridor.

6.5.10.4 Recommendations Overview

The field teams that conducted the reconnaissance of this corridor included Action Plan team members and two natural resource professionals from local Pueblos: Glenn Harper of Pueblo of Santa Ana and Rueben Duran of San Felipe Pueblo. The teams visited locations along US 550 and I-25 several times and made project recommendations.

Wild animals need structures placed at distances that match the scale of their daily movement (Bissonette and Adair, 2008) and corresponding to their willingness to move along a fence line to find crossing structures. Mule deer in southern Utah were documented to change their migration movements by moving 1 mile in either direction along a new wildlife exclusion fence (Cramer and Hamlin, 2019a). This should be considered the maximum distance this project would allow for mule deer to move toward a crossing structure when encountering a fence. Herds of elk are very reluctant to use most underpasses (Cramer, 2014; Cramer and Hamlin, 2019; Gagnon et al., 2015; Kintsch et al., 2021) unless they are span bridges (Gagnon et al., 2015 and 2017) or overpasses (Kintsch et al., 2021) or an elk herd adapts over time to an underpass (Kintsch et al., 2021; Sawyer and LeBeau, 2011). Overpasses are necessary to accommodate pronghorn due to general herd avoidance of underpasses (Sawyer et al., 2016; Simpson et al., 2016). One goal of the Action Plan is to allow herds of mule deer and elk to move beneath or above the highway in their daily and migration movements. The recommendations here are prescribed specifically for the focal species and overall for the species of concern along US 550 and I-25. Mule deer will use culverts that are large and short enough for them, span bridge underpasses, and overpasses. Elk herds will use span bridge underpasses and overpasses. Single elk may use culvert underpasses, but this type of structure is not sufficient for entire herds. Herds of pronghorn are predicted to use only overpass structures, with individual animals possibly using underpass structures.

The recommendations for US 550 are presented separately from those for I-25. The Pueblo of Santa Ana GPS data on wildlife movement were helpful in locating the most important existing and future structures to facilitate wildlife movement. Both roads have recommended miles of wildlife exclusion fence and recommended retrofits to existing structures that include adding fence, which could be done with more expediency than a longer fence project.

The US 550 locations for the highest numbers of crashes and carcasses in this corridor were from MP 7 to MP 12. There are existing bridges that span drainages where seasonal waters flow. The existing bridge at MP 9.2 is the top choice to immediately place wildlife exclusion fence 1 mile in each direction to help guide wildlife to this high and wide bridge. It is in a large wash, and near the locations of the wildlife crashes. Additionally, there are several locations for potential wildlife overpasses.

On I-25, most wildlife does not even attempt to cross the highway, and the Pueblo of Santa Ana GPS data demonstrate animals coming up along the sides of I-25, but no data points occurring across the highway. The two carnivores, cougar and black bear, have been recorded as carcasses along I-25 between MP 245 and MP 246. Top choices for wildlife mitigation to help provide habitat connectivity include fencing to existing large bridges that span washes, replacing smaller older box culverts with arch culverts or bridges, and placing overpasses to the north to facilitate pronghorn movements over the highway. There is a recommended 6-mile stretch of fence on I-25 without any suitable wildlife crossing structures. The fence would help to save wildlife from getting killed on the highway if they did not perceive the risk of getting killed, which may be a far greater risk then keeping them one side or the other of the highway.

There are 11 potential species of concern in the area that could all benefit from the proposed project recommendations. The overpasses should be readily used by elk, mule deer, and pronghorn (Gagnon et al., 2021a and 2021b). Black bear and cougar have been documented using underpasses more readily than overpasses in Colorado (Kintsch et al., 2021) and Utah (Cramer, 2014), and underpasses in Arizona (Gagnon et al., 2011) and New Mexico (Loberger et al., 2021). The needs of these two carnivores may be best accommodated if the culverts are along draws and streams. Hog-nosed skunks have been documented using culverts in Arizona (Grandmaison et al., 2021), and can be expected to use structures in ways similar to striped skunks, which have been documented using culverts in Arizona (Gagnon et al., 2011), New

Mexico (Loberger et al., 2021), Utah (Cramer, 2012), and Colorado (Kintsch et al., 2021). It is therefore expected that the recommended culverts would accommodate this species. Javelina are expected to use the culverts and bridges (Traphagen, 2021), and even overpasses, as documented in Arizona (AZGFD, 2021). Kit fox have been documented using wildlife crossing structures including overpasses (Gagnon et al., 2017), and may be expected to use underpasses in manners similar to red fox. Red fox have been recorded using overpass structures in Colorado (Kintsch et al., 2021) and underpass structures in New Mexico (Loberger et al., 2021), Colorado (Kintsch et al., 2021; Cramer and Hamlin, 2021), and Utah (Cramer and Hamlin, 2019 and 2021). The ornate box turtle has not yet been found using structures, but would be expected to more readily use the overpasses and underpasses if they contained logs, tree stumps, large rocks and boulders, and native vegetation.

Figure 6-68 shows the priority mitigation actions along with land ownership information. The full complement of mitigation recommendations is provided in Table E-10 (Appendix E).

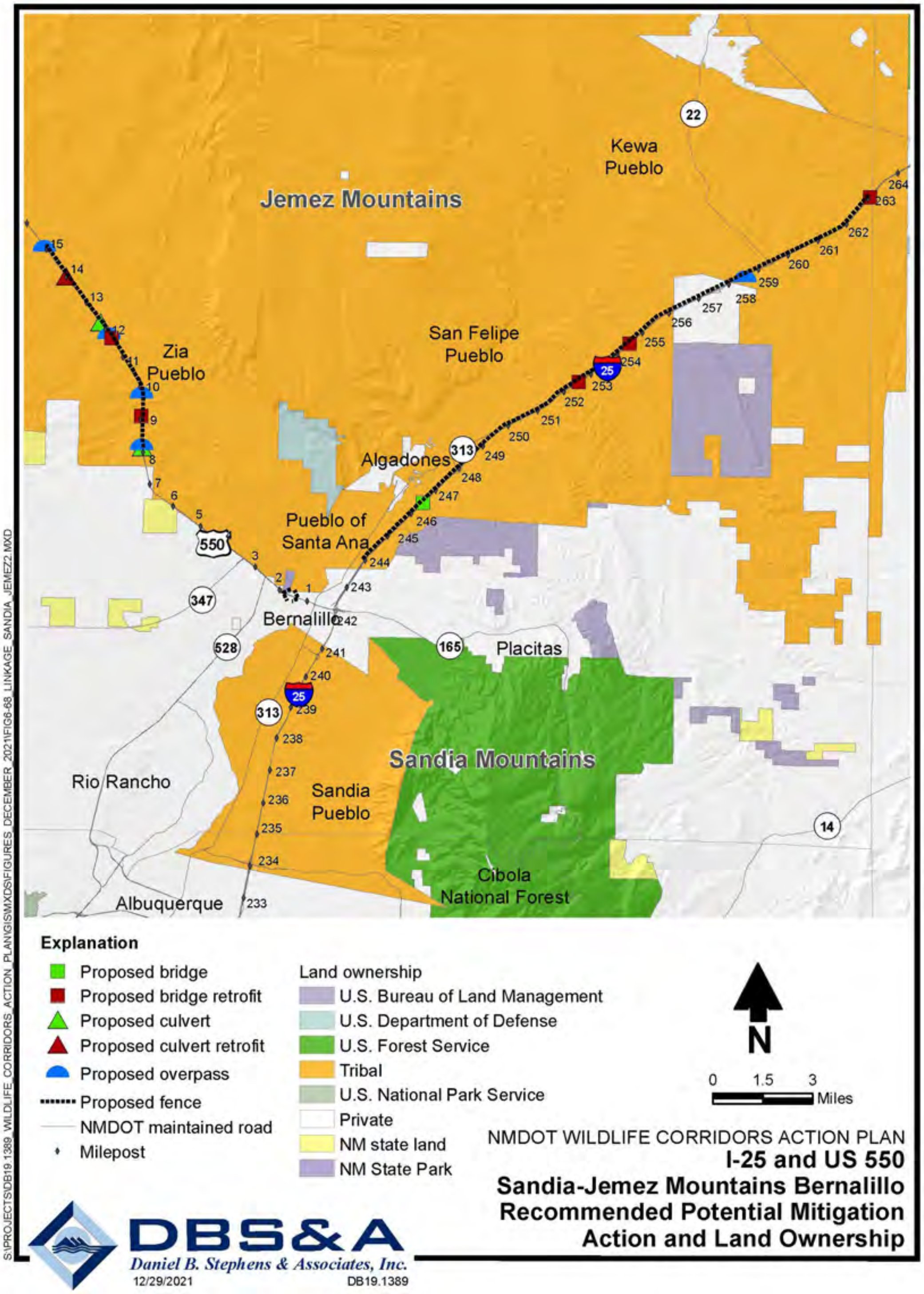

Figure 6-68. Land ownership and recommended project mitigation actions in the Sandia-Jemez Mountains wildlife corridor.

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The priority recommendations are presented in Figure 6-69.

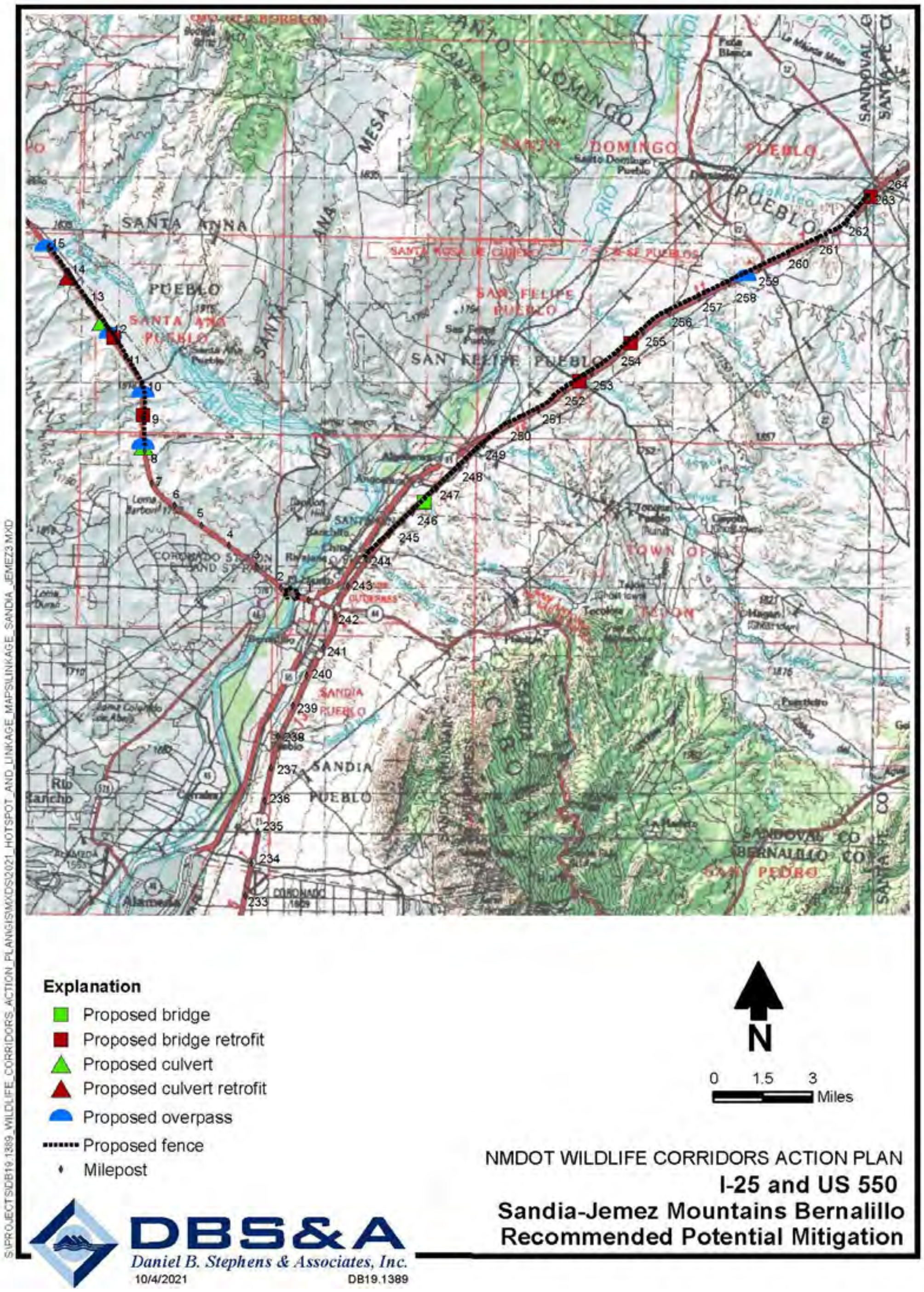

Figure 6-69. Top priority mitigation recommendations for the Sandia-Jemez Mountains wildlife corridor.

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6.5.10.5 Specific Wildlife-Highway Mitigation Recommendations

The recommendations give an overview estimate of what can be done for wildlife mitigation. Many of the existing culverts and bridges are presented in Table E-10 (Appendix E) to provide evidence of opportunities to replace them with more wildlife-friendly structures—for example, when the infrastructure is replaced or when there is a transportation project nearby. The Action Plan team is not presenting these recommendations as the final and only opportunities for enhancing wildlife movement below and above the roads. Rather, these are the top recommendations based on a one-day field reconnaissance of each project area, existing road conditions, 2021 costs, and the current state of the science and practice of transportation ecology.

6.5.10.5.1 Cost-Effective Short-Term Solutions

Both roads in this corridor are four-lane highways, which preclude any driver warning systems due to the high speeds of the vehicles, traffic volumes, and the widths of the highways.

The most cost-effective short-term solution in this corridor would be to provide maintenance to the existing structures to remove landowner/livestock manager fences across structures or in NMDOT right-of-way, work with those landowners to replace five-strand fence with wildlife friendly fence and move fences back from the mouth of structures, and clear the debris of sand and other build-up in structures that are placed along arroyos. This would help larger wildlife to pass beneath the highway in these structures.

6.5.10.5.2 Retrofit Existing Infrastructure

Many of the following actions can be conducted in a matter of months after the release of the Action Plan, within the usual NMDOT daily maintenance and operations activities. The fence projects will take longer to secure funding and install.

- *US 550 MP 14 Four-Cell Culvert:* Place fence at the existing four-cell box culvert bridge from abutments out in both directions, and for distance determined by wildlife ecologists from NMDOT, NMDGF, and Pueblo of Santa Ana. Clear the sediment in the culverts. Remove fence blocking the culverts on west side. Plan for this culvert to be replaced by a bridge in the future.
- *US 550 MP 11.8 Three-Cell Culvert:* Place fence at the existing three-cell box culvert bridge from abutments out in both directions, and for distance determined by wildlife ecologists from NMDOT, NMDGF, and Pueblo of Santa Ana. Clear the sediment in the culverts.

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Remove fence blocking the culverts on west side. Plan for this culvert to be replaced by a bridge in the future.

- *US 550 MP 9.2 Bridge:* This is the most important retrofit of an existing structure in this entire corridor, and should be prioritized immediately. Place approximately 1 mile of wildlife exclusion fence, 8 feet high out from this bridge in both directions of the highway.
- *US 550 MP 8.5 Culvert*: Place fence extending out from the culvert in both directions of the highway. Trim some of the vegetation nearby so animals can find it and prey species can be less wary of predators. Remove and pull back landowner barbed wire fence at west entrance.
- *US 550 MP 1.6 Rio Grande Bridge:* Work with government agencies and the public to decide how much fence to place along the highway from bridge abutments. The Action Plan recommends 0.25 mile of fence in each direction off of each corner of the bridge to guide wildlife to it. Design the fence in a manner that helps keep wildlife off the highway; learn how to do this with field visits by agency wildlife ecologists.
- *I-25 MP 252.5 Bridge:* Place wildlife exclusion fence extending out from this bridge. Work with well-qualified wildlife biologists working for NMDOT, NMDGF, and the Pueblo of Santa Ana as to how far out to extend this fence. Plan for a future project where the fence will extend well beyond this retrofit fence both north and south.
- *I-25 MP 254.5 Bridges:* Place wildlife exclusion fence extending out from both bridges that support opposite lanes of traffic. Possibly work with San Felipe Pueblo biologists on how far to extend it. Also include NMDOT and NMDGF biologists regarding the distance of fence placement. There are elk in the area, so this is a concern.
- *I-25 MP 263.1 Bridge:* Place wildlife exclusion fence extending out from the bridge. Possibly work with Kewa Pueblo biologists on how far to extend it. The field visit found signs of mule deer, elk, and canid species.

6.5.10.5.3 Intermediate Solutions - New Structures

Intermediate solutions would involve the installation of new underpasses for wildlife. Because elk herds are not typically willing to use these unless they are large bridges, underpasses may not be a full solution. If there are places with only mule deer problem areas, then underpass structures could be a full solution. Underpass choices for elk in this area are only span bridges, which elk have used readily in Arizona (Dodd et al., 2007; Gagnon et al., 2011), and in an ongoing New Mexico study (Gagnon and Loberger, 2021). The following new structures are for both culverts and bridges. It is understood that the new wildlife underpass culverts would not be expected to accommodate elk herds. These animals would be expected to use the overpasses, and existing and new bridges.

- *US 550 MP 12.3 New Wildlife Underpass Culvert:* Replace the existing three-celled box culvert with a single span bridge, arch culvert, or large box culvert. A bridge is preferred if its cost is similar to culvert costs.
- *US 550 MP 8.2 New Wildlife Underpass Culvert*: Replace the existing three-cell box culvert with an arch culvert. Place at least 0.25 mile of wildlife exclusion fence extending from both ends of the bridge if there is no continuous fence project extending the fence further.

6.5.10.5.4 Solutions Based on Best Management Practices

- *US 550 MP 15.1 West Fence End:* For a full mitigation project, the wildlife exclusion fence would start here and extend east-southeast.
- *US 550 MP 8.2 East Fence End:* For full mitigation project. If not fully placed for the 6.9 miles, ensure wing fences at all existing and new structures.
- *US 550 MP 15.1 Wildlife Overpass:* This overpass location has Pueblo of Santa Ana lands on both sides. The Pueblo supports an overpass at this location, which was selected in conjunction with the Pueblo's Range and Wildlife Division Manager, Mr. Harper. Mule deer, elk, cougar, and black bear are known to use this area.
- *US 550 MP 14 – New Wildlife Underpass Bridge:* Replace the four-cell culvert bridge with a span bridge. This is a major arroyo and the landscape is open for all types of wildlife. A bridge would help accommodate future flooding expected with climate changes when spring runoff and monsoonal rains may be heavier than historically.
- *US 550 MP 11.9 Wildlife Overpass:* This overpass location has Pueblo of Santa Ana lands on both sides. The Pueblo supports an overpass at this location, which was selected in conjunction with the Pueblo's Range and Wildlife Division Manager, Mr. Harper. It is another important location for the movement of mule deer, elk, pronghorn, black bear, and cougar.
- *US 550 MP 11.8 – New Wildlife Underpass Bridge:* Replace existing three-cell culvert bridge with a bridge. With the heavy sediment accumulation from arroyo water events, a bridge would result in lower maintenance costs over the years, and much more wildlife movement than the existing culverts.

- *US 550 MP 9.9 Wildlife Overpass:* This proposed overpass location has Pueblo of Santa Ana lands on both sides. The Pueblo supports an overpass at this location, which was selected in conjunction with the Pueblo's Range and Wildlife Division Manager, Mr. Harper. There are many wildlife crashes recorded near MP 10, and this is an important area for wildlife, with GPS data showing that mule deer, elk, pronghorn, black bear, and cougar all move close to and over the road nearby.
- *US 550 MP 8.3 Wildlife Overpass:* Suitable topography for an overpass, which would be located in an area with Santa Ana lands on both sides. The Pueblo supports an overpass at this location, which was selected in conjunction with the Pueblo's Range and Wildlife Division Manager, Mr. Harper. Still in a high wildlife-vehicle crash zone.
- *I-25 MP 244 South Fence End:* This southern fence end would be placed in conjunction with actions to retrofit existing structures and building new structures to help wildlife pass beneath I-25.
- *I-25 MP 263.1 North Fence End:* This would entail 19 miles of wildlife exclusion fence.
- *I-25 MP 246.5 New Wildlife Underpass Bridge:* Replace the existing three-cell box culverts with a bridge. This area is a top priority for wildlife habitat connectivity. Consult with San Felipe Pueblo. Black bear and cougar recorded killed near MP 245, and NMDOT crash data indicate mule deer killed here. This location is in one of the top priority smaller corridors for movement. Replace culvert with bridge as soon as possible.
- *I-25 MP 258.5 Wildlife Overpass:* This is the number one overpass location for helping pronghorn cross I-25. Pueblo of Santa Ana data show pronghorn activity solely on the northwest side of I-25. This location is on Kewa Pueblo lands.

6.5.10.6 Benefit-Cost Analysis

There are several types of benefit-cost analyses. However, they all share the same basic premise, which is to use a benefit-cost ratio with the benefit in the numerator and the cost in the denominator. The cost is associated with the construction and maintenance of the proposed mitigation infrastructure. The estimated monetary benefit is derived from the reduction in the number of crashes over the lifetime of the mitigation.

The unique approach here is based on the Colorado DOT's new method of including the economic value of elk and mule deer not killed in crashes as a result of the mitigation among the benefits (Kintsch et al., 2019).

6.5.10.6.1 Ballpark Estimates for Costs of Infrastructure

Table 6-46 presents the costs per unit for overpasses, bridges, and culverts placed on a four-lane highway as estimated by the Action Plan development team's engineers based on NMDOT 2019 cost estimates. The price of 8-foot wildlife exclusion fence per mile for both sides of the highway, double cattle guards, also known as game guards, and escape ramps are all taken from Colorado DOT estimates in the West Slope Study (Kintsch et al., 2019).

Table 6-46. Sandia-Jemez Mountains wildlife corridor project wildlife mitigation rough cost estimates.

Infrastructure	Cost per unit	Cost for Infrastructure
US 550 MP 15.1 overpass (4-lane)	$7,280,000	$7,280,000
US 550 MP 11.9 overpass (4-lane)	$7,280,000	$7,280,000
US 550 MP 9.9 overpass (4-lane)	$7,280,000	$7,280,000
US 550 MP 8.3 overpass (4-lane)	$7,280,000	$7,280,000
I-25 MP 258.5 overpass (4-lane)	$7,280,000	$7,280,000
US 550 MP 12.3 culvert (4-lane)	$2,280,000	$2,280,000
US 550 MP 8.2 culvert (4-lane)	$2,280,000	$2,280,000
I-25 MP 246.5 bridge (4-lane)	$2,520,000	$2,520,000
26 miles of fence: US 550 7 miles; I-25 19 miles.	$100,000/mile	$2,600,000
Approximately 30 double cattle guards	$60,000	$1,800,000
Escape Ramps, 4 per mile x 26 miles = 104	$14,000	$1,456,000
Total		$49,336,000

6.5.10.6.2 Animal-Vehicle Crash Costs

From 2009 to 2018, there were 57 crashes that involved animals in this wildlife corridor. The crash severity of these included 51 property damage only crashes, 2 Class C injury crashes, 3 Class B injury crashes, 1 Class A injury crash, and 0 fatal crashes.

The NMDOT 2019 and FHWA 2018 (Harmon et al., 2018) cost values for these crashes are presented in Table 6-5. Based on these values, the costs of the animal crashes in this hotspot were calculated (Table 6-47).

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Table 6-47. Calculation of wildlife-vehicle crash costs in the Sandia-Jemez Mountains wildlife corridor using NMDOT and FHWA crash cost values.

Crash Type	NMDOT-Estimated Individual Crash Costs to Society	Total NMDOT Value of Crashes	FHWA-Estimated Individual Crash Costs to Society Based on Harmon et al. (2018)	Total FHWA Value of Crashes
51 property damage only	$7,400	$377,400	$ 11,900	$606,900
2 possible injury (Type C)	$44,900	$89,800	$125,600	$251,200
3 minor injury (Type B)	$79,000	$237,000	$198,500	$595,500
1 incapacitating/serious injury (Type A)	$216,000	$216,000	$655,000	$655,000
0 fatality	$4,008,900	0	$11,295,400	0
Total		$920,200		$2,108,600

The benefits portion of the ratio is estimated by examining the expected reduction in crash costs. These benefits are estimated by taking the crash costs and multiplying by the, 90 percent reduction of crashes the mitigation can be expected to provide, expected 75-year lifespan of the mitigation project, and economic value of mule deer and elk saved by the mitigation over 75 years (Table 6-48).

Table 6-48. Estimated value of the mitigation benefits, Sandia-Jemez Mountains wildlife corridor.

	NMDOT Crash Values	FHWA Crash Values
Total value of crash costs over 10 years	$920,200	$2,108,600
Crash cost per mile per year	$2,556	$5,857
Crash cost for 36 miles of project over 75 years of infrastructure (Cost/mile/year x 36 x 75)	$6,901,200	$15,813,900
If mitigation reduced crashes by 90%, over 75 years, that value would be:	$6,211,080	$14,232,510
Wildlife Lost and Saved Values		Estimated Value of Elk and Mule Deer Saved over 75 years of Mitigation
It would be expected that approximately 0.6 elk, and 1.0 mule deer will be involved in crashes annually for the 6 elk and 10 mule deer crashes recorded in 10 years of crash data. If 90% of these were expected to be reduced from the above mitigation, this would equate to 0.9 x these amounts: 0.54 elk annually, and 0.9 mule deer annually. At a value of: $2,392 for each elk, and $2,061 for each mule deer, then the value of animals saved each year x 75 years of mitigation= Elk ($2,392 x 0.54 x 75 years) + Mule deer ($2,061 x 0.9 x 75 years) = Elk - $ 96,876 + Deer = $ 139,118 = $235,994		$235,994

6.5.10.6.3 Benefit-Cost Ratio

- NMDOT values for crashes:
  Benefit/Cost Equation = $6,211,080+ $235,994/$49,336,000 = 0.14
- FHWA Values for Crashes
  Benefit/Cost Equation = $14,232,510+ $235,994/$49,336,000 = 0.29

At this time, the full list of mitigation measures would not be expected to pay for the reduction of crashes over 75 years. If the full list of mitigation measures equaled approximately $6.75 million, the project would be expected to possibly pay for itself over the same time period based on NMDOT crash costs.

6.5.11 NM 38 Questa to Red River Wildlife Corridor Recommendations for Wildlife Mitigation Projects

- *9-mile corridor, 7.7 miles of mitigation*
- *Taos County*
- *NMDOT District 5*

6.5.11.1 *Project Area Overview*

The Questa wildlife corridor is based primarily on the needs of Rocky Mountain bighorn sheep to cross the road and their involvement in WVCs. Mule deer and elk are also involved in WVCs in this corridor and could benefit from transportation wildlife projects (Figure 6-70).

Figure 6-70. Bighorn sheep (top) are the focus of this wildlife corridor, but it is also designated to help wildlife of all species to move across this landscape (photo credit: AZGFD and M. Watson).

The project area is located within the Taos Mountains subrange of the Sangre de Cristo Mountains. Vegetation is dominated by ponderosa pine and mixed conifer forest, typical of the Southern Rocky Mountains ecoregion at this elevation. The Red River follows along the south side of NM 38 throughout most of the project area, and the Carson National Forest borders this stretch of roadway intermittently. The Chevron Questa Mine, previously known as the Molycorp Mine, is owned by Chevron Mining Inc., and borders the project area for approximately 5 miles on the north side of the road. The mine was added to the National Priorities List as a Superfund Site by the U.S. Environmental Protection Agency in 2011, and was permanently closed in 2014.

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The mine is currently undergoing reclamation and attracts Rocky Mountain bighorn sheep to the restored plantings.

NM 38 from Questa to Eagle Nest is part of a well-known scenic driving route called "The Enchanted Circle Scenic Byway." Along the route are several well-known tourist destinations—such as Taos, Red River, and Angel Fire—that draw visitors year-round. This area offers numerous outdoor recreational opportunities and cultural attractions.

NMDGF identified this area as one of primary importance for bighorn conservation within its S.O. 3362 Action Plan. Deer, elk, and bighorn sheep summer in the high elevations, but exact wintering areas and movement corridors are unknown. Human development associated with the recreation industry and mineral extraction makes this area at high risk for habitat fragmentation, which would further sever movement between summer and winter ranges (NMDGF, 2020). The S.O. 3362 Action Plan states that "[t]aking mitigation actions to reduce wildlife-vehicle collisions at high-risk areas," could benefit big-game herds in the Northern Sangre de Cristo Mountains (NMDGF, 2020).

NMDOT wildlife crash data are shown on a map of the corridor in Figure 6-71.

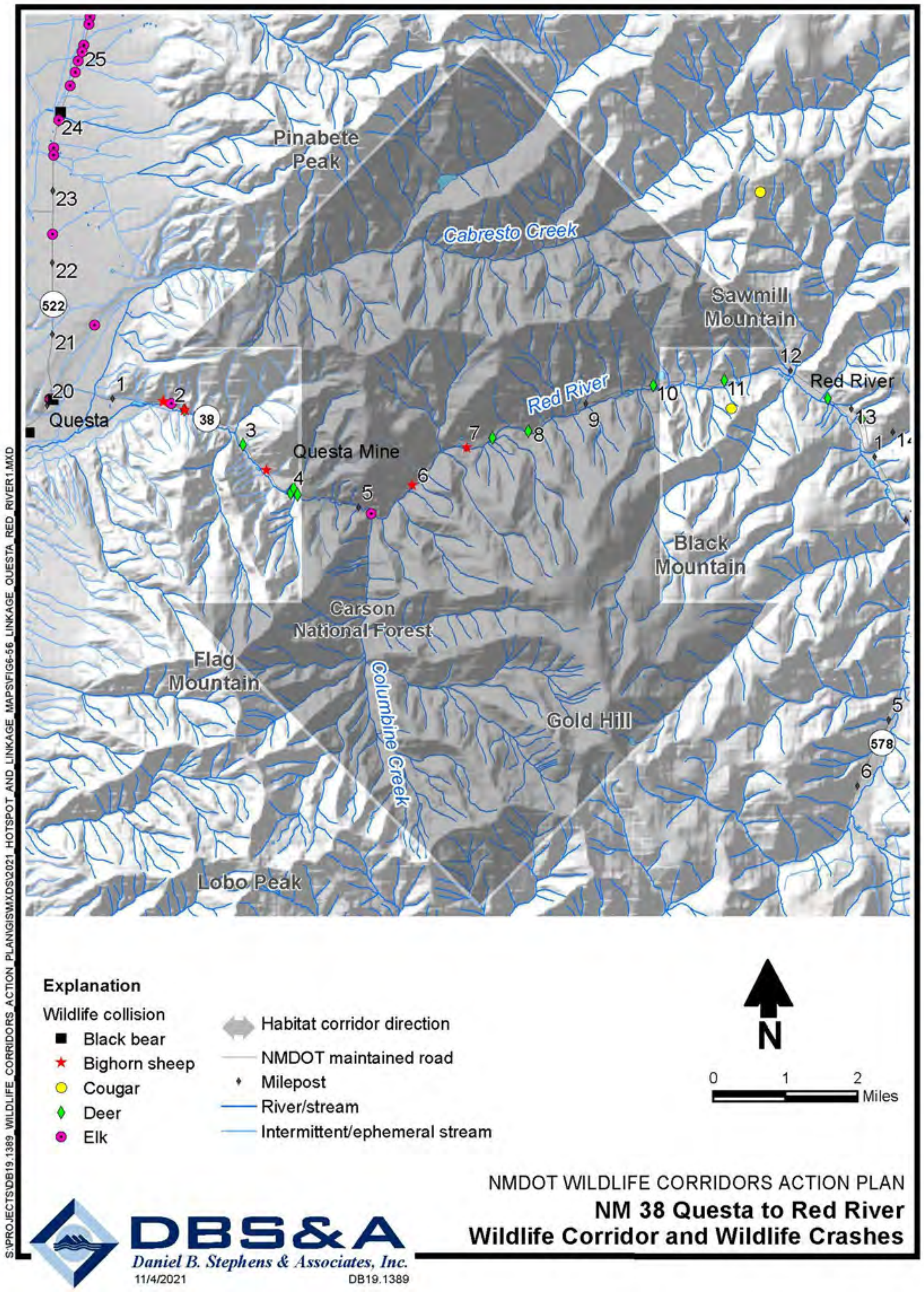

Figure 6-71. Wildlife-vehicle crashes and wildlife movement in the Questa wildlife corridor.

6.5.11.2 Transportation – Safety Statistics

The crash data reported in the following subsections include both animal-vehicle crashes and wildlife-vehicle crashes to better reflect the impact of collisions with all animals. Animal-vehicle crashes include wild and domestic animals and livestock. Using all animal statistics to evaluate the situation helps the reader to differentiate where there are strictly wildlife problem areas, and where these domesticated animals may also be involved. The recommended wildlife mitigation that includes wildlife exclusion fences would be expected to reduce all these crashes, not just those with wildlife. Therefore, the total animal crashes are reported and then used in the benefit-cost analyses of the value of the recommended infrastructure. The reported wildlife crashes are those strictly with the six focal species: mule deer, elk, pronghorn, bighorn, black bear, and cougar.

6.5.11.2.1 Wildlife-Vehicle Crashes per Mile per Year

According to NMDOT data, there were 24 reported crashes involving all animals and 19 reported crashes involving the focal species in this wildlife corridor between 2009 and 2018 (Table 6-49).

Table 6-49. Questa wildlife corridor, NMDOT crashes with all animals and with the six focal species, 2009-2018.

Length (miles)	Total Crashes with All Animals	Total Crashes with Focal Species	Wildlife Crashes per mile per year	Crashes with Six Focal Species					
				Deer	Elk	Black Bear	Cougar	Pronghorn	Bighorn Sheep
9	24	19	0.21	8	3	0	0	0	8

6.5.11.2.2 Seasonality of Wildlife-Vehicle Crashes

WVCs occurred most frequently during June, with smaller peaks in March and October (Figure 6-72). WVCs involving bighorn sheep are mostly concentrated in spring, with additional spikes from fall to early winter, while WVCs involving deer occur during the warmer months (May through October). NMDGF biologists have observed bighorn sheep using this area from late winter through early summer.

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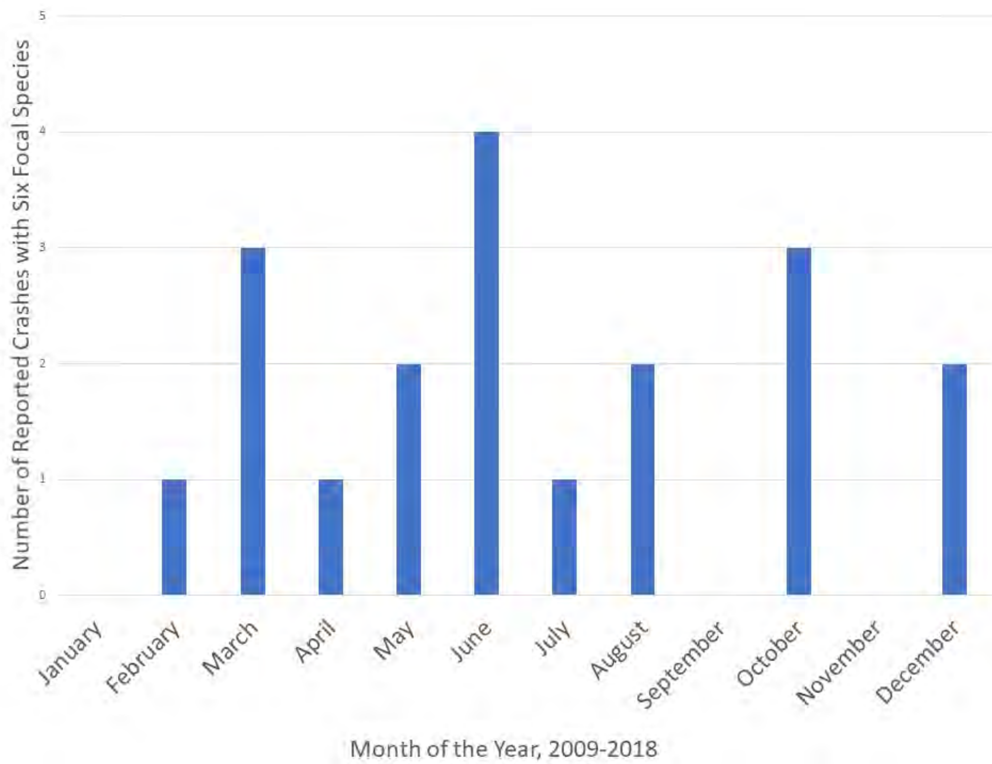

Figure 6-72. Number of reported crashes with focal species by month in the Questa wildlife corridor.

6.5.11.2.3 WVC Species Percentages

Of the WVCs in this wildlife corridor, 42 percent involved mule deer, 16 percent involved elk, and 42 percent involved bighorn sheep.

6.5.11.2.4 Wildlife-Vehicle Crashes as Percentage of All Crashes

There were 51 total crashes in this corridor from 2009 to 2018. Of these, 24 crashes were with animals. There were 19 reported crashes with the focal species, representing 37 percent of all crashes.

6.5.11.2.5 Average Annual Daily Traffic (AADT)

AADT is important in estimating if large wild animals such as the six focal species have opportunities to cross the roads under scrutiny. Traffic volumes can form a complete barrier to wildlife movement all day and into the night once AADT reaches well above 20,000 vehicles per day. At 10,000 vehicles per day there is still a barrier, with some opportunity for nocturnal movements across roads. Wildlife can find limited opportunities to cross roads with AADT

between 2,000 and 10,000 vehicles per day. However, at AADT of 2,000 and 10,000 per day, wildlife will try to cross roads, and will have greater mortality in some areas because of the lower perceived risk by wild animals but the continued presence of vehicles (Charry and Jones, 2009; Ng et al., 2004; Seiler, 2005).

AADT in the corridor was 1,643 vehicles per day in 2018, but is projected to decrease to 1,291 vehicles per day by 2038.

6.5.11.2.6 Number of Lanes

The road has two lanes throughout the corridor.

6.5.11.2.7 STIP Possibility

None, but there is one adjacent, east of project.

- STIP Control Number 5101410, NM 38 Pedestrian Improvements, Bicycle and Pedestrian. MP 11-13. District 5, 2024 start. Total Programmed = $1,157,614.

6.5.11.3 Ecological and Feasibility Considerations

6.5.11.3.1 Species of Concern

There are eight species of concern that could potentially be found in this corridor: bighorn sheep, mule deer, elk, black bear, cougar, red fox, American badger, and white-tailed jackrabbit. Mule deer, elk, and bighorn sheep have been involved in some of the recorded WVCs in the corridor.

6.5.11.3.2 Data

NMDGF bighorn sheep vehicle-strike data were used to help identify this area and locations where bighorn sheep were most often struck by vehicles, apart from NMDOT crash data. NMDGF also provided black bear and cougar mortality data, which included locations where these species were killed by vehicles on roads, and additional locations where mortality was related to other causes. However, no cougar or black bear WVCs were identified in this corridor.

6.5.11.3.3 Public Land

The USFS (Carson National Forest) owns land for 5 miles on one side and 4 miles on both sides of NM 38.

6.5.11.3.4 Support

NMDGF bighorn sheep biologist Eric M. Rominger, Ph.D. submitted the following information (February 21, 2020):

> At the moment the only population that we think is at risk of population level mortality is the Red River herd, and even there it would take a semi-truck type collision with many more sheep than have been killed to date on an annual basis. All other cases of road strike are incidental and essentially rare. None are associated w/ state lands/parks/wildlife areas.

NMDGF Biologists Mike Herman conveyed the following:

> Rocky Mountain bighorn sheep spend time in winter/spring along roadway and have been hit, including a human fatality. NMDGF placed portable messaging boards in Spring 2020.

The human fatality may not have been documented as a WVC; therefore, animal-vehicle and wildlife-vehicle crash analysis did not confirm this information. However, M. Watson of the Action Plan development team is aware of the incident, which involved two people on a motorcycle hitting a bighorn sheep herd on the road.

6.5.11.4 Recommendations Overview

Only an overpass—or several overpasses—would work for bighorn sheep. If the goal is to ensure that all genders and age groups can safely cross NM 38, then overpass structures are the only option. Along SR 68 in Arizona, AZGFD monitored underpasses built for bighorn sheep and, over a 2-year period only documented a few dozen ram crossings, and no ewe or lamb crossings (Bristow and Crabb, 2008). Results from the AZ SR 68 study led to the addition of three overpasses for desert bighorn sheep along US 93 in the same mountain range as SR 68. Researchers documented more than 6,000 successful bighorn sheep movements over the overpasses involving all gender and age classes (Gagnon et al., 2017). In Colorado, SH 9 had two overpasses and five underpasses placed for wildlife. The bighorn sheep in the area preferred using the overpasses, with all genders and ages recorded moving across them in much higher proportions than expected from the ratio of overpasses to underpasses that were available (Kintsch et al., 2021).

Placement of wildlife exclusion fence is only recommended if multiple wildlife crossing structures will be placed in conjunction with the fence. With daily traffic levels well below 1,700 vehicles on NM 38, there is still an opportunity for many types of wildlife species to cross this road when traffic is not present, such as at night and during off-seasons for recreationists. If the full mitigation package (a single project to be installed all at once, including the potential overpass and bridge structures) presented below is not an option, then only wing fences are recommended on the existing structures most likely to allow multiple species of wildlife to move beneath the road. Most of the existing culverts are too small for ungulates, and could not be used by these focal species; therefore, care should be taken in any fence placement.

The 9-mile corridor presents challenges to placing wildlife crossing structures that bighorn sheep will use. None of the existing culverts and bridges could be retrofitted to encourage use by herds of bighorn sheep. Only new overpasses would be expected to provide bighorn sheep habitat connectivity. The placement of wildlife overpasses has to be strategic and minimal given the cost. The Action Plan team recommends both overpass structures and animal detection driver warning systems to help mitigate this road for bighorn sheep and other wildlife. Gagnon et al. (2019) found that animal detection systems hold much potential for reducing WVCs and allowing wildlife to safely cross the road in the areas where they are placed. The animal detection driver warning system would be placed at each fence end to warn motorists of wildlife entering the roadway. The addition of electrified mats or pavement or double cattle guards (game guards) at the fence ends can significantly reduce the probability of wildlife entering the fenced right-of-way, where they could become trapped between the fences. However, there is a need for the electric technologies to continue to be monitored to gauge how they may work and their maintenance needs over extended periods of time. Only two existing concrete box culverts were identified as marginally sufficient for mule deer movement. Both culverts contain Red River flow throughout their usable width; thus, terrestrial wildlife passage would be difficult. Additional visits to these culverts during various seasons will help NMDOT and NMDGF determine if they have value for terrestrial wildlife movement. The top-priority recommendations for the installation of three wildlife overpasses and one underpass bridge, along with the two retrofitted culverts, would help ensure opportunities for wildlife habitat connectivity across NM 38 for all species of concern.

There are eight potential species of concern in the area that could all benefit from the proposed project recommendations. The overpasses should be readily used by bighorn sheep, elk, and mule deer. The black bear and cougar should readily use all the culverts, especially those along drainages. The mule deer could readily use larger and short culverts. Elk would be expected to use both areas under larger bridges and overpasses. American badger and red fox will also benefit. Both of these carnivores have been recorded using overpass structures in Colorado (Kintsch et al., 2021) and underpass structures in New Mexico (Loberger et al., 2021), Colorado

(Kintsch et al., 2021; Cramer and Hamlin, 2021), and Utah (Cramer and Hamlin, 2019 and 2021). The white-tailed jackrabbit is expected to use both underpass and overpass structures, as other species of jackrabbit have used structures in Colorado (Cramer and Hamlin, 2021; Kintsch et al., 2021), Arizona (AZGFD, 2021), and Utah (Cramer and Hamlin, 2019). Smaller animals such as medium-sized and small mammals, lizards, snakes, amphibians, and invertebrates would benefit from the placement of logs, tree stumps, large rocks and boulders, and native vegetation all along the road-crossing structures.

Overall the research team recommendation priorities included: three new wildlife overpasses, one new bridge, and fence from MP 1.3 to MP 9.

Figure 6-73 shows the priority mitigation actions along with land ownership information. The full complement of mitigation recommendations is provided in Table E-11 (Appendix E).

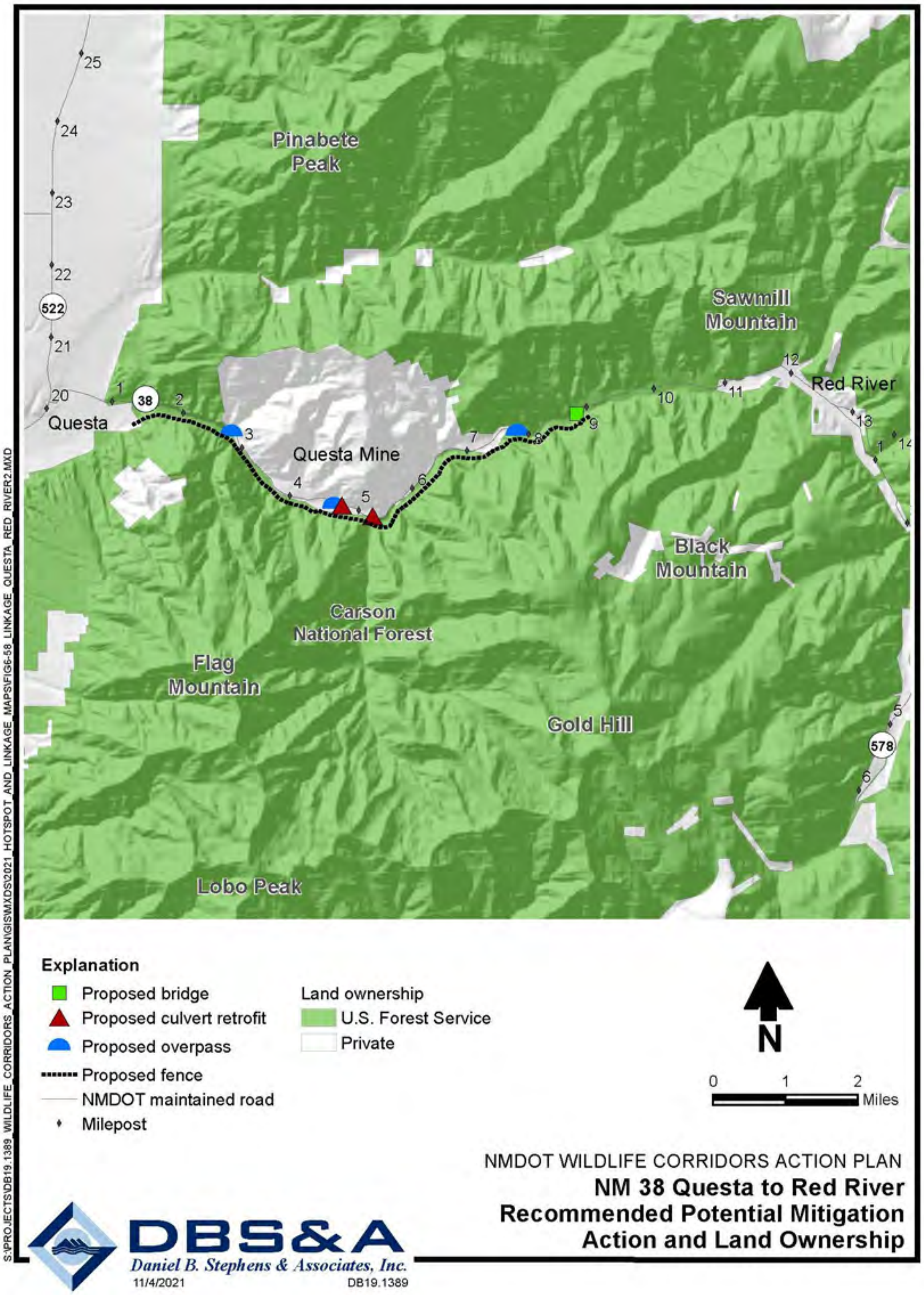

Figure 6-73. Land ownership and recommended project mitigation actions in the Questa wildlife corridor.

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The priority recommendations are presented in Figure 6-74.

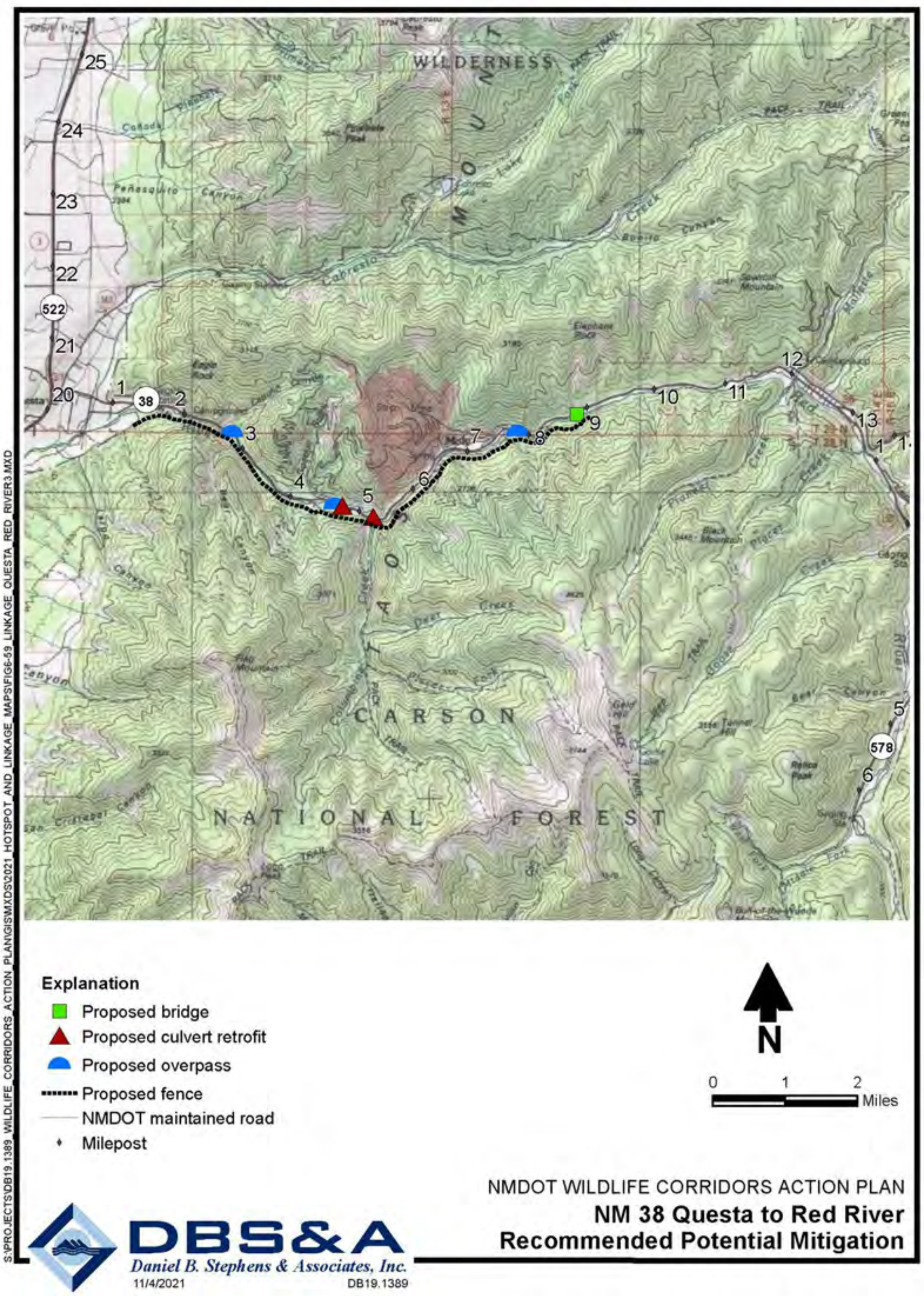

Figure 6-74. Top priority mitigation recommendations for the Questa wildlife corridor.

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6.5.11.5 Specific Wildlife-Highway Mitigation Recommendations

The recommendations give an overview estimate of what can be done for wildlife mitigation. Many of the existing culverts and bridges are presented in Table E-11 (Appendix E) to provide evidence of opportunities to replace them with more wildlife-friendly structures—for example, when the infrastructure is replaced or when there is a transportation project nearby. The Action Plan team is not presenting these recommendations as the final and only opportunities for enhancing wildlife movement below and above the roads. Rather, these are the top recommendations based on a one-day field reconnaissance of each project area, existing road conditions, 2021 costs, and the current state of the science and practice of transportation ecology.

6.5.11.5.1 Cost-Effective Short-Term Solutions

Variable message boards should be placed on each end of the corridor starting in December. They should indicate the level of danger and keep a tally of crashes to date to keep local drivers engaged. Place eastbound message boards at MP 1.5 and westbound message boards at MP 7.0. State the length of the road segment associated with an elevated risk of WVC. Boards may be removed in the early summer or when peak wildlife activity passes. Placement of variable message boards within this wildlife habitat linkage is the current approach taken by NMDGF.

6.5.11.5.2 Retrofit Existing Infrastructure

Two existing culverts, one at MP 4.8 and one at MP 5.3, were recommended as retrofits by placing wing wildlife exclusion fence. These are very minimally passable by terrestrial wildlife, and should be reviewed in various seasons to see if terrestrial wildlife passage by mule deer and smaller animals is possible. If not, no fences should be installed.

6.5.11.5.3 Intermediate Solutions - New Structures

Ungulates need structures approximately every mile (Bissonette and Adair, 2008), although Dodd et al. (2007) found that 2 miles between crossing structures was acceptable for elk in Arizona. A system of overpass structures, some underpass structures, fences, and escape ramps is important to a fully mitigated corridor. Based on the spacing between proposed crossing structures in this corridor, a partially constructed mitigation project for the Questa wildlife corridor is not recommended. There is either sufficient wildlife crossing structures for various types of animals plus wildlife exclusion fence or there are several structures with wing or short distances of wildlife exclusion fence, which would suffice to provide movement opportunities for bighorn sheep and other wildlife in places where there is not a sufficient wildlife crossing structure and they can cross the road at grade.

6.5.11.5.4 Solutions Based on Best Management Practices

Large overpasses and bridge structures are the only recommended wildlife mitigation solution deemed to be a best management practice. The Action Plan development team recommends that the wildlife overpasses be 150 feet wide to encourage use by bighorn sheep. In areas where overpass structures cannot be placed, the alternative would be to warn drivers to slow down and watch for wildlife on the road.

- *MP 1.3 and MP 9.0 – Animal Activated Detection System:* The two separate systems would be placed at the proposed fence ends. At MP 1.3 the warning signs would be several hundred feet west of the fence end. The animal activated detection system would be installed at a later date when such systems have been refined enough to be reliable. A separate driver warning system would be placed at MP 9.0.
- *MP 2.7 Wildlife Overpass:* This is the top priority wildlife overpass location. Bighorn sheep have been involved in WVCs to the west closer to MP 2. The USFS lands are on the south side of the highway, and the Questa Mine lands are on the north side. Placement would need to involve working with Chevron.
- *MP 4.6 Wildlife Overpass:* Mule deer and elk have been killed nearby. The USFS lands are on the south side of the highway, and the Questa Mine lands are on the north side. Placement would need to involve working with Chevron mine owners.
- *MP 7.8 Wildlife Overpass:* This overpass would need to span the river at this location. The most eastern bighorn sheep crash occurred near MP 6.8, west of here. This would be the easternmost overpass location for bighorn sheep based on crash data. The USFS owns land on both sides of the road at this location.
- *MP 8.8 Wildlife Underpass Bridge:* This bridge could replace the current culvert, which is ill-suited for water flow. The new bridge could better meet drainage needs and changes in hydrology caused by climate change. A new bridge would restore aquatic and terrestrial connectivity and processes in the stream. It would not be for bighorn sheep, but for other mammals, large and small. If fencing extends this far east, this is an important structure for all wildlife. The USFS owns land on both sides of the road at this location.

6.5.11.6 Benefit-Cost Analysis

There are several types of benefit-cost analyses. However, they all share the same basic premise, which is to use a benefit-cost ratio with the benefit in the numerator and the cost in the denominator. The cost is associated with the construction and maintenance of the proposed mitigation infrastructure. The estimated monetary benefit is derived from the reduction in the number of crashes over the lifetime of the mitigation.

The unique approach here is based on the Colorado DOT's new method of including the economic value of elk and mule deer not killed in crashes as a result of the mitigation among the benefits (Kintsch et al., 2019).

6.5.11.6.1 Ballpark Estimates for Costs of Infrastructure

Table 6-50 presents the costs per unit for overpasses, span bridges, as estimated by the Action Plan development team's engineers based on NMDOT 2020 cost estimates. The Animal Activated Driver Warning System costs were estimated based on a private animal detection system contractor recent cost estimates. The structure cost estimates are identified as being applicable to two-lane highways. The price of 8-foot wildlife exclusion fence per mile for both sides of the highway, double cattle guards, also known as game guards, and escape ramps are all taken from Colorado DOT estimates in the West Slope Study (Kintsch et al., 2019).

Table 6-50. Questa wildlife corridor project wildlife mitigation rough cost estimates.

Infrastructure	Cost per unit	Cost for Infrastructure	Total for Segment
One overpass (2-lane): MP 2.7	$4,460,000	$4,460,000	
One overpass (2-lane): MP 4.6	$4,460,000	$4,460,000	
One overpass (2-lane): MP 7.8	$4,460,000	$4,460,000	
One span bridge (2-lane): MP 8.8	$1,070,000	$1,070,000	
Two ADS: MP 1.3 and 9.0	$350,000	$700,000	
Fence: MP 1.4-9.0 = 7.6 miles	$100,000	$760,000	
Approximately 21 double cattle guards	$60,000	$1,260,000	
Escape ramps @ 4/mile = 7.6 x 4 = 31	$14,000	$434,000	
Total for corridor			$17,604,400

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6.5.11.6.2 Animal-Vehicle Crash Costs

From 2009 to 2018, there were 24 crashes involving collisions with animals along this wildlife corridor. The crash severity of these included 23 property damage only crashes, 1 Class C injury crashes, 0 Class B injury crashes, 0 Class A injury crashes, and 0 fatal crashes (although there was a known fatal crash that was not included in the animal-vehicle and wildlife-vehicle crash analysis).

The NMDOT 2019 and FHWA 2018 (Harmon et al., 2018) cost values for these crashes are presented in Table 6-5. Based on these values, the costs associated with animal-vehicle crashes in this wildlife corridor were calculated (Table 6-51).

Table 6-51. Calculation of wildlife-vehicle crash costs in Questa wildlife corridor using NMDOT and FHWA crash values.

Crash Type	NMDOT-Estimated Individual Crash Costs to Society	Total NMDOT Value of Crashes	FHWA-Estimated Individual Crash Costs to Society based on Harmon et al. (2018)	Total FHWA Value of Crashes
23 property damage only	$7,400	$170,200	$ 11,900	$273,700
1 possible injury (Type C)	$44,900	$44,900	$125,600	$125,600
0 minor injury (Type B)	$79,000	$0	$198,500	$0
0 incapacitating/serious injury (Type A)	$216,000	$0	$655,000	$0
0 fatality	$4,008,900	$0	$11,295,400	$0
Total		$215,100		$399,300

The benefits portion of the ratio is estimated by examining the expected reduction in crash costs. These benefits are estimated by taking the crash costs and multiplying by the 90 percent reduction of crashes the mitigation can be expected to provide, expected 75-year lifespan of the recommended mitigation, and value of mule deer and elk saved by the mitigation over 75 years (Table 6-52).

Table 6-52. Estimated value of mitigation benefits, Questa wildlife corridor.

	NMDOT Crash Values	FHWA Crash Values
Total value of crash costs over 10 years	$215,100	$399,300
Crash cost per mile per year	$2,390	$4,437
Crash cost for 9 miles of project over 75 years of infrastructure (Cost/mile/year x 9 x 75)	$1,613,250	$2,994,975
If mitigation reduced crashes by 90%, over 75 years, that value would be:	$1,451,925	$2,695,478
Wildlife Lost and Saved Values		Estimated Value of Elk and Mule Deer Saved over 75 years of Mitigation
If 12.5% of animal crashes were with elk (3 out of 24 animal crashes), and 33% were with deer (8 out of 24 animal crashes), and there have been 2.4 crashes with animals per year, there were 0.30 elk crashes and 0.79 mule deer crashes annually on average. If the full mitigation project is enacted, it is predicted to reduce crashes by 90 percent, there would be animal crashes prevented per year. Over 75 years this mitigation would be expected to save the following numbers of elk and mule deer: Elk = 0.30 x 75 x 0.9 = 20.5 elk saved. Mule Deer =0.79 x 75 x 0.9 = 54 mule deer saved. At a value of $2,392 for each elk and $2,061 for each mule deer, the value of animals saved each year x 75 years of mitigation = Elk ($2,392 x 20.5) = $49,036; mule deer ($2,061 x 54) = $111,294; Total = $160,330 These values do not represent the bighorn sheep lost in collisions, which are typically valued far higher than mule deer and elk. Bighorn sheep estimates have not been included in the Action Plan, in an effort to follow estimates similar to Colorado's in Kintsch et al. 2019, which only estimated mule deer and elk values.		$160,330

6.5.11.6.3 Benefit-Cost Ratio

- NMDOT values for crashes:
  Benefit/Cost Equation = $1,451,925 + $160,330/$17,604,000 = 0.09
- FHWA Values for Crashes
  Benefit/Cost Equation = $2,695,478 + $160,330/$17,604,000 = 0.16

Whether the NMDOT or FHWA crash values are used, the mitigation would not be expected to pay for itself over 75 years, with a benefit-cost ratio between 0.09 and 0.16. Though some cost savings could be incurred through reducing the amount of fence and double cattle (game) guards needed, the cost would far exceed the economic benefits gained from the mitigation. Even if a wildlife-related fatality were confirmed in the project area, the benefit-cost ratios would still fall well short of 1. If the full list of mitigation measures equaled approximately $1.61 million, the project would be expected to possibly pay for itself over the same time period based on NMDOT crash costs.

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Chapter 7. Outlook and Monitoring

Future efforts to protect and restore wildlife corridors in New Mexico will need to consider climate change projected impacts across the state and establish a robust wildlife mitigation monitoring program. In this chapter, we first review the most recent scientific modeling data on predicted statewide changes in climate, and then present a framework to monitor changes in WVC numbers and mitigation efforts that are implemented to maintain and restore habitat connectivity for wildlife. Monitoring is especially important in the context of accelerating climate change impacts on ecosystems and species, potentially affecting future wildlife movements at the landscape level (Cartron et al., in press).

7.1 Climate Outlook and Impact on Wildlife Movements

The changing climate is projected to cause major shifts in the geographic ranges of species (e.g., Lawler et al., 2006; Mawdsley et al., 2009). To persist, many wildlife populations and individual animals will likely need to depend heavily on their ability to disperse in search of new home ranges with suitable climatic conditions, vegetation cover, and food resources (Nathan et al., 2008; Heller and Zavaleta, 2009; Littlefield et al., 2017). Whether climate-driven movements are successful hinges largely on individual dispersal abilities, but also on the absence of major anthropogenic barriers along dispersal routes (McGuire et al., 2016).

The southwestern U.S. has been experiencing a more rapid warming trend than average for North America, with a concurrent decline in snowpack (Cartron et al., in press). Climate projections show that mean maximum winter temperature may rise by nearly 4 degrees Celsius (°C) in parts of New Mexico by the middle of the century (2041-2061), and that mean maximum July temperature may rise by at least 1.3°C throughout the state (up to nearly 2.2°C in the east and northeast). Over the same general period, climate projections also show a general trend toward increased aridity, though these results are associated with a smaller degree of certainty. The climate projections presented by Cartron et al. (in press) are based on Coupled Model Intercomparison Project, Phase 5 (CMIP5) simulations under a standardized future greenhouse gas scenario commonly used in climate research (Meinshausen et al., 2011).

The 2050 (2041-2061) climate change projection maps are provided as Figures 7-1 through 7-4.

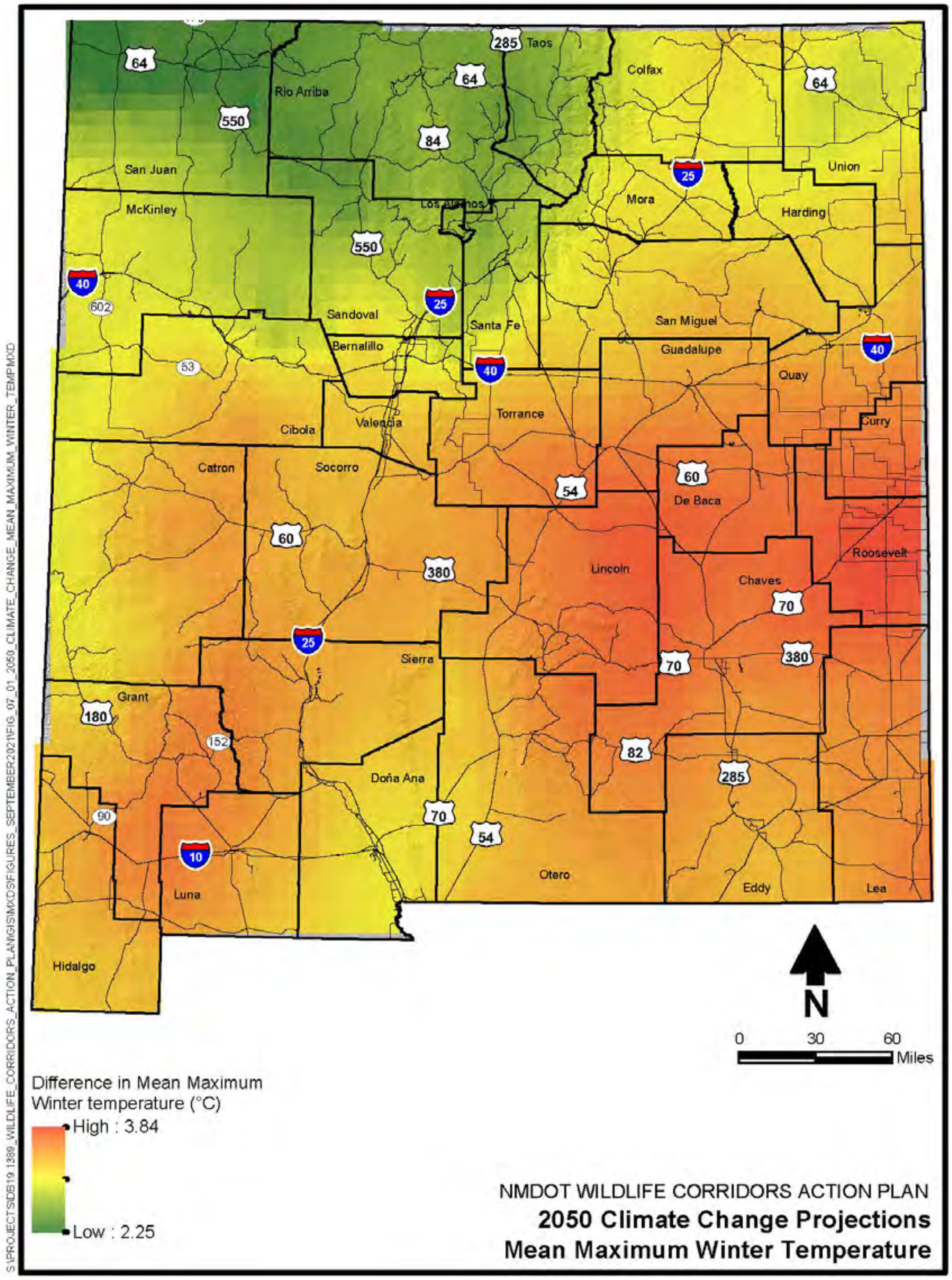

Figure 7-1. Projected changes in mean maximum winter temperature by 2050. Reproduced with permission from Cartron et al. (in press).

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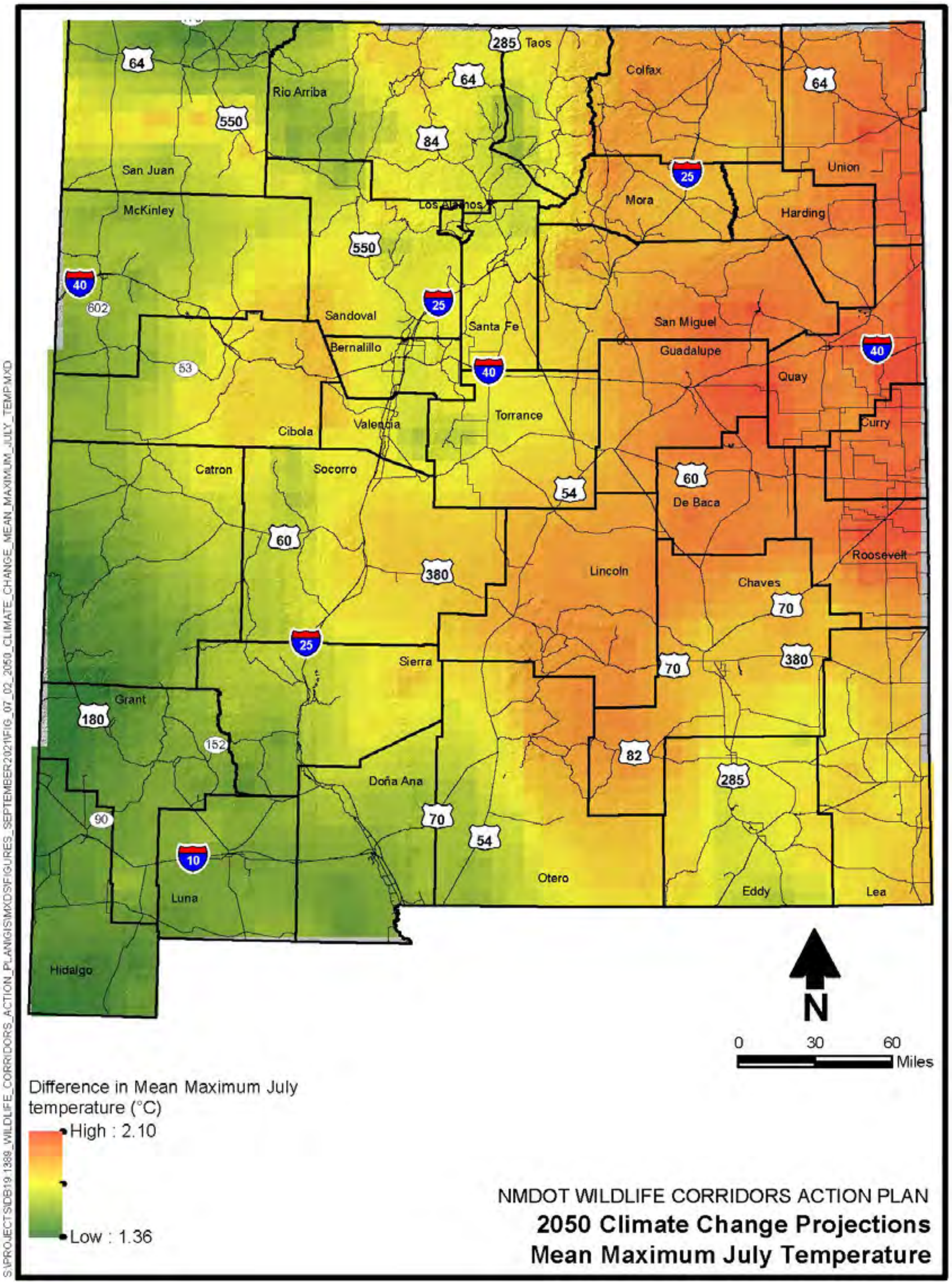

Figure 7-2. Projected changes in mean maximum July temperature by 2050 (2041-2061). Reproduced with permission from Cartron et al. (in press).

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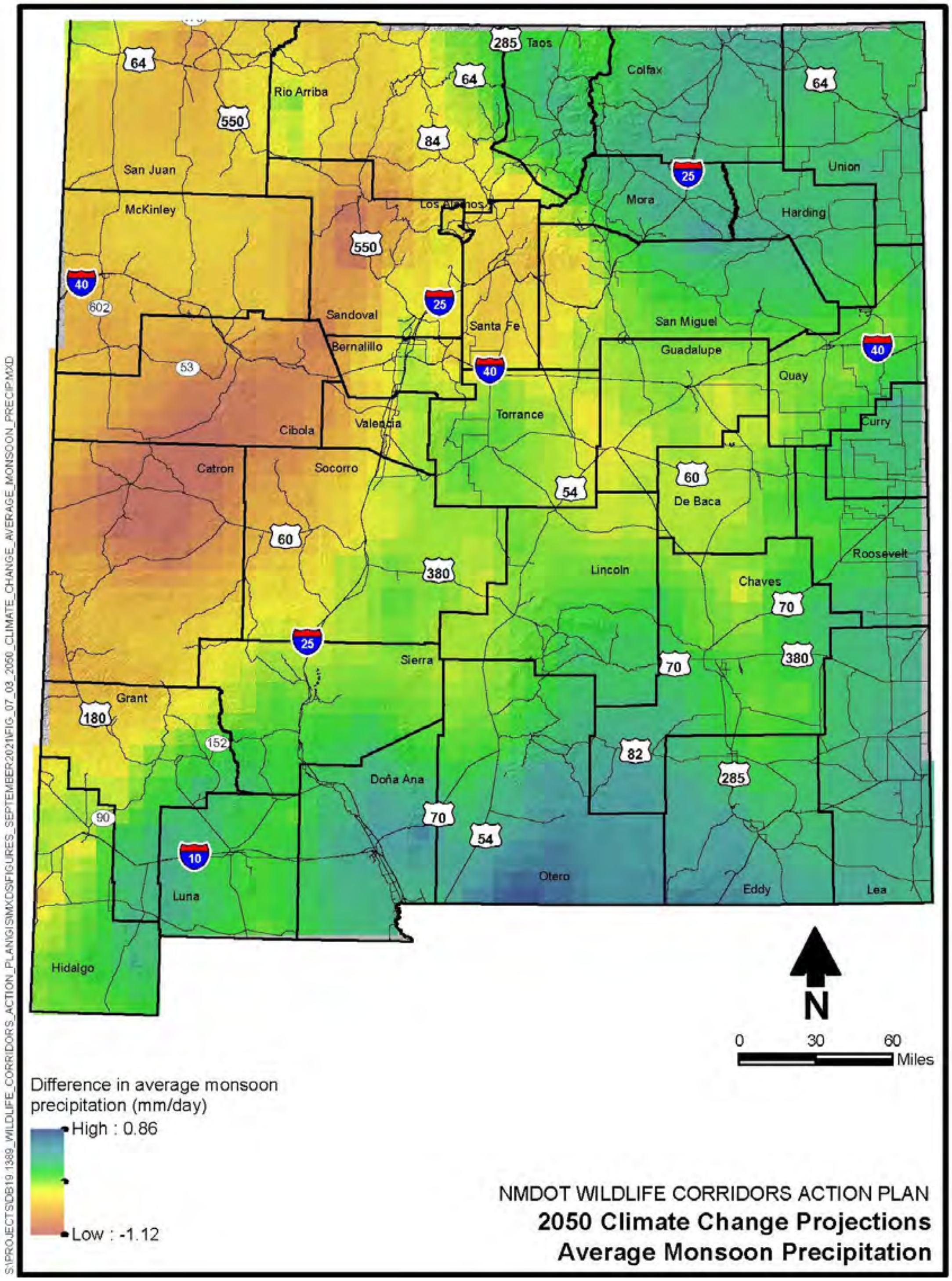

Figure 7-3. Projected changes in average monsoon precipitation by 2050 (2041-2061). Reproduced with permission from Cartron et al. (in press).

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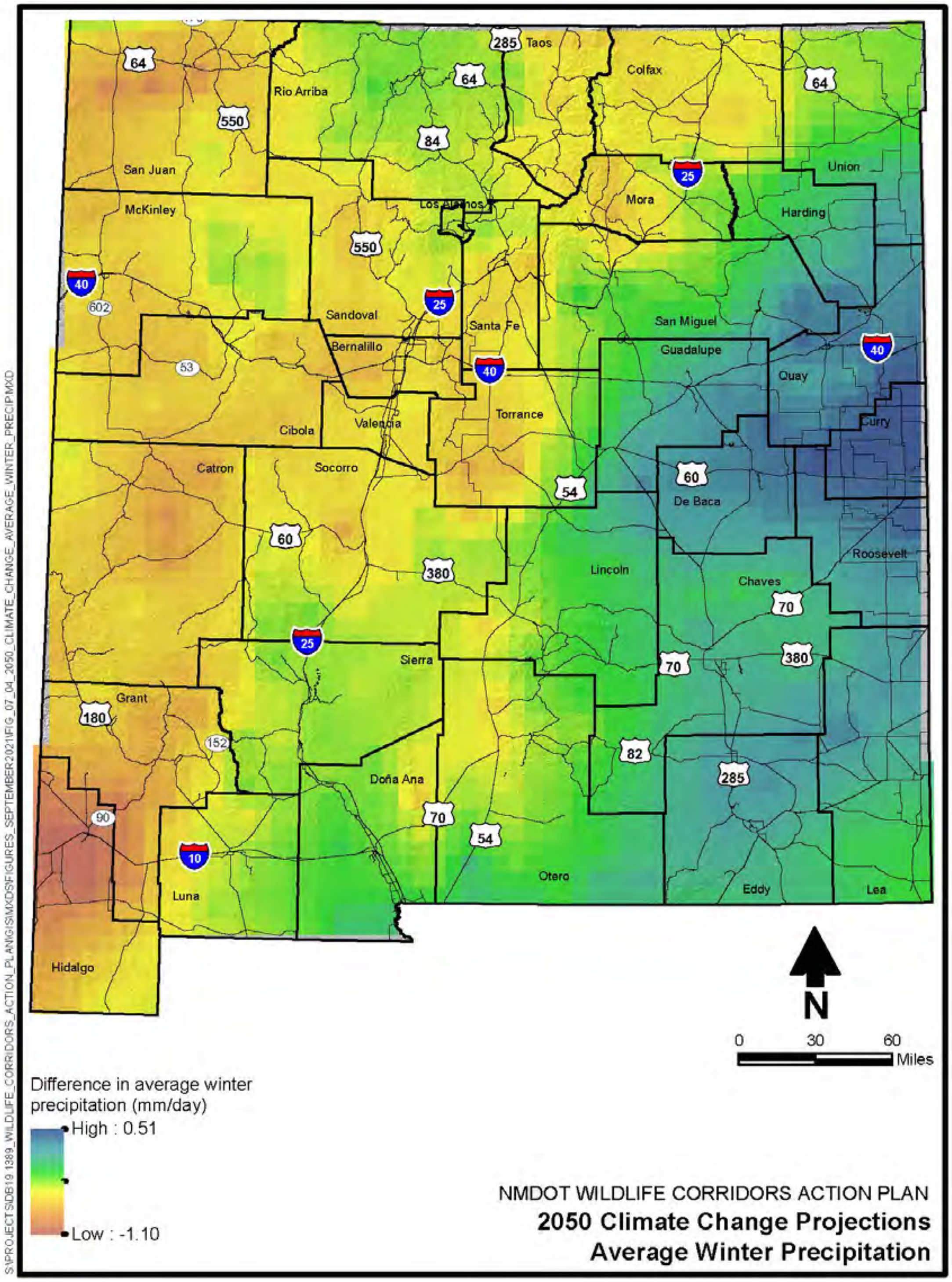

Figure 7-4. Projected changes in average winter precipitation by 2050 (2041-2061). Reproduced with permission from Cartron et al. (in press).

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Cartron et al. (in press) also build onto previous work by one of the study's co-authors, Dr. F. Jack Triepke (U.S. Forest Service), to predict shifts in the boundaries of New Mexico's main ecosystem types by the late 21st century. Woodlands and forests are projected to shrink in size while the state's southern deserts expand and progress northward. Current and late-century ecosystem type boundaries are presented in Figure 7-5.

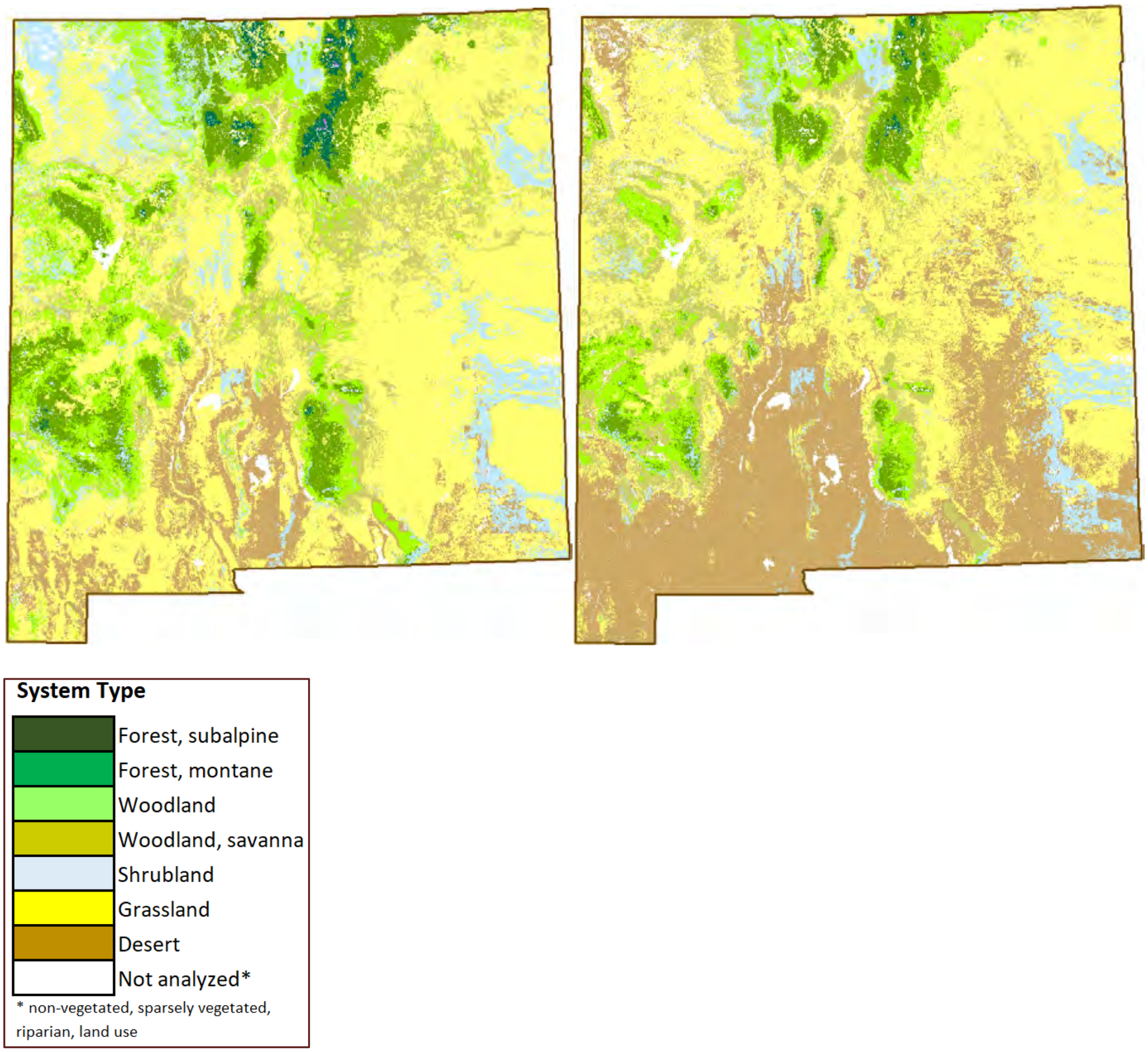

Figure 7-5. Current (left) and projected (right) distribution of general ecosystem types for New Mexico. Reproduced with permission from Cartron et al. (in press).

From projected climate and ecosystem type boundary shifts, Cartron et al. (in press) make a number of predictions regarding the distribution, population size, and ecology of carnivores in New Mexico. Unless climate change can be curbed, the size of New Mexico's black bear (*Ursus americanus*) populations will likely decline in the next several decades, as will those of other carnivores associated with woodland and forest ecosystems. The kit fox (*Vulpes macrotis*), another species of concern identified in the Action Plan, could see its distribution expand and its population grow in the state (Cartron et al., in press). Movements of carnivores (primarily juveniles and adult males) could increase in many areas of the state, with a resulting potential for more wildlife-vehicle collisions (WVCs). Wild ungulates are outside the scope of the Cartron et al. (in press) analysis, but similar climate-driven impacts can be expected for elk and deer in particular, as these two species are largely tied to woodlands and forests.

7.2 Monitoring

Monitoring of WVCs and habitat fragmentation mitigation efforts is essential to our understanding of successful and unsuccessful project components. Without monitoring, the iterative process of improving upon current projects through adaptive management and incorporating those modifications into future projects cannot occur (Figure 7-6).

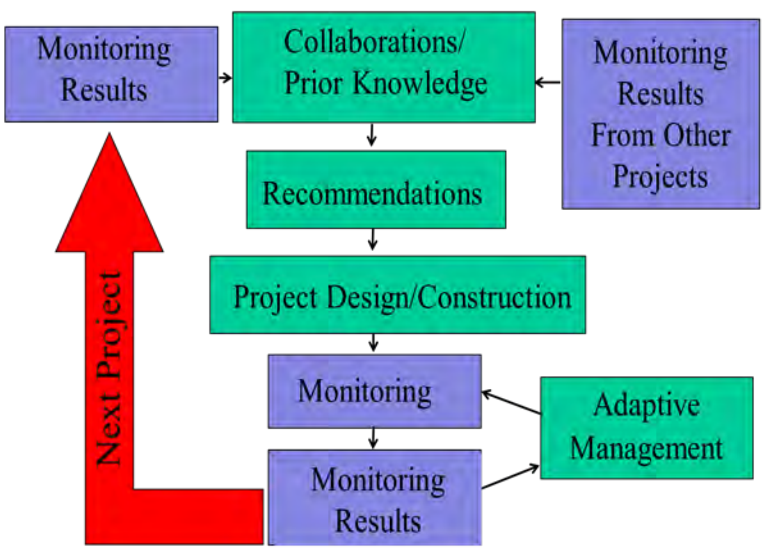

Figure 7-6. Flow chart showing the importance of monitoring in the iterative process of improving WVC and habitat connectivity mitigation projects.

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7.2.1 Data Types

Four primary measures for assessing the success, or lack thereof, of WVC mitigation measures are (1) WVC or roadkill rates, (2) wildlife use of mitigation project structures and success and failure passage rates, (3) roadway permeability rates and crossing locations using telemetry data, and (4) for certain projects, motorist response to mitigation. These measures are discussed in the following subsections.

7.2.1.1 Wildlife-Vehicle Collision and Roadkill Data

WVC data reflect the combined effects of wildlife making the decision to cross a road and motorists not responding in a manner that allows them to avoid the collision. In many cases, WVC data are the most important metric to a Department of Transportation (DOT) because they involve motorist safety. Most DOTs have mission statements that emphasize a commitment to provide safe transportation to the traveling public, thus implicitly recognizing the need to reduce or minimize WVCs. All DOTs use data to track the numbers and causes of accidents, usually referred to as crash data, which help to pinpoint areas of concern and make decisions on where to focus efforts for improving motorist safety. Crash data usually include human fatalities, serious injuries, and significant property damage (above a set dollar amount). In many cases, specific information is captured in the crash dataset, and it is the most consistent tool available to track improvements, or lack thereof, in motorist safety when mitigation is implemented. In 2021, Arizona completed a Statewide Wildlife-Vehicle Conflict Study that identifies WVC hotspots throughout the state, provides baseline data for comparison to the success of future mitigation efforts, and provides an example of how crash data are used to guide recommendations (Williams et al., 2021).

Crash data, although consistent over time, have limitations, as they cannot efficiently track collisions with wildlife that may not cause enough damage to be captured in the dataset, or even slow down vehicles. Tracking collision occurrence with animals smaller than a deer requires a more active data collection effort. Roadkill, or carcass data, can provide a more thorough evaluation of the number of animals actually getting killed on the road—from larger-sized animals such as elk (*Cervus canadensis*) down to smaller animals such as amphibians and reptiles. For example, thorough roadkill surveys in Saguaro National Park in Arizona led to an estimate of nearly 30,000 vertebrates per year killed on less than 80 miles of road (Gerow et al., 2010). If crash data had been used for the study in Saguaro National Park, only a fraction of the collisions would have been documented. Thorough roadkill surveys can therefore be particularly important to provide baseline data and mitigation success for listed or candidate threatened and endangered species, as in many cases they will not make it into the crash database. Roadkill and carcass data require another caveat, which is the importance of consistent detection efforts both before and after mitigation is conducted. Inconsistent data collection can lead to misinformed conclusions and future recommendations. For example, if the roadkill monitoring effort is intensified following mitigation, it can lead to the incorrect conclusion that mitigation efforts are ineffective. Conversely, a roadkill monitoring effort that is more robust prior to mitigation than after mitigation can lead to the false conclusion that collisions have been reduced, thus promoting the use of an ineffective mitigation option going forward.

Ultimately, consistency is essential regardless of the method used to track WVCs. Monitoring carcasses is also important for identifying the species most often involved in WVCs. In turn, species identification allows wildlife professionals to better identify what types of mitigation will work to reduce WVCs based on species preferences for different types of crossing structures and mitigation.

Figure 7-7. Larger species like elk (left) are more likely to be documented in DOT crash data; however, smaller species, such as the American badger (right) would not be identified without roadkill or carcass surveys.

7.2.1.2 Use of Mitigation Features

Monitoring of mitigation measures can help determine their success in functioning as intended. For example, cameras capturing deer using an underpass to cross under a road can help document successful mitigation if used correctly. Another example could be elk crossing a wildlife guard or using an escape ramp backwards to enter the fenced right-of-way, which would help determine that mitigation features are not functioning properly and need to be improved. In both cases, monitoring helps inform future decisions and contributes to the incremental process of improvement.

One mistake that is commonly made is collecting images of animals using a mitigation feature (successes), such as a culvert, and making assumptions and recommendations without a frame of reference regarding how many animals are not using the same structure (failures). This monitoring approach can, and in some instances has, set the clock back substantially in the field of road ecology. For example, if 3 to 4 elk are observed using a culvert and 100 elk approach, but then do not use the culvert (and none of the approaches are documented), calling the mitigation a success can muddle or even compromise forward progress and adaptive management over time.

It is essential to collect both success and failure rates (sometimes also called passage rates and repel rates, respectively) to accurately capture the effectiveness of a mitigation measure. To do so, one must capture the number of animals that approach a feature and the number that actually use the feature. Dividing the number of uses by total approaches calculates the success (or passage) rate (successes/approaches = success rate). For example, if 100 deer approach a culvert and 50 deer actually cross through the culvert the success rate is 0.50, or 50 percent.

The failure (or repel) rate is essentially 1 minus the success rate, and can be more informative for options where repelling animals is intended. For example, if monitoring shows that 100 deer approached a cattle guard to access the right-of-way, but only 10 deer cross the guard, the repel rate is 0.90 (1 – 10 crossings/100 approaches), or 90 percent.

These rates not only help standardize wildlife response to mitigation measures for consistent comparisons through time or between mitigation projects; they also work for different population densities of the same species. If, in an area characterized by a higher density of deer, 1,000 deer approach an underpass but only 300 of them cross the road using the underpass, then the success rate is 30 percent. In an area with lower deer densities, researchers may document 30 deer using the road-crossing structure out of 100 animals approaching it. The rate of success is similarly 30 percent even though one structure has 10 times the number of crossings as the other. The conclusion that the two structures (the one used by 300 deer, the other by 30 deer) are equally effective would have been impossible to reach without documenting all approaches as opposed to simply relying on the numbers of successful passages for the structures.

Success and failure rates are especially important for smaller structures or novel features, for which no general information may exist regarding success rates or target species from monitoring efforts elsewhere. There are instances, however, when calculating success rates rather than relying on numbers of passages may not be cost-effective. This is true in particular for large viaducts and bridges. In such cases, simple documentation of use still provides a relative measure of success that can be compared to nearby structures in areas characterized by the same wildlife population densities. Also, in many cases involving structures like large bridges over streams, there is already enough evidence collected in the field of road ecology all suggesting that the structures will provide passage for most wildlife species; adequate monitoring in such cases can be based on simply documenting the number of passages by individual species. By comparing the species observed using the road-crossing structures and those documented during surveys away from the road in the same areas, researchers can then determine which ones may not even be approaching the structures (Figure 7-8). It is important to also consider movements of animals parallel to a road-crossing structure. In such instances, the animals are shown to simply graze or walk along the fence line and structure rather than trying to move through the structure. These movements typically represent around 10 percent of observed animal responses to the presence of a new structure (Cramer and Hamlin, 2019a; Kintsch et al., 2021).

Figure 7-8. Example of adequate monitoring at a small culvert (left) and at a larger road-crossing structure (right) in New Mexico using motion-triggered, remote cameras. The cameras capture both approaches and crossings of deer and other wildlife at the culvert, allowing for the calculation of passage rates, thus contributing to knowledge about the effectiveness of mitigation measures. At the larger structure, most approaches are expected to result in the successful passage of wildlife, at the same time that documenting all approaches is logistically more difficult; the use of cameras is more geared toward documenting the number of passages and the full range of species using the structure (right).

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A camera placed at each end of a culvert or on each side of a bridge is typically sufficient to calculate success rates, rates of repellency, and parallel rates. Some structures may be wider than the ability of the cameras to capture animal movement at night, which is typically about 30 feet. If this is the case, additional cameras may be necessary to collect data most accurately.

It is also important to evaluate structure success for all the animals present in the area. For instance, if elk are known to be in the area but they are not using the structure—a common problem—the structure did not function as providing habitat connectivity for elk. One way to assess an area for the species present outside of the structure entrances is to place a camera at the edge of the road right-of-way fence, facing out to the wild area. This camera can then evaluate species of animal and numbers of those animals nearby but not using the structure. This has proven helpful in studies in Utah (Cramer and Hamlin, 2019) and Colorado (Cramer and Hamlin, 2021; Kintsch et al., 2021) (Figure 7-9).

Figure 7-9. Elk outside the fenced right-of-way on US 160 east of Durango, Colorado. Despite 74 elk movements recorded over 2.5 years, none of the animals approached the wildlife crossing structure only 130 feet away (Cramer and Hamlin, 2021). This information greatly helped Colorado DOT better plan for future elk crossing structures.

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Evaluating structures for functional connectivity or permeability is another step in the evaluation of wildlife crossing structure success. If just a few individuals of a species cross through the structure, and they are not representative of all age classes and genders, there is low functional connectivity for the population of that species. If all ages and genders of a species have used the structure, and in proportions similar to those of the local population, the structure may be considered to have high or full functional connectivity. Recording the gender, age, and numbers of animals using the structure is critical to this evaluation. See Kintsch et al. (2021) for how these levels of connectivity were used as performance measures for multiple species for Colorado's SH 9 wildlife crossing structures.

7.2.1.3 Telemetry Movement Data

Even if mitigation projects lead to a reduction in the number of WVCs and monitoring documents the use of the road-crossing structure(s) by wildlife, the overall positive or negative impact on wildlife might not be fully evaluated without also taking into consideration any potential changes in the ability of animals to cross the road, and where. Telemetry data can help to determine the ultimate outcome of a mitigation project by identifying shifts in animal movement or levels of highway permeability. If a large portion of the local wildlife population simply shift their movements after implementation of a mitigation measure to other non-mitigated areas along roads or simply adjust their daily and seasonal migrations elsewhere, then the project did not work as intended; this outcome may not be captured without the use of telemetry data. Measuring highway permeability can help determine the success of a project in maintaining or restoring movements across roads. For example, if a project reduces accidents by 90 percent but significantly reduces the ability of animals to cross the road, then it may be considered a success from a motorist safety perspective but not from an ecological perspective, as it leads to further habitat fragmentation. Likewise, if a road acts as a complete barrier to a species (the lack of movements across the road by two isolated populations is reflected in the complete absence of observed carcasses), telemetry data can show if the mitigation effort reconnected the two populations. Telemetry data were historically limited to larger species; however, recent advances in technology have reduced GPS and VHF telemetry units down to sizes as small as those of reptiles and amphibians. GPS telemetry monitoring is the easiest type to conduct because once an animal has been fitted with a collar, the level of effort to track movements is small. For much smaller species, VHF telemetry tends to be used but requires regular and consistent field visits to determine if animals are moving across a mitigated area at different rates before and after construction.

7.2.1.4 *Motorist Response to Mitigation*

While most forms of wildlife-vehicle conflict mitigation, such as wildlife crossings and fences, are geared toward altering the behavior of the animals, other methods may provide an opportunity to evaluate motorist behavior. Although changes in WVC rates are one form of motorist response to a mitigation effort, further examination of motorist behavior can help to further determine why a mitigation is effective or ineffective. Mitigation methods such as signage, speed reduction zones, roadside vegetation removal, and animal-activated detection systems (AADSs) are intended to modify driver behavior in a manner that causes motorists to either avoid collisions completely or strike an animal at a slower speed, reducing the potential for injury (Huijser et al., 2008). The "Elk Crosswalk" completed in 2007 along SR 260 in Arizona is an excellent example of measuring motorist behavior in response to the implementation of a WVC mitigation measure. This AADS uses complex software linked to thermal detection to identify animals large enough to potentially pose a safety concern to motorists (set at fox-sized or larger animals). The software also calculates speed, thermal differences, direction of travel, and other identifiers to confirm the target. Once the software identifies the target as a large animal that is moving toward the road, it triggers a series of signs in an attempt to alert the motorist in time to brake or avoid collision (Figure 7-10).

Figure 7-10. Example of thermal target acquisition software used to activate motorist alert signs (left) and sign activated when a target is identified as wildlife large enough to pose a safety concern to motorists.

Over nine years of monitoring, motorist speeds were reduced by 13 percent and there was a 5-fold increase in braking response with the signs on versus off, contributing to the 97 percent reduction in elk-vehicle collisions achieved as a result of the mitigation project being implemented (Gagnon et al., 2019). This information could not have been obtained without long-term monitoring of motorist behavior. A study of motorist response to the AADS south of Cuba was recently initiated.

7.2.2 Phases of Monitoring

7.2.2.1 Pre-Mitigation Monitoring

Pre-mitigation monitoring provides a baseline for evaluating the effectiveness of a mitigation measure at the same location. When gathered consistently, occurrences of WVCs and carcass data can be compared directly across pre- and post-mitigation phases to determine the level, if any, of reduction in collisions or roadkill, or if hotspots change or reveal themselves throughout project monitoring. Pre-mitigation telemetry movement data can help not only to identify suitable locations for implementation, but also provide baseline levels of roadway permeability and distributions of approaches and crossings. These data can then be compared to post-mitigation telemetry data to see changes in the ability of animals to cross the road or if there is a shift in crossing locations.

Pre-mitigation camera monitoring is also helpful in identifying all the animal species present in an area and assessing their numbers. If placed properly, the cameras can also evaluate the rate of success for animals attempting to cross the road. This baseline rate of successful crossing can then be used as a performance metric for assessing future improvements due to the mitigation. In Colorado, Kintsch et al. (2021) were able to study the species present prior to SH 9 construction and determine the minimum numbers of animals expected to use the crossing structures by species. The study was especially useful for less common species such as pronghorn and cougar.

7.2.2.2 Post-Mitigation Monitoring

Post-mitigation monitoring provides valuable insight into the effectiveness of implemented mitigation measures, and is the most essential phase of monitoring. At an individual project component level, post-mitigation monitoring can assess the effectiveness of site-specific mitigation features (e.g., wildlife crossing structures, escape ramps, wildlife guards) that can be compared across the study area or to results from other properly conducted evaluations in the field. If there is enough variation in feature design across the study area, valuable insights on design and measurements of successful components can be gained and added to the field of knowledge.

Long-term monitoring provides insights on the ultimate effectiveness of mitigation features, as well as opportunities for adaptive management to make project improvements. Without long-term monitoring, researchers and managers are at risk of obtaining short-term, sporadic results that can lead to misinformed recommendations for future projects. In many instances, it takes wildlife a number of years to adapt to features and make use of them. For example, elk along SR 260 took approximately 4 years to fully adapt to wildlife crossing structures, with long-term monitoring showing an increase through time in the effectiveness of the project (Dodd et al., 2007; Gagnon et al., 2011). Mitigation projects along US 89 in Utah showed similar learning curves over time for the 78,610 mule deer (*Odocoileus hemionus*) documented crossings, with success rates reaching 90 percent at several of the structures over time (Cramer and Hamlin, 2019).

7.2.2.3 US 93 Bighorn Sheep Project Long-Term Monitoring Case Study

In the early 1990s, US 93 in northwestern Arizona was in the planning stages of being upgraded from a 2-lane road to a higher-speed, 4-lane divided highway. To address concern for the safety of both the local desert bighorn sheep (*Ovis canadensis*) and motorists, as well as the potential for additional habitat fragmentation affecting the local sheep herd, the ADOT and federal partners worked closely with the AZGFD throughout the planning and implementation processes, from the early 1990s through completion of the project in 2011 (Cunningham and Hanna, 1992; McKinney and Smith, 2007; Gagnon et al., 2014). Sheep-vehicle collision data were collected over time, and telemetry data from collared sheep were used to locate suitable locations for road-crossing structures and provide baseline levels of highway permeability (Figure 7-11). Using results from a nearby study on the lack of use of wildlife underpasses by desert bighorn sheep, the planning team implemented three wildlife overpasses in the reconstruction of US 93 (Bristow, 2008).

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Figure 7-11. Capture of desert bighorn sheep (left) along US 93 to locate suitable wildlife overpasses (right) and provide baseline levels of highway permeability.

During post-mitigation monitoring, AZGFD assessed the effectiveness of specific project components and pre- and post-project level sheep-vehicle collision and highway permeability rates, and adaptively managed project components to improve their effectiveness (Figure 7-12).

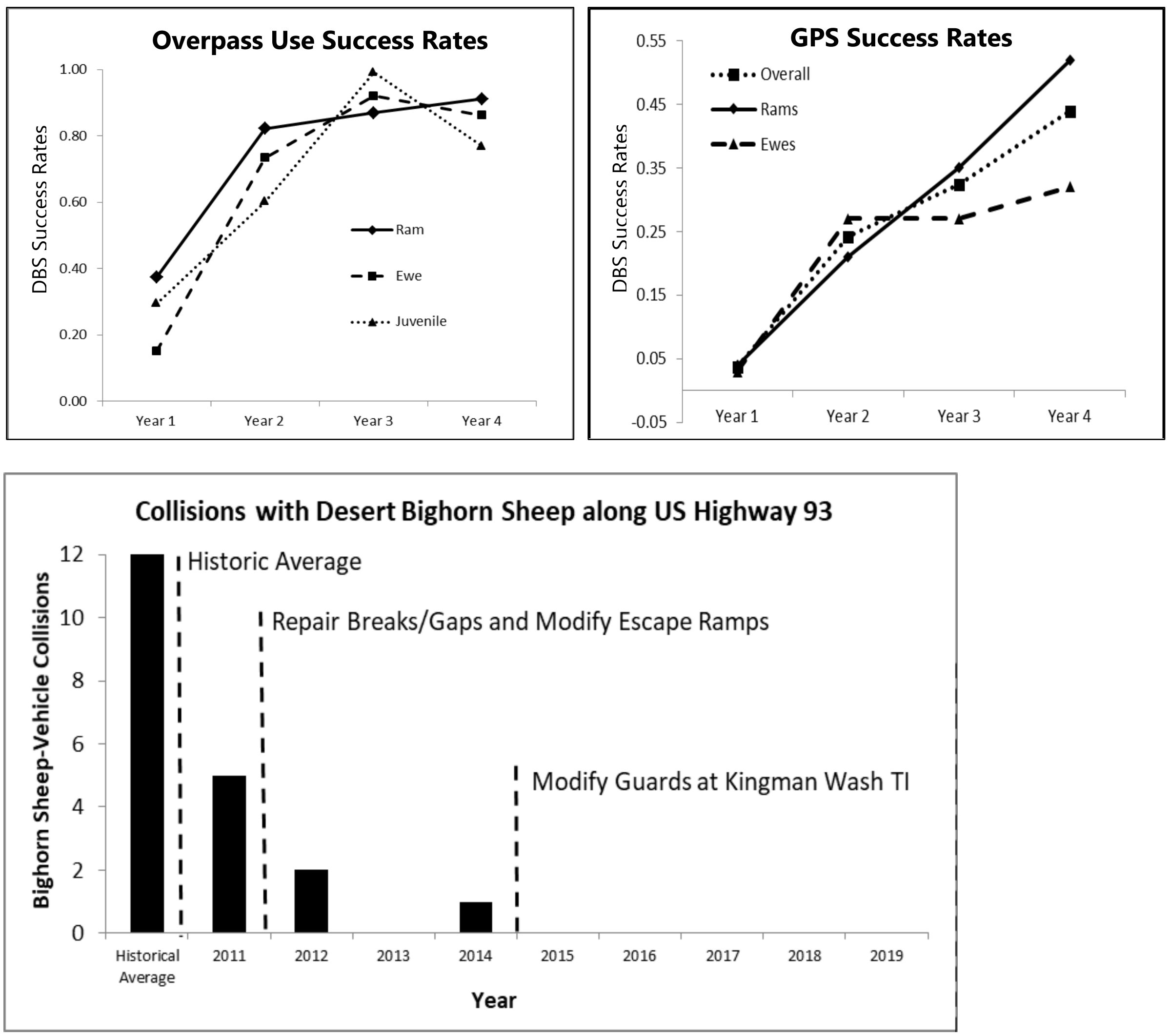

Figure 7-12. Results of a US 93 bighorn sheep study illustrating the importance of long-term monitoring in determining the ultimate success of a project. Upper left graph shows success rate of GPS-collared sheep crossing US 93 over time. Upper right graph shows success rate of sheep using the overpasses over time. Lower graph shows reduction in collisions over time through adaptive management and continued monitoring.

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The research team found relatively low levels of sheep use of the overpasses in the first year (214 sheep crossings and 26 percent passage rate). By the end of the project, however, sheep had learned and accepted the overpasses, with almost 6,000 sheep crossings and a nearly 90 percent success rate, dwarfing use and success of the underpasses and culverts. Collared sheep showed more than 200 percent increases in both crossing and passage rates by the fourth year; however, crossing and passage rates actually decreased in the first year, and had to initially recover as sheep found the crossings. Sheep-vehicle collisions were initially reduced by only 55 percent, but subsequent modifications and continued monitoring led to an 85 percent reduction in sheep-vehicle collisions during the project period. As of the date of this publication, there has not been a documented sheep-vehicle collision in the past 7 years (Gagnon et al., 2017). Had the US 93 research team not conducted long-term monitoring, the ultimate success of the project would not have been confirmed and the project might have been deemed a failure, the preliminary results providing misinformed recommendations for future projects. Instead, AZGFD was able to apply knowledge gained from that project for a collaborative cross-border effort with NDOT and NDOW along Boulder City Bypass Phase II. As of the date of this report, monitoring of this more recent project is currently underway; in the first two years of monitoring, bighorn sheep used the structure nearly 5,000 times and zero sheep-vehicle collisions were documented, pointing to the utility of the iterative learning and improvement process that can be guided through monitoring.

7.2.2.4 BACI Study Design

The Before After Control Impact (BACI) design is the scientifically most robust set up to understand how the changes implemented in the “impact” section of the highway affected the response variable (Rytwinski et al., 2015). This approach uses pre- and post-construction monitoring with wildlife cameras and, if analyzing crash data, pre- and post-construction reported crashes. BACI focuses on the mitigated area or impact section of road, and one or more nearby control areas representing road sections that have not been affected by the implementation of mitigation measures including new road-crossing structures. The examination time periods are the before and after mitigation periods. Using the BACI design, researchers can control for any changes occurring over time, such as those involving weather, traffic volume, and wildlife numbers. These potential confounding factors would be presumed to be the same for the control and impact sections of road and during the before and after mitigation construction time periods.

Without baseline and/or control data, it is difficult to determine the effectiveness of a mitigation measure in reducing WVCs or maintaining or promoting habitat connectivity. For example, if monitoring of a mitigation project documented five WVCs in a year, it would be important to know if there were more or fewer than five WVCs per year previously, or if that number is higher or lower than along adjacent or control road sections. Regardless of the comparisons used, consistent data collection is essential to these monitoring efforts.

At the project level, pre- and post-mitigation monitoring is best paired with pre-mitigation monitoring and equivalent control areas in a BACI study design. Monitoring tools would be placed for the purpose of evaluating an animal response to the mitigation. This response would be measured as the rate of approaches to an area over time, or the percentage of successful movements over the road. Animal responses to the mitigation might also require a comparison of the number of species and numbers of animal per species that were photographed in an area before and after construction.

BACI analysis has been used to compare crash rate changes between pre- and post-construction in the control sections with crash rate change between pre- and post-construction in the mitigation section (Cramer and Hamlin, 2019; Kintsch et al., 2021). For example, Colorado's US 160 wildlife mitigation project east of Durango was evaluated for changes in wildlife-vehicle crash rates inside and outside the mitigated area (Cramer and Hamlin, 2021). The crashes per mile per year were calculated for each section for the pre-construction period and post-construction period. The changes in rates from pre- to post-construction were then compared for each control section with respect to the mitigation section (Table 7-1).

Table 7-1. Number of crashes per mile per year before and after construction in the mitigated and control road sections along US 160 east of Durango, Colorado.

Time Period	Crashes per mile per year		
	West Control	Mitigation	East Control
Pre-construction	4.4	4.0	4.9
Post-construction	3.2	1.8	3.7
Change	–1.2	–2.2	–1.2

Statistical analyses, with either high-level statistics or a simple T-test (as in this case), can help determine if the changes in crash rates among the controls and mitigation were significant enough to confidently say the mitigation was the cause of the differences. In this Colorado US 160 example, the pre-construction crash rate was different from the post-construction crash rate in the “Mitigation” section ($p = 0.11$), and the crash rate changes between pre- and post-construction in the “West Control” and “East Control” sections were different than the crash rate change between pre- and post-construction in the “Mitigation” section ($p = 0.12$ for West Control; $p = 0.16$ for East Control). There was good evidence that the change in wildlife-vehicle crash rates in the “Mitigation” section was due to mitigation. This type of analysis should be carried out with every wildlife mitigation monitoring project.

In some instances, BACI can be impractical or unattainable because a project may already be complete or sufficient control sites are unavailable. Where possible, at least one of the comparisons of the mitigation site—pre- and post-mitigation (BA) or to sufficient controls (CI)—is the next best option.

7.2.3 Camera Security

Camera traps continue to be a cost-effective tool to collect data on mitigation effectiveness. Unfortunately, theft of cameras is quite common during monitoring. Although the cameras can be replaced, the data stored within cannot be replaced, and in some instances are more valuable than the camera itself. Taking precautions to secure cameras is therefore essential to maintain consistent and continuous monitoring. Each monitoring location provides different challenges; therefore, the best options for security should be determined on a case-by-case basis (Figure 7-13). Permits and approval of plans are required by DOTs before camera installation and monitoring.

Figure 7-13. Consistent data collection from cameras is important to determine mitigation success, and taking measures to secure cameras is essential. Options like these being used in New Mexico can help reduce theft, and include articulated mounts that deter cutting with power or hand tools (upper left), flush mounts with robust anchors to hinder prying (upper right), cameras welded to poles and set in concrete (lower left), and hiding cameras in discrete locations such as behind a guardrail (lower right).

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7.2.4 Status of the Monitoring of WVC and Habitat Fragmentation Mitigation in New Mexico

Since 2004, NMDOT has completed 10 main WVC mitigation projects. In 2016, the NMDOT Research Bureau funded AZGFD in a collaborative interstate effort to evaluate 4 of these sites to determine project effectiveness. Researchers determined that the projects have markedly reduced WVCs, and that crossing structures are being effectively used by wildlife. During the three-year Phase I study, researchers captured more than 1.25 million images that showed 18,034 animals belonging to 21 different species at the structures. A total of 14,242 successful animal movements through road-crossing structures were thus documented: 12,408 by mule deer, 220 by elk, 169 by black bears, and 45 by cougars (*Puma concolor*) (Loberger et al., 2020). Phase II monitoring was funded in 2020 and will continue through 2026. Phase II will include additional sites, areas where pre-mitigation data were collected during Phase I, and an AADS evaluation (Figure 7-14).

Figure 7-14. Examples of mitigation types and phases being monitored in a collaborative interstate effort by NMDOT Research Bureau and AZGFD, including post-construction deer use of culverts at Aztec (upper left), pre-construction monitoring at Raton Pass (upper right), comparison of use of culverts with and without obstructions at multiple sites (lower left), and an animal detection system at Cuba (lower right).

Monitoring of WVC mitigation in New Mexico is in various stages of implementation—both at the project level and for individual features. Monitoring will include post-mitigation monitoring only on older projects and pre- and post-mitigation or BACI design on projects where timelines have now provided that option.

7.3 Monitoring Plan for NMDOT Wildlife-Vehicle Collision and Habitat Fragmentation Mitigation Projects

As shown throughout this chapter, a thorough monitoring plan is essential to determine the efficacy of mitigation measures put in place to reduce wildlife-vehicle conflict and minimize habitat fragmentation. For future projects, we recommend that NMDOT develop project-specific plans to conduct pre- and post-mitigation monitoring, as well as collaborations with experienced biologists throughout the process.

We recommend the following be implemented pre-mitigation:

- Determine a consistent approach for wildlife-vehicle crash and carcass data collection prior to project implementation based on the type of proposed project and the species of interest, and use the same approach before and after completion. For example, standard crash data may suffice for large animals like elk, but more thorough roadkill surveys may be required for smaller animals or more thorough evaluations.
  - Where possible, collect data within the planned treatment area at a minimum, but preferably beyond the extent of the treatment area to identify end-runs and controls where appropriate.
  - A period of at least 2 years of pre-mitigation WVC data collection is recommended to account for variation in seasonality and changes in precipitation that can affect WVC rates.
- Where possible, collect GPS movement data to obtain baseline levels of highway permeability and determine the distribution of crossing locations. This is particularly important for species that show high road avoidance and are associated with low WVC incidence.
- Consult with experienced biologists on both monitoring and construction plans to make sure both are implemented properly.

The following recommendations should then be implemented during mitigation construction:

- Regularly consult with experienced biologists to ensure mitigation components, such as wildlife crossings, fences, escape ramps, and detection systems, are installed correctly. Also, coordinate with experienced biologists or monitoring teams to ensure that any integrated monitoring equipment, such as built-in camera boxes and video surveillance systems, are properly incorporated.

Our recommendations for the post-construction phase consist of the following:

- Conduct long-term, post-mitigation monitoring for 3 to 4 years (5 years for elk and pronghorn) to allow for wildlife to adapt to the new mitigation structures, account for seasonal variation, and identify adaptive management opportunities to improve the project.
- Collect WVC data using the same methods and consistency as pre-mitigation—at a minimum at the mitigation site, but if possible in adjacent sections and control sections (if monitored during pre-construction).
- Where appropriate, collect camera or video data on use, or lack thereof, of mitigation features. Collect approach and crossing information to determine success and failure rates. Extend camera monitoring to areas outside of the right-of-way to identify animals occurring locally but too skittish to approach the road crossing structures.
- Where possible, collect additional GPS movement data to assess levels of post-mitigation highway permeability and distribution of crossing locations. If GPS data are collected pre-mitigation, then permeability can be compared to determine changes, if any, in highway permeability.

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Appendix A

Supplemental Information on Implemented and Potential Mitigation Projects in New Mexico

Appendix A. Supplemental Information on Implemented and Potential Mitigation Projects in New Mexico

Table A-1 lists some of the areas where significant conflicts between wildlife movements and highways have been documented in New Mexico. In some of these areas, wildlife-vehicle collision mitigation projects have already been completed. In others, mitigation projects are being discussed with early public involvement under the umbrella of the Wildlife Corridors Act. Problem areas and potential or implemented mitigation projects are presented in Table A-1 together with the names of those individuals who helped identify or sponsor them. Table A-1 is organized by NMDOT district (see Figure A-1), with completed mitigation projects presented first (Figure A-1), followed by potential projects. One habitat connectivity mitigation project not associated with roads is included at the end of the table. More details on all of the individual projects can be found in Section A-2.

Table A-1. Past, current, and potential future wildlife-vehicle collision mitigation projects along roads in New Mexico. NMDOT Districts are hyperlinked to sections in the document.

Road Number	Location	Species at Risk	Contact People	Comments
NMDOT District 1 – Deming, Southwest				
District 1 Potential Project				
I-10	Lordsburg – AZ border, Peloncillo Mountains	Desert bighorn sheep	Eric Rominger and Caitlin Ruhl, NMDGF bighorn sheep biologists	I-10 is a major barrier to desert bighorn sheep habitat connectivity on both sides of I-10 in the Peloncillo Mountains.
NMDOT District 2 – Roswell, Southeast				
District 2 Completed Projects				
US 70	Tularosa	Elk	Mark Watson, NMDGF	Highly concentrated, narrow elk crossing area in 3-mile segment of US 70 between Tularosa and Ruidoso at Bent. NMDGF placed two portable messaging boards from December 2019 to March 2020 and December 2021 to March 2021 to warn motorists.
US 54	Corona	Mule deer	Mark Watson, NMDGF, James Hirsch, NMDOT	2 miles of wildlife fence just north of Corona.

Hyperlinks in banner rows will take the reader to the corresponding subsection in this document.

Table A-1 (continued)

Road Number	Location	Species at Risk	Contact People	Comments
NMDOT District 3 – Albuquerque, Central				
District 3 Completed Projects				
BNSF rail lines	Abo Canyon south of Albuquerque	Bighorn sheep and other wildlife	Mark Watson, NMDGF	Worked with BNSF Railways to place fence around tracks to force wildlife to move beneath railroad bridges. Successful mitigation.
I-40	Tijeras Canyon Phase 1	Mule deer, black bear, and other wildlife	Mark Watson, NMDGF	Flagship, high-visibility project with fencing to direct animals to cross below I-40 at existing bridges and construction of at-grade wildlife crosswalk. AZGFD is researching the effectiveness of the mitigation project.
I-40	Phase 2 and 3	Mule deer, black bear, and other wildlife	Mark Watson, NMDGF, James Hirsch, NMDOT	Two additional fence projects were constructed to guide wildlife to existing underpass bridges and culverts.
NMDOT District 4 – Las Vegas, Northeast				
District 4 Completed Projects				
US 64	Chicorica Creek	Mule deer	Mark Watson, NMDGF, James Hirsch, NMDOT	0.10 mile of 8-foot fence constructed on both sides of bridge. AZGFD researching in 2020.
I-25	Raton	Mule deer, elk, black bear, pronghorn	Mark Watson, NMDGF, James Hirsch, NMDOT	NMDOT placed fence to existing structures. AZGFD researching in 2020.

Hyperlinks in banner rows will take the reader to the corresponding subsection in this document.

Table A-1 (continued)

Road Number	Location	Species at Risk	Contact People	Comments
NMDOT District 4 – Las Vegas, Northeast (cont.)				
District 4 Completed Projects (cont.)				
I-25	Raton Pass	Mule deer, elk, black bear	James Hirsch, NMDOT	In construction. AZGFD researching existing culverts in 2020.
District 4 Potential Projects				
NM 120	Wagon Mound to Ocate	Pronghorn	Mike Herman, NMDGF, Raton	Potential Project - Pronghorn attempting to cross the road, Herman suggests fence modifications.
I-25	Glorieta Pass	Mule deer, black bear, cougar	USFS – Karl Malcolm, James Malonas, Daryl Ratajcsak	During Wildlife Corridors Act public comment period, USFS Santa Fe National Forest strongly recommended a series of mitigation measures in this area for multiple species.
I-25	Raton South	Mule deer	Matt Ordonez, NMDGF, Raton, Mike Herman, NMDGF Raton	Extend fence to mile marker 449 or 446 to prevent deer from entering I-25 road corridor.
I-25 to I-40	NE NM	Pronghorn (and deer)	Nicole Tatman, NMDGF	These interstates sever pronghorn and probably deer movements.

Hyperlinks in banner rows will take the reader to the corresponding subsection in this document.

Table A-1 (continued)

Road Number	Location	Species at Risk	Contact People	Comments
NMDOT District 5 – Santa Fe, Northwest-Central				
NMDOT District 5 Completed Projects				
I-25	Apache Canyon at Cañoncito Interchange		Mark Watson, NMDGF, James Hirsch, NMDOT	A small stretch of 8-foot fence was constructed to force deer to use existing culverts.
US 64	Lumberton	Mule deer, elk	Mark Watson, NMDGF, James Hirsch, NMDOT	3 miles of fence to new bridges on each end of project area.
US 64	Chama	Mule deer	Mark Watson, NMDGF, James Hirsch, NMDOT	Blinking lights associated with deer crossing signs installed from south to north of Chama associated with legislative memorial.
US 550	Aztec	Mule deer	Mark Watson, NMDGF, James Hirsch, NMDOT	NMDOT's first wildlife-vehicle collision mitigation project. Three large concrete box culverts were built for wildlife, replacing smaller existing culverts. AZGFD researching in 2020.

Hyperlinks in banner rows will take the reader to the corresponding subsection in this document.

Table A-1 (continued)

Road Number	Location	Species at Risk	Contact People	Comments
NMDOT District 5 – Santa Fe, Northwest-Central (cont.)				
District 5 Potential Projects				
NM 38	Questa and Red River	Bighorn sheep	Eric Rominger and Caitlin Ruhl, NMDGF bighorn sheep biologists, Mike Herman, NMDGF, Raton	Potential Project - Rocky Mountain bighorn sheep spend time in winter/spring along roadway and have been struck by traffic vehicles, resulting in one case of human fatality. NMDGF placed portable messaging boards in spring 2020.
US 285	Taos	Elk, pronghorn	Nicole Tatman, NMDGF	GPS-collared elk and pronghorn are using the area where the fence is laid down.
US 64 NM 522, 38	Sangre de Cristo Mountains	Elk, mule deer, pronghorn, bighorn sheep	Nicole Tatman, NMDGF	Big game species are moving in these mountains and to lowlands. Exact routes will not be known until after a winter 2020-21 collaring study ends.
NMDOT District 6 – Grants/Milan, Central West				
District 6 Completed Projects				
US 550	Cuba South	Mule deer, elk	Mark Watson, NMDGF, James Hirsch, NMDOT	NMDOT placed fence to existing structures, and double cattle guards. New ADSs installed. AZGFD researching in 2020.

Hyperlinks in banner rows will take the reader to the corresponding subsection in this document.

Table A-1 (continued)

Road Number	Location	Species at Risk	Contact People	Comments
NMDOT District 6 – Grants/Milan, Central West (cont.)				
District 6 Potential Future Project				
US 550	Cuba North	Mule deer, elk	USFS Karl Malcolm, James Malonas, Daryl Ratajcsak	USFS Santa Fe National Forest strongly recommended a series of mitigation measures in this area for mule deer and elk. Comments recorded during WCA public meetings.
Case Studies Outside of Roads				
Taos Plateau Fence Improvement Project		Pronghorn, mule deer	Jeremy Romero, BLM, NMWF, NWF, NM Association of Conservation Districts	Agencies/organizations worked together to modify and remove existing fences for wildlife.

Hyperlinks in banner rows will take the reader to the corresponding subsection in this document.

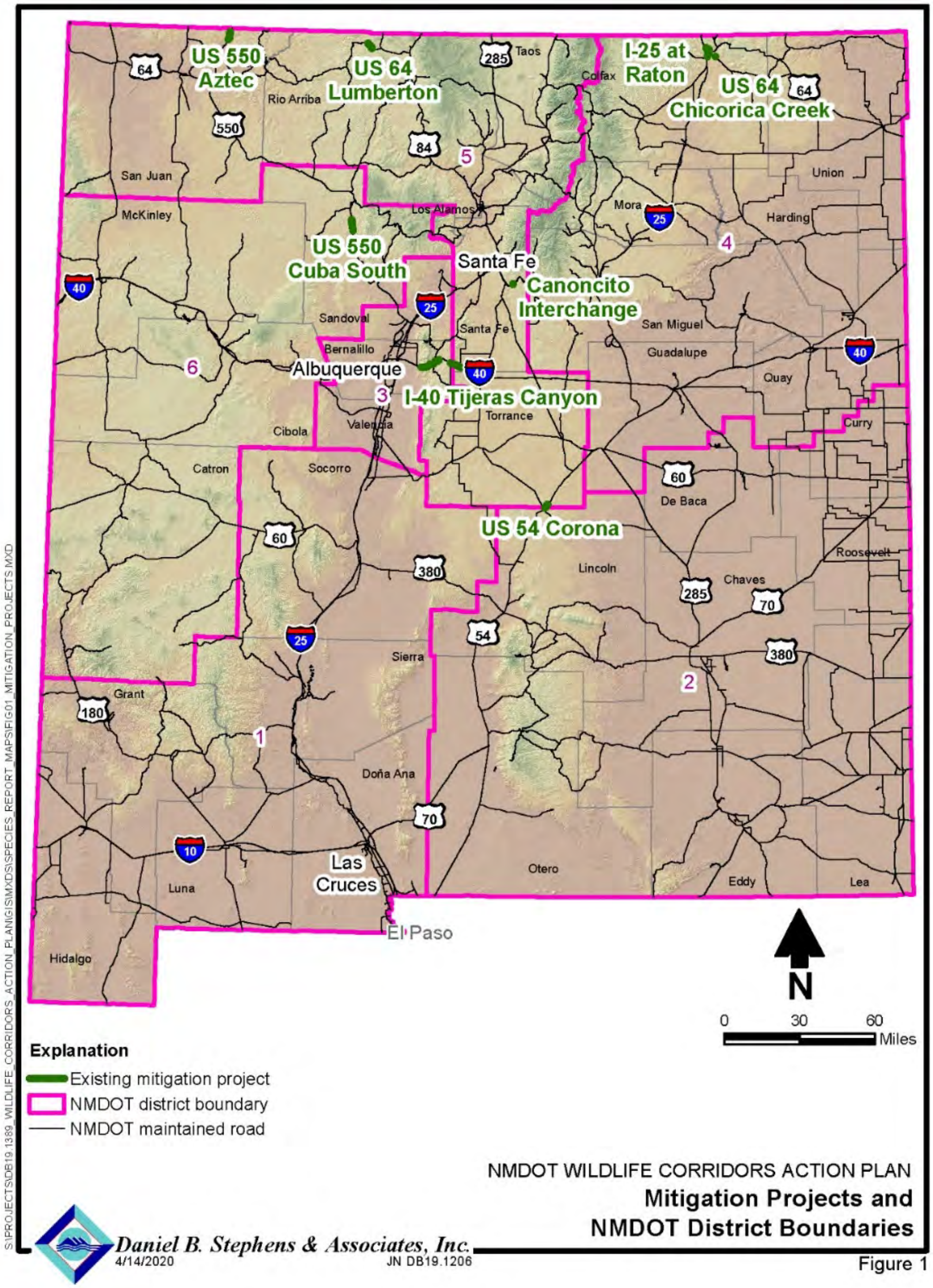

Figure A-1. Main New Mexico wildlife and road mitigation projects and NMDOT district boundaries.

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A.1 NMDOT District 1 – Deming, Southwest

I-10 Peloncillo Mountains Bighorn Sheep – Potential Project

I-10 is a major barrier to desert bighorn sheep movement on both sides of the freeway in the Peloncillo Mountains. One or more mortalities have been documented. There is local support for a mitigation project by landowners and conservation groups. This potential project was recommended to the Action Plan development team by NMDGF biologists.

A.2 NMDOT District 2 – Roswell, Southeast

US 54 Corona – Mule Deer

In 2013, 3 miles of game fence were constructed along US 54 just north of Corona in central New Mexico in association with a highway reconstruction project. The area was a known deer-vehicle collision hotspot. One issue during project construction was the installation of double cattle guards without removing the wing braces. This created a gap that deer can easily jump over or crawl under to access the roadway. NMDOT Environmental Bureau and NMDGF personnel visited with the local patrol yard regarding this issue. The patrol yard modified the cattle guard wings and added short run a game fence (Figure A-2).

Figure A-2. US 54 double cattle guard with wing and tire to prevent wildlife from walking across the guard (photo credit: Mark Watson).

US 70 Tularosa Elk

NMDGF purchased and placed two portable variable message boards along US 70 in the winters of 2019/2020 and 2020/2021 to warn drivers of elk in a narrow 3-mile corridor between Tularosa and Ruidoso at Bent. As mentioned in a video (social media – Facebook page for NMDGF, published movie on the project: https://www.facebook.com/nmdgf/videos/554675078649398/), a local landowner notified NMDGF about the high elk collision risk in the area. NMDGF deployed the message boards with NMDOT Tularosa patrol yard staff assistance (Figure A-3).

Figure A-3. Installation of driver warning variable message board along US 70.

A.3 NMDOT District 3 – Albuquerque, Central

BNSF Rail Lines Abo Canyon Bighorn Sheep

New Mexico may be unique in having once had relatively high mortality (n = 20+) of bighorn sheep from collisions with trains traveling through Abo Canyon in central New Mexico. During the installation of a second track through Abo Canyon, NMDGF partnered with Burlington Northern Santa Fe Railroad (BNSF) to install 8-foot fence to force bighorn sheep and other wildlife to move beneath the tracks at five high trestles throughout the 5-mile canyon. Since the installation of the fencing, there have been no known instances of bighorn sheep mortality.

I-40 Tijeras Canyon

To date, the Tijeras Canyon Safe Passage Project represents New Mexico's highest-profile mitigation project to reduce wildlife vehicle collisions. Tijeras Canyon is east of Albuquerque and separates the Sandia and Manzano Mountains. The mitigation took place along I-40 and NM 333. The 12.5-mile project was completed in three phases. In 2008, Phase 1 was completed from Carnuel at MP 170 in the west to the Village of Tijeras at approximately MP 175. The project included approximately 5 miles of 8-foot chain link fence, electric fence, escape ramps, electrified barriers, and two wildlife detection systems. The fence was placed to funnel wildlife beneath I-40 at three large bridges over Tijeras Arroyo. The bridges were MP 170 Mid-Bridge (25 feet high, 53.9 feet wide, and 186 feet long), MP 171 East Bridge (29.8 feet by 54 feet by 196.9 feet), and the MP 173.7 Public School Bridge (20.6 feet by 53.8 feet by 153 feet).

First-generation electrified mats were installed to preclude wildlife from entering the interstate at on- and off-ramps and to keep wildlife in the crosswalk. A major challenge was determining how to get wildlife across NM 333. An at-grade wildlife crosswalk was implemented over NM 333 using electrified mats to keep wildlife in the crosswalk, and an animal detection system was installed by Econolite to warn motorists of impending wildlife crossings. This ADS never functioned, however, and NMDGF has received a Wildlife and Sport Fish Restoration Act grant to replace the system and has contracted with W.H. Pacific and their subcontractor Crosstek to develop the design for a new system similar to the one installed on US 550 south of Cuba.

The Arizona Game and Fish Department (AZGFD) is currently researching wildlife use of the structures at the three above-mentioned bridges (MP 170, MP 171, and MP 173.7) and a fourth bridge at MP 184.9, the Juan Thomas Bridge (4.2 m by 11.5 m by 35.8 m), along with the crosswalk.

Another critical aspect of implementing the wildlife crosswalk was securing the 63-acre Hawkwatch Property, indicated in purple in Figure A-4. This was a private tract of land that connects with the Sandia Mountains Wilderness and funnels wildlife down to the crosswalk. Figures A-5 and A-6 provide photographs of wildlife crossings within this project area.

The Hawkwatch property was for sale and could have been purchased by a developer. NMDGF worked closely with the Tijeras Canyon Safe Passage Coalition and the New Mexico Land Conservancy to facilitate purchase of the property as Albuquerque Open Space. Today, it remains the only Albuquerque Open Space property purchased and managed exclusively as a wildlife corridor.

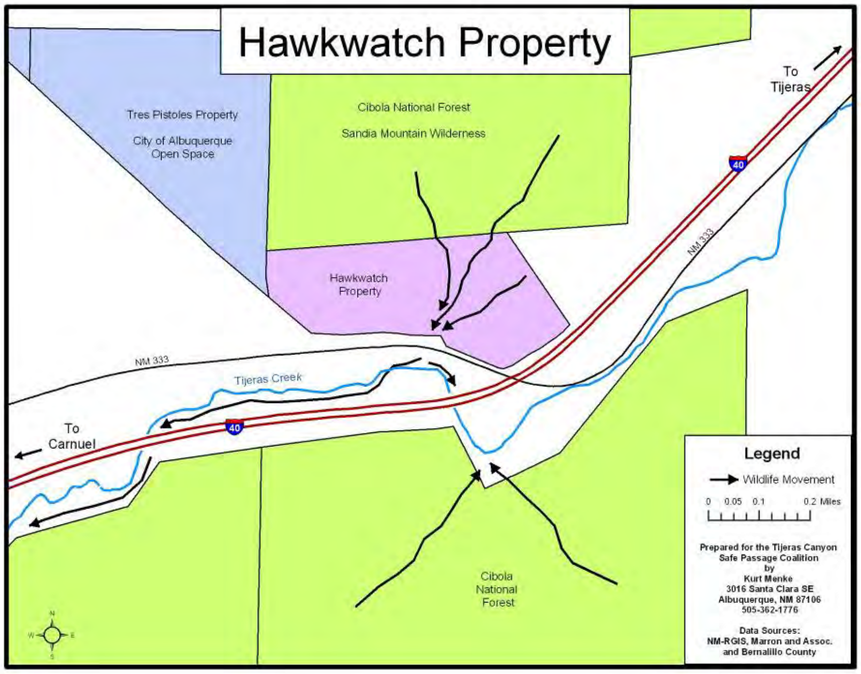

Figure A-4. Map of properties at Tijeras Canyon mitigation project.

Figure A-5. A mule deer buck moves beneath I-40 at the East Bridge, Tijeras Canyon Mitigation Site (photo credit: AZGFD, NMDOT).

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Figure A-6. I-40 Middle Bridge over Tijeras Arroyo where wildlife moves beneath the highway (photo credit: M. Watson).

Phases 2 and 3 included additional fence projects along I-40 to force deer and other wildlife under existing underpasses and concrete box culverts. The fence was extended 3 miles east from Tijeras to Zuzax in Phase 2. In Phase 3, the fence was extended 4 miles from Edgewood west to NM 217 (Figure A-7). These two areas were identified as having high deer-vehicle collision rates in the I-40 feasibility study.

Figure A-7. Bridge under I-40 used by wildlife near Edgewood (photo credit: M. Watson).

The electrified barriers at the crosswalk (Figures A-8 and A-9) have been replaced twice, most recently in 2017.

Figure A-8. Tijeras Canyon Safe Passage Project electrified concrete barriers at NM 333 wildlife crosswalk (photo credit: AZGFD).

Figure A-9. Two mule deer bucks entering and exiting the NM 333 crosswalk (photo credit: AZGFD and NMDOT).

A.4 NMDOT District 4 – Las Vegas, Northeast

I-25 Raton Pass, Mule Deer, Elk, Black Bear, Cougar

Construction of this project began in 2020. It involves about 5½ miles of wildlife exclusion fence and a 32-foot-wide arched culvert, the latter to be installed under the interstate to provide safe wildlife passage for mule deer, elk, black bear, and other wildlife. This project is part of a larger roadway reconstruction project that also involves rock fall mitigation, bridge rehabilitation, metal barrier replacement, and drainage improvements. AZGFD is monitoring two concrete box culverts in this stretch of I-25, at MP 458.1 and MP 458.9 (Figures A-10 through A-13).

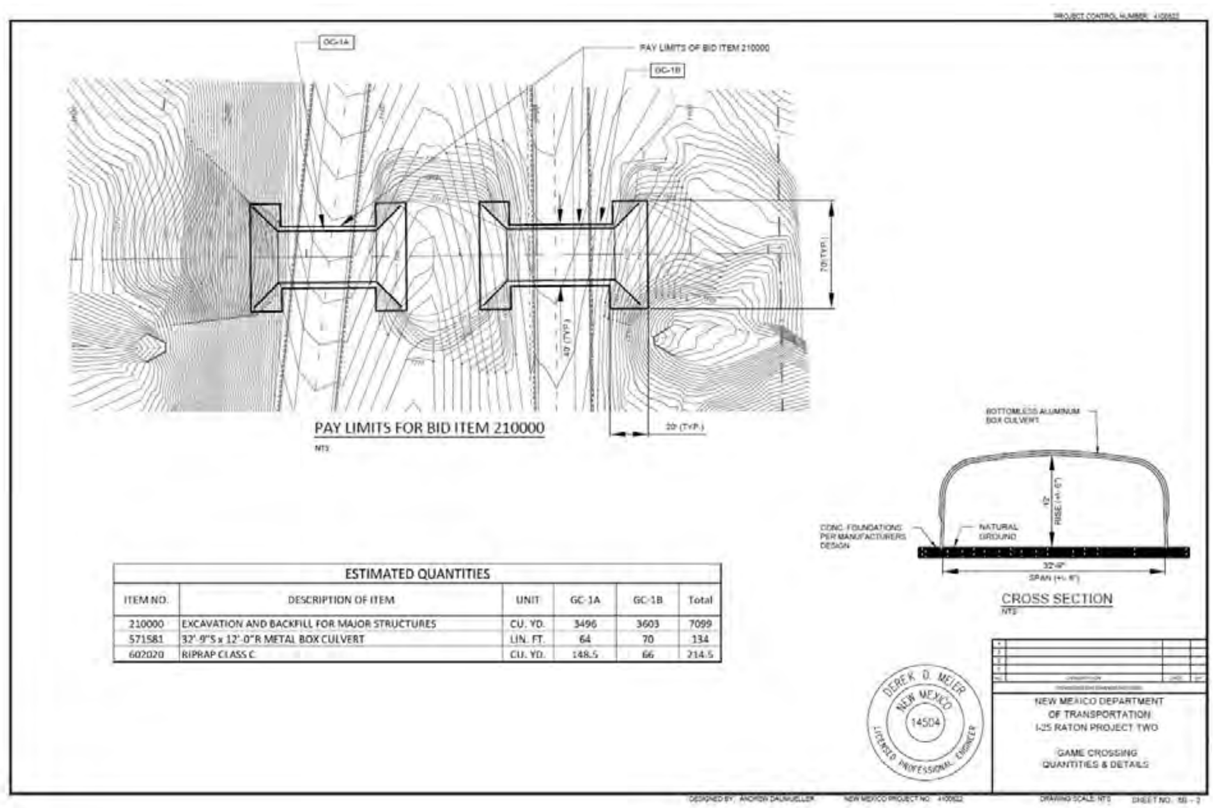

Figure A-10. I-25 Raton Pass plans for wildlife crossing metal arch culverts.

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Figure A-11. I-25 Raton Pass MP 458.1 box culvert (photo credit: AZGFD).

Figure A-12. Black Bear ponders before eventually using an existing box culvert under I-25 at Raton Pass MP 458.1 (photo credit: AZGFD, NMDOT).

Figure A-13. A bobcat using an existing box culvert at MP 458.9 (photo credit: AZGFD, NMDOT).

US 64 Chicorica Creek Mule Deer

A small fencing project was implemented in 2004 to address a relatively high deer-vehicle collision hotspot along US 64 in northeast New Mexico between Raton and Clayton. Chicorica Creek contains a riparian area and perennial water in shortgrass prairie habitat. A 0.10-mile length of game fence was constructed on each end of a bridge that was enlarged during the US 64 highway improvement project (Figure A-14). AZGFD began monitoring in 2020.

Figure A-14. US 54 Bridge at Chicorica Creek

I-25 Raton – Mule Deer

I-25 from MP 450 to MP 455 located in Raton was identified as having the highest number of wildlife-vehicle collisions on this interstate in New Mexico. The I-25 Raton Wildlife Mitigation project placed wildlife exclusion fence (8 feet), electrified concrete mats, and double cattle guards to exclude mule deer, elk, cougars, and black bears from the highway and guide them to four existing road-crossing structures. The project was completed in 2017, and AZGFD is monitoring wildlife use of existing structures including a roadway bridge (overpass) that spans the interstate. NMDOT and AZGFD documented mule deer use of the roadway bridge that spans I-25 (Figure A-15). Past studies in Arizona have not documented large ungulate use of similar structures. Large ungulate use of the roadway bridge is likely because the study area is within an urban environment where deer, bear, and other wildlife are habituated to humans and transportation infrastructure.

Figure A-15. Mule deer crossing First Street vehicle bridge spanning I-25 at Raton (photo credit: AZGFD, NMDOT).

NMDOT and AZGFD found that the MP 454 box culvert had a gate placed at the entrance by a landowner to keep horses from moving through, which heavily impacted mule deer passage rates. NMDOT maintenance personnel worked with the landowner to remove the gate and build a wildlife-friendly right-of-way fence 40 feet from the opening; this greatly enhanced deer passage rates in a matter of days (Figures A-16 and A-17).

Figure A-16. Gate placed by landowner on box culvert to keep livestock from using culvert (photo credit: AZGFD, NMDOT).

Figure A-17. Mule deer using the culvert after removal of the gate (photo credit: AZGFD, NMDOT).

I-25 Glorieta Pass Potential Project, Mule Deer, Black Bear, Cougar

As indicated in a Santa Fe National Forest memorandum, Glorieta Pass is located on I-25, east of Santa Fe (Figure A-18). This area is identified as a mule deer corridor in U.S. Forest Service (USFS) habitat mapping data. Black bears and cougars also get struck by vehicles in this area, and there are elk populations on both sides of the highway. The primary species affected are mule deer, black bear, and cougar, but wildlife crossings would also benefit numerous other species, such as elk, fox, skunk ,and coyote, just to name a few. These species are frequently observed as roadkilled carcasses throughout this area. The interstate (I-25) has USFS land on both sides (Sangre de Cristo Mountains to the north and Glorieta/Rowe Mesa to the south) where USFS restoration projects are being planned and implemented. These vegetation projects would include improvement of wildlife habitat and connectivity. This section of the interstate does not have culverts or bridges large enough for ungulates to readily use. The public and USFS have voiced their concerns for habitat connectivity needs and wildlife passage in this area. Also, because it is such a short drive from the state's capital city, it can serve as a showpiece demonstration project.

Figure A-18. Potential project location, I-25 Glorieta Pass east of Santa Fe.

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A.5 NMDOT District 5 – Santa Fe, North Central

Cañoncito Interchange – Mule Deer

This mitigation project installed a short section of 8-foot high, woven wire fence that tied into a cliff face. This directed mule deer, black bear, and cougar to existing concrete box culverts that provide safe passage under the interstate. A concrete retaining wall was also constructed to address visual issues but this structure also directed wildlife to safely pass through concrete box culverts.

US 64 Lumberton – Mule Deer and Elk

In 2012, the US 64 project near Lumberton in the northwest corner of the state was completed. The project constructed about 3 miles of wildlife exclusion fence to force elk and mule deer to use a new enlarged bridge constructed over Amargo Creek at the south end of the project area (Figure A-19). The large bridge over Amargo Creek was constructed to address vertical and horizontal geometry issues, while at the same time facilitating deer and elk passage. On the west end of the project area, the fence ties into a reconstructed small openness factor bridge that has some deer and elk movement underneath. However, at the western fence end, the roadway emerges from a canyon and enters sagebrush flats with greater sight distance for motorists. No detection system was installed.

Figure A-19. US 64 near Lumberton Bridge over Amargo Creek at MP 144.8.

Adaptive management and additional construction and maintenance challenges for this project have included plugging holes after the fence was installed and maintaining the fence. Deer were found to be crawling over the rocks at the gap in the fence between the end post and cliff face. This gap was closed by placement of wooden posts. A boulder took out a portion of the fence, and a game trail developed through the gap. These gaps were repaired by NMDOT maintenance personnel.

Trail cameras have documented deer, elk, and other wildlife safely passing under these bridges (Figures A-20 and A-21), but a local rancher has installed a poorly constructed barbed-wire fence under these bridges that hinders some wildlife movement. Generally, adult deer and elk can jump the fence and fawns and calves can crawl through or underneath it.

Figure A-20. Mule deer hesitate at a rancher-placed barbed wire fence at NMDOT Bridge (photo credit: NMDGF).

Figure A-21. Elk moving beneath US 550 Lumberton Bridge (photo credit: NMDGF).

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US 64 Chama – Mule Deer and Elk

Legislation passed in 2011 directed NMDOT, NMDGF, and state police to work cooperatively in selecting a project that addressed wildlife-vehicle collisions. US 64/84 between Tierra Amarilla and Chama was selected as an area of concern. Illuminated deer crossing signs were installed at multiple locations along with some vegetation control within the roadway right-of-way.

US 550 Aztec – Mule Deer

This is the first wildlife-vehicle collision mitigation project implemented in New Mexico, and was completed in 2004. This project originated from public concern over more than 100 deer-vehicle collisions per year over a 15-mile stretch of US 550 between Aztec and the New Mexico/Colorado border. A total of 3 miles of fence was constructed along the northern end of the project area from MP 169.5 to MP 172.8. No fence was installed farther south due to a high number of driveways and turnouts near Aztec. Three small corrugated metal culverts were replaced with three large concrete box culverts at MP 170, MP 171, and MP 172.8 (all 15.7 feet high; two 20 feet wide, one 11.8 feet wide; all 91.5 to 124 feet long) to facilitate mule deer passage (Figures A-22 through A-25).

Figure A-22. US 550 original corrugated metal culvert (left) replaced with a wildlife crossing concrete box culvert (right) in Aztec Project (photo credit: M. Watson).

Figure A-23. US 550 wildlife crossing concrete box culverts (photo credit: AZGFD).

Figure A-24. Mule deer buck using concrete box culvert to move beneath US 550 (photo credit: AZGFD, NMDOT).

Figure A-25. Mule deer bucks using the wildlife crossing box culvert to move beneath US 550 (photo credit: AZGFD, NMDOT).

Openness factor averages 2.86 for the three structures. AZGFD was monitoring these culverts as of 2020 and found that mule deer routinely use all three culverts, with 6,133 mule deer successful movements through the three structures over the monitoring study up to the first quarter of 2020. Both the number of successful movements and the 83 to 91 percent success rate, or passage rate, make these the most successful wildlife crossing structures in New Mexico, far exceeding the numbers and success rates at the structures studied in Tijeras, Raton, and Cuba.

NM 38 Questa to Red River Bighorn Sheep Potential Project

This population of bighorn sheep is the most susceptible to vehicle collisions in the state according to NMDGF. The increasing size of the herd down at the road is slowing down traffic according to Mike Herman of the NMDGF Raton office. Mike Herman also communicated that the animals appear to be traveling from the north side of NM 38, the mountainous area, to the south side, near Red River.

A.6 NMDOT District 6 – Grants/Milan, Central West

US 550 Cuba South – Mule Deer, Elk

Wildlife-vehicle collisions were fairly high in this 6-mile stretch from MP 50 to MP 56. From 2002 to 2013, there were 22 reported crashes involving wildlife. A motorist was killed in one of these crashes. The project was designed to use 4 miles of 8-foot-high, woven wire fence to direct deer, elk, and other wildlife to cross safely under two existing bridges. The project also included electrified concrete mats and double cattle guards. NMDOT has also placed a thermal-based camera system with a motorist warning system that is activated by any wildlife as it approaches the road at the fence ends. The project was completed in 2019. AZGFD began monitoring the bridges at MP 52.7 and MP 53.6 in 2017 for both pre- and post-fence wildlife use of the structures, and will continue to monitor beyond 2020. Photographs from this project are provided as Figures A-26 and A-27. An example of thermal detection imagery is shown in Figure A-28. Photographs obtained as part of the monitoring effort are provided as Figures A-29 and A-30.

Figure A-26. Wildlife-activated driver warning system on US 550 (photo credit: NMDGF, NMDOT).

Figure A-27. Driver warning signs and electric pavement at fence end on US 550 (photo credit: AZGFD).

Figure A-28. Screen capture of thermal camera image of elk cow and calf on Arizona State Road 260 (photo credit: AZGFD).

DRAFT

Figure A-29. Elk moving beneath bridge at MP 53.6 under US 550 (photo credit: AZGFD, NMDOT).

Figure A-30. Mule deer moving beneath US 550 north bridge near Cuba (photo credit: AZGFD, NMDOT).

US 550 Cuba North Potential Project, Mule Deer, Elk

As explained by USFS Santa Fe National Forest staff, wildlife mitigation is needed north of Cuba along US 550 (Figure A-31). A segment of US 550 south of Cuba was the focus of a very successful, completed wildlife crossing project but it corresponds to a less traveled corridor for elk and mule deer, and vehicle strikes appear to be more common on the north side of Cuba. As US 550 veers to the west north of Cuba, there are Santa Fe National Forest lands on the south side of the highway and the north side of the highway is a mix of both public (Bureau of Land Management [BLM]) and private lands. This section would likely need overpasses because it lacks underpasses large enough for ungulates to use.

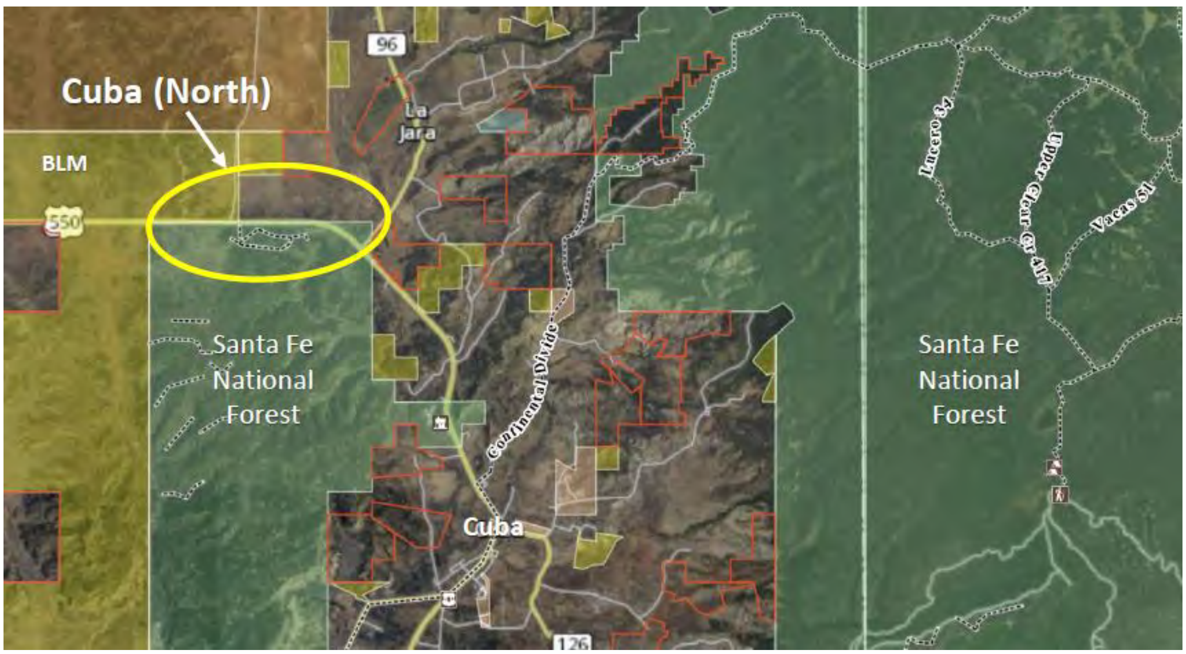

Figure A-31. USFS Map of Cuba North Potential Project

Appendix B

Public Outreach

February 12, 2020

Stakeholder's name

Address

Re: **Commencement of Wildlife Corridors Action Plan**

Dear [name of stakeholder]:

The New Mexico Department of Transportation (NMDOT) in partnership with the New Mexico Department of Game and Fish (NMDGF) has begun developing the Wildlife Corridors Action Plan (Plan) in accordance with New Mexico Senate Bill 228, the Wildlife Corridors Act (Act).

The Act, signed into law by New Mexico Governor Michelle Lujan Grisham in 2019, directs the NMDOT and the NMDGF to develop the Plan for NMDOT roads statewide. The Plan will identify wildlife-vehicle collision hotspots that pose a risk to the traveling public, identify wildlife corridors from ecological data, and provide a list of priority projects based on the results of the Plan's analysis. The Plan will provide information on wildlife movement with an emphasis on large mammals such as elk, deer, bear and mountain lion. A team of national experts led by Daniel B. Stephens and Associates (DBS&A), under contract with NMDOT, will develop the Plan in partnership with NMDGF. The DBS&A team will use a science-driven approach to identify areas per the Act that "*pose a risk to successful wildlife migration or that pose a risk to the traveling public*" and will be based on NMDOT crash data and ecological information on wildlife movements.

The Plan will build on past and ongoing efforts and is intended to raise support for and consensus in the identification of priority wildlife corridors and priority projects across New Mexico. Development of the Plan will also involve soliciting input from the general public, tribal governments and interested stakeholders.

We are writing to inform you that this is an opportunity for the public and engaged stakeholders to provide input and support for potential actions that will increase public safety and promote wildlife habitat connectivity.

There will be 8 public meetings to be held around the state to introduce the project and we invite you and your organization to participate. Attached please find the meeting locations, dates and times as well as details on how to submit comments. We look forward to working with the public and engaged stakeholder's as this process continues.

Thank you for your interest.

Sincerely,
DANIEL B. STEPHENS & ASSOCIATES, INC.

Julie Kutz
Biologist

Attachment: Public Meeting Information and Public Input Instructions

New Mexico Wildlife Corridors Action Plan

Public Meeting Information and Public Input Instructions

Participation in the public meetings is not mandatory to provide input. Comments can be provided through email, meetings, and personal interactions with NMDOT and NMDGF personnel and the DBS&A Team. Additionally, written comments on the Plan can be provided by mail to the following: Daniel B. Stephens & Associates, Attn: Wildlife Corridors Action Plan, 6020 Academy Road NE, Suite 100, Albuquerque, NM 87109; by email to Wildlife.Corridors@state.nm.us; or in person at one of the meetings listed below. We will accept comments for this stage of the process through April 18, 2020.

Public Meeting Locations and Schedule:

Location		Date	Time
Raton	NMDGF Office, 215 York Canyon Road	Tuesday, February 25, 2020	6:30-8:00pm
Albuquerque	NMDGF Office, 7816 Alamo Road NW	Thursday, February 27, 2020	6:30-8:00pm
Santa Fe	Santa Fe Higher Education Center, 1950 Siringo Road	Tuesday, March 3, 2020	6:30-8:00pm
Farmington	McGee Park, 41 County Road 5568, Multi-Purpose Building (located south of Sun Ray Park & Casino)	Thursday, March 5, 2020	6:30-8:00pm
Las Cruces	NMDGF Office, 2715 Northside Drive	Tuesday, March 10, 2020	6:30-8:00pm
Santa Clara (Silver City)	Santa Clara Community Center, 11990 Hwy 180 E., Santa Clara	Wednesday, March 11, 2020	6:30-8:00pm
Roswell	NMDGF Office, 1615 West College Boulevard	Thursday, March 12, 2020	6:30-8:00pm
Taos	Sagebrush Inn, 1508 Paseo Del Pueblo Sur	Wednesday, March 18, 2020	6:30-8:00pm

Public Involvement Plan for
New Mexico Wildlife Corridors
Action Plan

Prepared for **New Mexico Department of Transportation**

January 22, 2020

Daniel B. Stephens & Associates, Inc.

6020 Academy NE, Suite 100 • Albuquerque, New Mexico 87109

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Appendix

1. Introduction

Daniel B. Stephens & Associates, Inc. (DBS&A) was contracted by the New Mexico Department of Transportation (NMDOT) to assist with the development and implementation of a public involvement plan (PIP) as part of the New Mexico Wildlife Corridors Action Plan (Action Plan). The Action Plan is to be developed in accordance with the 2019 New Mexico Wildlife Corridors Act (the Act).

The Act was passed for the purpose of "identifying and protecting wildlife corridors; requiring a Wildlife Corridors Action Plan to be created that provides comprehensive guidance to State agencies for identifying, prioritizing and maintaining important areas for wildlife movement; providing powers and duties; directing the development of a list of priority projects based on the Action Plan." The Act states that NMDOT and the New Mexico Department of Game and Fish (NMDGF) shall prioritize projects within the wildlife corridors project list by assessing, among other criteria, "local community support for proposed wildlife corridors infrastructure" and "surrounding land-use and ownership, especially tribal lands, and an evaluation of the need for conservation easements or other real estate instrument necessary to maintain the viability of a proposed wildlife corridor." This emphasis on developing the project list in concert with public and agency input and support is important to the development and successful implementation of the Act.

This PIP has been prepared to ensure that meaningful input is sought and incorporated into the process. It has been developed in accordance with NMDOT public involvement plan guidance (NMDOT, 2018). The PIP is to be used as a "living" document, updated throughout the development and implementation of the Action Plan. This PIP includes (1) initial identification of stakeholders, including tribes, government agencies, non-profit organizations, and special interest groups, (2) techniques for communicating with these groups, (3) goals of working with the community and stakeholders, (4) analyses of the background context, (5) opportunities to express local values and discussion of specific consideration of potential issues, (6) incorporation of local knowledge of wildlife-vehicle collision hotspots and big game migration and movement corridors, and (7) possible methods for addressing concerns.

There are no federal funds allocated for the implementation of the PIP; therefore, there are no federally mandated public involvement requirements. Rather, this PIP was developed based on the mandate of the New Mexico State Legislature in accordance with the Act. Other public involvement requirements include those required under highway safety plans. This PIP will therefore also incorporate the safety planning process per 23 CFR 1300.11(a)(2 and 4).

2. Project History

New Mexico has a history of legislative mandates and responding actions that addressed identification of problem areas for wildlife-vehicle conflict and finding solutions to these problems. Since 2002, NMDOT and NMDGF have worked together to design and implement wildlife crossing safety measures, including the first wildlife crossing structures in New Mexico on U.S. Highway 550 (US 550) near Aztec, New Mexico. Since that time, workshops and public meetings have been held and priority maps have been created. Other projects, including the 2007 Tijeras Canyon Safe Passage Project and, most recently, the 2019 US 550 wildlife crossing project, have also been implemented to guide wild animals to safe areas for crossing roads.

In 2019, New Mexico was the first state to pass a Wildlife Corridors Act. The Act instructs NMDOT and NMDGF to develop a comprehensive Wildlife Corridors Action Plan to identify and prioritize important areas for wildlife movement and key barriers to those movements, such as roads. The Act instructs that approaches to solutions to wildlife-vehicle conflict should be considered from not only the public safety viewpoint, but also from the wildlife movement viewpoint. The Action Plan will build on previous studies and will identify new, science-based wildlife corridor priorities. It will be developed with meaningful input from the public.

New Mexico has a history of involving stakeholders and the public in workshops focusing on wildlife needs for connectivity and the safety of motorists from wildlife-vehicle collisions. Recent efforts began with the NMDOT Critical Mass Workshop in 2003, which gathered input on statewide high-risk locations for wildlife-vehicle collisions and produced a map of high-risk areas on New Mexico highways. In 2013 the New Mexico State Legislature passed a memorial (House Memorial 1, Senate Memorial 11) directing NMDOT and NMDGF to jointly host a workshop to identify priority road segments for future wildlife-vehicle collision mitigation measures. During the subsequent workshop, a total of 49 participants helped identify 32 priority segments across New Mexico, all of which merited further investigation. Crash and carcass data were considered and field visits were conducted in each district to evaluate the feasibility of new mitigation projects at these locations. The field review identified three road segments that could most feasibly be mitigated by NMDOT: US 70 east of Alamogordo, Interstate 25 (I-25) at

Raton, and US 550 south of Cuba. NMDOT was instructed by the memorial to submit Highway Safety Improvement Program (HSIP) funding applications for these top potential mitigation measures. NMDOT received HSIP funds. Work along I-25 at Raton was completed in November 2017, and the US 550 south of Cuba project was completed in August 2019.

In recent years, a model has been developed for agency and public participation in efforts to coordinate statewide and across state line efforts concerning wildlife connectivity, centered on the Upper Rio Grande Valley. In 2016 the University of New Mexico (UNM) New Mexico Natural Heritage Program and Colorado State University (CSU) Colorado Natural Heritage Program hosted the 2016 Wildlife Doorways Workshop (https://nhnm.unm.edu/Wildlife_Movement_Workshop), which brought together a diverse group of stakeholders to discuss wildlife movement patterns and management practices in the Upper Rio Grande. The National Wildlife Federation, with partner organizations, led the 2017 and 2019 Upper Rio Grande Wildlife Corridor and Connectivity Summits (https://www.heinrich. senate.gov/photos/wildlife-corridor-and-connectivity-summit-august-22-2017 and https:// connectedcorridors.com/event/forest-summit-2019/) and the Rio Grande Wildlife Connectivity and Corridor Collaborative Working Group. The goals of the workshops and working group are to collaborate and share current data, ideas, and policies on landscape connectivity in New Mexico and Colorado.

The PIP will help develop the Action Plan in a manner that will build upon these past and ongoing efforts to raise support and consensus in the identification of wildlife corridors across New Mexico and the necessary actions to mitigate roads for wildlife and to help keep motorists safe in these areas.

3. Public Involvement Process

The objectives of the PIP are two-fold:

- Provide transparency during the Action Plan development through public meetings, publications and discussions of the scientific process methods used to identify wildlife-vehicle conflict hotspots, priority wildlife corridors, and recommended actions to take in these corridors and wildlife-vehicle hotspots along roads.

- Provide opportunities for public input on areas of concern for wildlife-vehicle collisions, the findings of the Action Plan, and strategies and/or tools to implement solutions in the priority areas.

The Action Plan, which will not be finalized until public comment is received and incorporated as appropriate, will draw from meaningful participation of stakeholders in planning activities. The main goal of the public involvement process will therefore be to build support through collaboration with local communities, stakeholders, and other groups, and to address potential needs and concerns. This strategy for public education and involvement will assist the research team in creating successful outcomes in conjunction with the Action Plan and subsequent wildlife mitigation infrastructure projects. Public outreach for this process is also intended to build dialogues between the NMDOT, NMDGF, and interested community members, tribal entities, and government and non-government organizations to find common ground and build partnerships for achieving the goals set out in the Act.

3.1 Transparency

NMDOT will ensure that the preparation of the Action Plan will be in a manner that will ensure a transparent process. The development of the Action Plan with the public's input will encourage and promote active public participation in a meaningful manner and will be documented for accountability throughout the process. As part of the process, one goal will also be to monitor the effectiveness of the public involvement effort, making adjustments as needed to ensure that trust and credibility are maintained.

Transparency in the development of the Action Plan will occur through (1) posting information about the Action Plan and public meetings, and (2) informing the public at selected intervals regarding planning and decisions made concerning priority projects for wildlife corridors. Details of progress made during development of the Action Plan will be posted through online media outlets (e.g., NMDOT and NMDGF websites, social media).

All decisions, data sources used, references cited, and methods used to compile data and set priorities will be scientifically documented. It is important to note that transparency is designed to inform the public and take their comments and concerns.

All public meetings will be publicized in advance via advertising by radio and/or newspaper, social media (i.e., agency Facebook, Twitter, and Instagram accounts), and personal outreach by state agency personnel as determined to be appropriate. NMDOT will collect and archive all public comments, both in meetings and submitted individually to both NMDOT and NMDGF. DBS&A will assist in development of a spreadsheet to catalog and categorize all comments received.

3.2 Seek Feedback

Feedback is important to the process of implementing mitigation solutions for the wildlife-vehicle collision hotspots and priority wildlife corridors and linkages identified through data analysis. The Action Plan will first be introduced through an early round of public meetings conducted by NMDOT and NMDGF. The methodology to be used for identifying and ranking wildlife-vehicle conflict hotspots and priority corridors and linkages will be presented and explained at those meetings. NMDOT and NMDGF will answer questions from the public regarding both the overall goals of the Action Plan and its methodology. Public comments will be documented, including any feedback on road hotspot areas that stakeholders view or recommend as priorities. Those perceived priorities might or might not be identified through data analysis, but they will be later cataloged and discussed in the Action Plan.

Once priority locations for wildlife corridors have been identified through data analysis and modeling and field visits have informed the recommendations for specific actions in the top-priority corridors, the research team will again work with the public to solicit feedback on the recommended actions. Public input will be sought from all interested parties, including tribal entities, land management agencies, public safety interest, non-government organizations (NGOs), and members of the public as to the specific mitigation actions to be implemented within priority areas and hotspots. It is understood that public involvement at this stage is intended to assess local community support for proposed wildlife corridor infrastructure in accordance with the Act. Any information received from stakeholders and the general public on wildlife vehicle collisions and perceived wildlife corridor priorities will be incorporated into the Action Plan

3.3 Lead Collaboration

With NMDOT in the lead along with NMDGF, the DBS&A team will work with stakeholders to catalog ideas, concerns, and input from the public, with the purpose of developing the best final Action Plan. The team will incorporate NMDOT guiding principles for developing the PIP. These principles include identifying and engaging stakeholders early and building and maintaining strong partnerships.

3.4 Appropriate Tools and Techniques

The PIP will be implemented through (1) existing agency social media sites (i.e., agency Facebook, Twitter, and Instagram accounts) and agency website postings of the progress and results of the project, (2) public meetings across the state, (3) review of public comments gathered by NMDOT, NMDGF, and DBS&A, and (4) posting of public comments on the Draft Action Planon the NMDOT and NMDGF agency websites (public comments received earlier, during the development of the Action Plan, will also be available upon request). Once the draft Action Plan is approved by the Advisory Panel, it will be published on the NMDOT and NMDGF websites. The public will have 30 days to submit comments on the Action Plan. The Action Plan will not be finalized until public comments are received and considered.

4. Identify Target Audiences

DBS&A will reach out to state and federal agencies, NGOs, the public, and other entities to introduce the project, receive initial input, and present the draft Action Plan. NMDOT will reach out to tribal entities.

Table 1 lists target stakeholders to be contacted.

Table 1. Target Stakeholders

Entity	Contact Person	Responsible for Contacting
Federal Government		
U.S. Forest Service [a]		
Carson	James Duran, Forest Supervisor 575-758-6200	DBS&A
Cibola	Steve Hattenbach, Forest Supervisor 505-346-3900	DBS&A
Coronado	Kerwin Dewberry, Forest Supervisor 520-388-8300	DBS&A
Santa Fe	James Melonas	DBS&A
Gila	Adam Mendonca, Forest Supervisor 575-388-8201	DBS&A
Kiowa	Steve Hattenbach, Forest Supervisor 505-346-3900	DBS&A
Lincoln	Travis Moseley 575-434-7200 Lincoln_General_Comments@usda.gov	DBS&A
U.S. Fish and Wildlife Service Southwest Region/Ecological Services Field Office	James Broska 505-761-4768 James_Broska@fws.gov	DBS&A
Bureau of Land Management [a]	John Sherman, Wildlife Program Lead jssherma@blm.gov	DBS&A
Military Bases/Ranges - New Mexico [a]	TBD	DBS&A
National Park Service [a]	TBD	DBS&A
BIA, Southern Pueblo Agency	Lawrence Abeita 505-563-3723	DBS&A
Senator Martin Heinrich Senator Tom Udall Congressman Ben Ray Lujan Congresswoman Deb Haaland Congresswoman Xochitl Torres-Small	TBD	DBS&A

Table 1 (cont.)

Entity	Contact Person	Responsible for Contacting
State Government		
Department of Game and Fish	Mark Watson, Advisory Panel	DBS&A
State Land Office	Sunalei Stewart Deputy Commissioner of Operations 505-827-5760 sstewart@slo.state.nm.us	DBS&A
New Mexico Department of Energy, Minerals and Natural Resources	TBD	DBS&A
Local Government		
Counties	All county commissioners	DBS&A
Council District 5, Las Cruces	Gill Sorg, Mayor Pro Tem, gsorg@las-cruces.org	DBS&A
Tribal [b]		
Pueblos		NMDOT Tribal Liaison: Genevieve Head
All Pueblo Council of Governors	Alicia Ortega, 505-470-1732	
19 pueblos [a]		
Pueblo of Santa Ana	Alan Hatch, alan.hatch@santaana-nsn.gov	
Jicarilla[a]	Kyle Tator, Wildlife Biologist 575-644-0521 kyle.tator@gmail.com	
Navajo Nation [a]	NN Department of Fish and Wildlife	
Mescalero [a]	Mescalero Big Game Hunts	
Fort Sill Apache [a]	TBD	
Non-Government Organizations		
National Wildlife Federation	Jeremy Romero (Team member), romeroj@nwf.org	DBS&A
Defenders of Wildlife	Michael Dax, mdax@defenders.org Bryan Bird, bbird@defenders.org	DBS&A
HECHO (Hispanics Enjoying Camping and Hunting Outdoors)	Kent Salazar, camilla@hechoonline.org	DBS&A
New Mexico Wildlife Federation	Jesse Deubel, jesse@nmwildlife.org	DBS&A
Western Landowners Alliance	Lesli Allison, lallison@westernlandowners.org	DBS&A
CVNM (Conservation Voters of New Mexico)	Ben Shelton, ben@cvnm.org	DBS&A
Animal Protection New Mexico	Jessica Johnson, jessica@apnm.org	DBS&A

Table 1 (cont.)

Entity	Contact Person	Responsible for Contacting
Non-Government Organizations (cont.)		
Theodore Roosevelt Conservation Partnership	John Cornell, jcornell@trcp.org	DBS&A
Backcountry Hunters and Anglers	Katie Delorenzo, delorenzo@backcountryhunters.org	DBS&A
Trout Unlimited	Toner Mitchell, toner.mitchell@tu.org Dan Roper, dan.roper@tu.org	DBS&A
Non-Government Organizations (cont.)		
Pew Charitable Trusts	Matt Skroch, mskroch@pewtrusts.org	DBS&A
NM Cattlemen’s Association	Tom Sidwell, Quay – President Albuquerque Office number: 505-247-0584	DBS&A
Wildlands Network	Phil Carter, phil@wildlandsnetwork.org	DBS&A
WildEarth Guardians	Chris Smith, csmith@wildearthguardians.org	DBS&A
Sierra Club	Teresa Seamster, ctc.seamster@gmail.com Brittany Fallon, brittany.fallon@sierraclub.org	DBS&A
Gila Conservation Coalition [a]	TBD	DBS&A
Nature Conservancy [a]	Conservation Manager Collin Haffey Phone: 505-946-2037 Email: collin.haffey@tnc.org	DBS&A
NM Wilderness Alliance [a]	Garret Veneklasen g.veneklasen@me.com	DBS&A
Santa Fe Conservation Trust [a]	Sarah Noss Executive Director Email: info@sfct.org Telephone: (505) 989-7019	DBS&A
NM Acequia Association [a]	Paula Garcia Executive Director Lamorena@lasacequias.org	DBS&A
Private Citizens		
Ms. J. Connors	Silver City, NM 88061	DBS&A
Ms. J. Demichele	Pinos Altos, NM 88053	DBS&A
Ms. C. Metzler	Silver City, NM 88061	DBS&A
Ms. C. O'Shea	carolynoshea@gmail.com	DBS&A

[a] To be determined, dependent upon location.
[b] All outreach to tribal entities will be facilitated by Genevieve Head, the NMDOT Tribal Liaison.

5. Outreach Methods

5.1 Outreach Options

Planned public outreach goes beyond seeking input on mitigation projects within priority areas; it includes presenting and explaining the scientific process that will result in the ranking and selection of those priority areas. It is also meant to develop consensus, provide answers to concerns and build support that may include partnerships for future wildlife-vehicle conflict mitigation efforts. It is important to define the appropriate measures to be taken for outreach and the appropriate time to seek input. Priority areas will be identified and ranked by scientific data analysis and field reconnaissance. Input will be sought for project development within the identified priority corridors. Any input received on hot spot locations and priority areas that may not otherwise be scientifically documented will be evaluated for inclusion. Recommendations may be made in the Action Plan based on input provided by the public. It is important that the process guiding the development of the Action Plan be explained to the public in detail.

Appendix A provides Tables 3.1 through 3.3 from the NMDOT public involvement plan guidance (NMDOT, 2018). The tables provide a variety of methods that may be used at various times during the process.

Outreach will be conducted as a stepped process depending on the corresponding phase of Action Plan development. These steps are further defined in Section 6.

5.2 Budget

Approximately 24 percent of the allocated budget for Action Plan development is dedicated to public outreach. Every effort will be made to find the most effective activity for outreach that is also cost effective. NMDOT (2018) provides guidance for the "pros and cons" of any specific activity and whether the activity is anticipated to be low cost or high cost. When determining an activity's effectiveness, Tables 3.1 through 3.3 from the NMDOT guidance (Appendix A) will be reviewed to evaluate the pros and cons of the activity prior to implementation.

6. Engagement Activities

This section is broken down into the stepped phases of Action Plan development. The timing is outlined in Table 2.

Table 2. Phases of Action Plan Development

Phase	Public Involvement and Action Plan Development	Approximate Timeline
1	Send out stakeholder letters with information sheet.	Quarter 1, 2020
1	NMDOT and NMDGF to conduct eight initial public meetings	Quarter 1, 2020
1	Gather input received from stakeholders and from public meetings for cataloging and evaluation as part of the Action Plan development	Quarters 1–3, 2020
2	Conduct three public meetings to present the corridor locations and the top recommendations.	Quarter 4, 2020– Quarter 1 2021
2	Gather appropriate input from the public on recommended actions for the designated priority wildlife corridors and wildlife corridor project list.	Quarter 4, 2021
3	Develop draft Action Plan.	
3	Announce and release draft Action Plan for public review.	30-day review
3	Release final Action Plan.	

6.1 Phase 1

During this time period, stakeholders and other targeted audiences (Table 1) will be notified through stakeholder letters that the project has begun, and that they are invited to an initial round of public outreach meetings and/or can provide input through e-mail or written hard-copy comments. DBS&A will prepare the letters and any needed attachments, as well as the mailing list. All tribal outreach will be handled by the NMDOT Tribal Consultation Coordinator, who will also send the letter to tribal entities.

During this time period, eight public meetings will be conducted around the state: four by the NMDOT and four by the NMDGF. The meetings will be held for the following purposes:

- Introduce the Action Plan and its mandated purpose based on the intent of the Act.
- Assuage any public concerns by providing information on the needs of any potential projects (e.g., land use restrictions, acquisition and/or temporary easements) that would result from areas identified in the Action Plan.
- Present the general approach for the Action Plan development and schedule for completion.
- Gather public input through a question/answer period and a session allowing for the markup of display maps.

NMDOT will coordinate and host outreach meetings at Albuquerque East Mountains (Cesar Chaves Community Center), Silver City, Santa Fe (NMDOT GO), and Farmington. NMDGF will coordinate and host public outreach meetings at each of their field office locations: Raton, Roswell, Las Cruces, and Albuquerque.

DBS&A will provide media packets to NMDOT and NMDGF for release to their public information officers and for updates to the agency social media sites, informing the public of the upcoming initial meetings and how to provide input if they do not attend the meetings. Included in the packet will be a meeting announcement with all pertinent information for the agencies to advertise and distribute as necessary.

DBS&A will develop a Microsoft PowerPoint presentation and display maps for the meetings in close coordination with NMDOT and NMDGF. DBS&A will collate comments received by land management agencies and other entities after these meetings. DBS&A will enter and categorize comments into a public input spreadsheet. Comments will be used to help with drafting future research recommendations and the design of future mitigation projects. The local community support for proposed wildlife corridors infrastructure will become part of the prioritization of projects within the wildlife corridors projects list.

Concurrent with and after the stakeholder letters and initial public meetings, a preliminary draft Action Plan will be developed, a list of potential project sites will be developed, and field reconnaissance of the sites will be conducted by researchers, NMDOT, and NMDGF. Input from stakeholders will be incorporated as appropriate. This will also be a time period for evaluating the effectiveness of public outreach (Section 7).

6.2 Phase 2

Additional public meetings will be conducted during this time period to seek feedback on the acceptance and feasibility of mitigation projects for specific road corridors identified as top priorities. There will be three meetings. The locations of the meetings will be based on the locations of the priority wildlife corridor and vehicle conflict sites that have been determined from the analysis. The purpose of the meetings will be to present the findings of the scientific analysis and to receive comments. Findings will be presented with a Microsoft PowerPoint presentation, project information sheet, and poster graphics. Representatives from NMDOT, NMDGF, and the leadership of the research team, including the primary investigator, project manager, and public relations specialist, will attend each meeting. An input or comment form will be developed and made available for the meetings. Input from these public meetings is not meant to change the designation of the scientifically based wildlife corridors, but rather to gather feedback on potential projects at the designated locations.

Again, a media packet will be prepared and notices of the three meetings will be posted on NMDOT and NMDGF websites and agency social media sites and e-mailed to designated lists of interested parties (e.g., stakeholders, previous meeting attendees, highway safety committees, community and constituent groups, NGOs, tribal and local governments, etc.). Advertising for each of the three meetings will include one local newspaper advertisement (¼-page) and other targeted outreach as determined depending on the community location.

In addition to the meetings, public outreach activities may include online engagement activities such as an online map and/or input forms for comment. Other opportunities for public outreach would include presenting the findings to special interest groups that may request additional meetings. These meetings would provide opportunities to express local values and to specifically discuss potential issues.

Following the public meetings, comments will be collected, including local knowledge of wildlife-vehicle collision hotspots, big game migration, and movement corridors, landowner concerns, conflicting activities in designated wildlife corridors, as well as other issues of concern. Comments will be evaluated on two levels: (1) for incorporation into the Action Plan, as needed and (2) to monitor the effectiveness of public outreach (Section 7).

6.3 Phase 3

The draft Action Plan will be developed during this phase. In order to prepare for the public release of the Action Plan, mailing lists will be updated and news of the forthcoming release of the Action Plan and where interested parties can access it on the internet, will be announced on the NMDOT and NMDGF websites. The draft Action Plan will be released for public review. Interested parties will be notified by e-mail (from the mailing list) that the Action Plan has been published on the NMDOT and NMDGF websites, and announcements will be made through various means, such as press releases and media interviews. Under no circumstances shall anyone other than the designated NMDOT spokesperson or an NMDOT-approved representative make any public statements or hold any press conferences or media interviews on behalf of NMDOT for the Action Plan.

The release of the Action Plan will mark the beginning of a 30-day public review period.

Following the 30-day public review, any necessary changes will be incorporated and the final Action Plan will be reviewed and released. Public input and review will be completed at this point.

6.4 All Phases

Included in all phases will be activities such as periodic e-mail updates to interested parties and social media posts with updates. Social media outlets will include NMDOT and NMDGF official

Facebook, Twitter, and Instagram accounts. When an update or an event such as a public meeting announcement is determined necessary, DBS&A will prepare a social media packet that will be submitted to the NMDOT Chief Communication Officer and NMDGF Information and Education Division for their approval and publication. In-person committee/working group meetings may be held as necessary or by request, contingent on NMDOT approval. Quarterly meetings with the Advisory Panel will be held during the entire process.

7. Effectiveness Monitoring

This PIP is meant to be a living document; the effectiveness of the PIP will be periodically monitored and the plan will be adjusted accordingly. There may be budgetary constraints to some activities or it may be determined that one activity has had greater impact than another. All activities listed as options in Tables 3.1 through 3.3 of the guidance (Appendix A) have pros and cons; therefore, adjustments will be necessary.

One tool to be used throughout preparation of the Action Plan is the Assessment of Public Interest and Concern (Appendix B), designed to anticipate and gauge the level of public interest or concern in relation to the Action Plan and to help guide the public involvement process. This assessment should be completed by the Advisory Panel at the beginning of the project and then at milestone events throughout the process.

Another possible tool to assess the effectiveness of community outreach will be to develop metrics that can track the success of the PIP throughout the process. The goal of this PIP is to inform and gain local community support for the Action Plan. Metrics can be used to determine whether or not the public involvement activities have been successfully implemented. The metrics used for this process should be easy to understand, timely so that corrections can be made quickly, insightful (i.e., provide information that will measure public outreach effectiveness), and controllable (Sullivan et al., 2004). Metrics for the PIP could include the following:

- The number of phone calls, e-mails, or other communications received and length of time for response
- The number of one-on-one interactions
- The percentage of times feedback is requested versus simply publishing data
- The number of positive press articles
- An evaluation of not just the number of comments received, but also the content of comments to determine whether the published information was easy to understand

- Graphics such as pie charts to determine support for the information presented
- The number of people attending the public meetings

References

New Mexico Department of Transportation (NMDOT). 2018. *Public involvement plan*. December 2018.

Sullivan, M.J., M.F. McDaniel, and R.D. Siegel. 2004. Using metrics to track community outreach progress. *CEP Magazine* (December). Available at <https://www.d.umn.edu/~rdavis/courses/che3791/Green/notes/Community%20Outreach.pdf>.

Appendix A

Tables 3.1 through 3.3 from NMDOT Public Involvement Plan

Table 3.1 Activity List - Provide Transparency

KEY: ① PHASE 1 ② PHASE 2 ③ PHASE 3 ∞ ALL PHASES ○ LESS EFFECTIVE ◐ EFFECTIVE ● VERY EFFECTIVE

Activity	Phase	Description	Pros	Cons	Cost	Audience Adaptability	EJ Outreach
Advertisements	①	Advertisements on the TV, radio, in newspapers, on public transit, etc. notifying the public about upcoming public meetings and the plan in general.	Potential to reach diverse audience	Difficult to measure effectiveness in reaching target audience	$$$	●	◐
Project Info Sheet	①	Brief, one-page descriptions of different plan topics, such as overviews of the plan, plan phases, or other information that can be distributed to stakeholders or the public. May contain graphics or diagrams to assist with communicating data.	Summarizes key project ideas in a concise, digestible format		$	◐	◐
Periodic Email Updates	∞	Plan updates at key milestones and information on upcoming meetings and events sent to those who have opted to receive communications. Emails can be sent to listservs, which is a list of emails that target a specific interest-group. Listservs can be maintained by NMDOT, but are often maintained by outside organizations.	Easy and low cost	Only engages those who have opted in; not accessible for those without internet access	$	●	◐
Social Media Posts	∞	Information about the plan posted on socia media feeds like Facebook or Twitter. Posts can be made from existing NMDOT accounts or project-specific accounts can be created. Hash tags can be utilized to link posts and encourage further engagement.	Easy, low cost, and instantaneous	Only engages followers; not accessible for those without internet access	$	○	◐
Project Website or Blog	∞	Provides meeting announcements, summaries, news releases, plan materials, public surveys, opportunites to leave comments, etc. Can be hosted on NMDOT website or another site.	Low cost and easy to update	Requires additional activity to promote awareness; not accessible for those without internet access	$	●	○
Press Releases/ Press Conferences	∞	Official statements about the plan issued to the media at key milestones. Press conferences can be recorded and posted on the NMDOT or project website and Youtube.	Generates press coverage	Dependent on media outlets to distribute in most cases	$$	◐	○
Media Interviews	①	TV, radio, newspaper, etc. interviews of project team staff; could result in an article or segment highlighting key aspects of the project.	Promotes plan to fairly diverse audience, if distributed to diverse media outlets	May require multiple interviews or translations if needed in more than one language	$	◐	○

Table 3.2 Activity List - Seek Feedback

KEY: ① PHASE 1 ② PHASE 2 ③ PHASE 3 ∞ ALL PHASES ○ LESS EFFECTIVE ◐ EFFECTIVE ● VERY EFFECTIVE

Activity	Phase	Description	Pros	Cons	Cost	Audience Adaptability	EJ Outreach
Roadshow Presentation	∞	Powerpoint with information and updates for each phase of the planning process presented at MPO or RTPO policy board and technical committee public meetings, professional conferences, and other public and non-public events (as needed or by request), by project manager, NMDOT planning liaisons, or MPO/RTPO planners.	Transferable to different audiences	Requires significant staff time	$	●	◐
Project Information Station	① ②	Poster displays with brochures and other plan materials at public or private events, such as festivals, conferences, and farmers markets where target audiences tend to congregate. Staff are on hand to answer questions and engage with the audience.	Potential to reach audience that may be traditionally difficult to engage; comfortable, informal setting	Requires at least some travel for staff	$$	●	◐
Online Input Map	②	Users draw lines and points to identify and comment on locations of interest.	Removes some barriers to access; data is easy to analyze	Not accessible for those without internet access	$$	◐	○
Targeted Interview/Focus Group	②	Project team meets with various existing groups, such as the NM Main Street Program Community Leaders and the Governor's Commission on Disability, to discuss plan aspects and obtain feedback.	Special interest groups are often good representatives of certain communities that may otherwise be difficult to engage	Engaging more than a few of these groups could be time-consuming	$$	◐	●
Statistically Valid Public Survey	②	Survey administered to a sample of the population that is representative of the entire state population.	One of the only ways to reach a diverse audience	Expensive and time consuming; responses are not guaranteed	$$$	○	●
Informal Targeted Survey or Comment Form	②	Informal survey, questionaire, or comment form distributed to event attendees that asks for feedback on the information discussed at event.	Typically high rates of participation	Only representative of select group	$	◐	◐
Online Public Survey	②	Informal survey with questions related to the plan available online.	Removes some barriers to access; ability to reach large number of people	Not accessible for those without internet access; results tend to be skewed towards interested parties	$$	◐	○
Public Review Period	③	Plan draft is open for public review on the project website for specified period of time, usually 45 days. Project team collects and records comments.	Allows for public to provide feedback	Requires effective promotion	$	●	○

Table 3.3. Activity List - Lead Collaboration

KEY: 1 PHASE 1 2 PHASE 2 3 PHASE 3 ∞ ALL PHASES ○ LESS EFFECTIVE ◐ EFFECTIVE ● VERY EFFECTIVE

Activity	Phase	Description	Pros	Cons	Cost	Audience Adaptability	EJ Outreach
In-person Committee/ Working Group Meeting	∞	Subject matter experts from public and private sectors (including staff from NMDOT Divisions and Districts, MPOs, RTPOs, other state and federal agencies, local governments, transit agencies, universities, private businesses, non-profit organizations, and transportation user groups) develop vision and goals, brainstorm strategies,and evaluate and review plan deliverables.	Enables input from participants with specific subject knowledge	May be difficult to convene all stakeholders in one place at one time	$	◐	◐
Pop-up Exhibit	2	Temporary exhibits about the project in community centers, libraries, storefronts, lobbies, or similar spaces. Staff may or may not be on hand to answer questions.	Opportunity to promote plan in different geographic areas/locations target audience tends to frequent	Site identification may have costs associated with the use	$$	◐	●
Mobile Meeting	2	Project staff conduct interactive excercise, such as participatory mapping, walk audits, etc. at preexisting community events.	Potential to reach audience that may traditionally be difficult to engage	Requires at least some travel	$$$	◐	●
In-person Public Meeting with In-teractive Exercise	2	Staff presentation followed by interactive exercise with opportunity for discussion and questions.	Opportunity to promote comprehension of the plan and obtain input	Historically low rates of attendance	$$$	◐	◐
Virtual Open House or Webinar	2	Virtual presentation; opportunity for attendees to ask questions in real-time.	Removes some barriers to access	Not accessible for those without internet access	$$	◐	○
School Outreach Programs	1	Staff conduct special events or interactive exercises with school children and provide informational material to take home to parents.	Targets often overlooked audience; potential to reach audience that may be traditionally difficult to engage	Difficult to assess effectiveness in reaching parents; requires incentive for children to deliver materials to parents	$$	○	◐

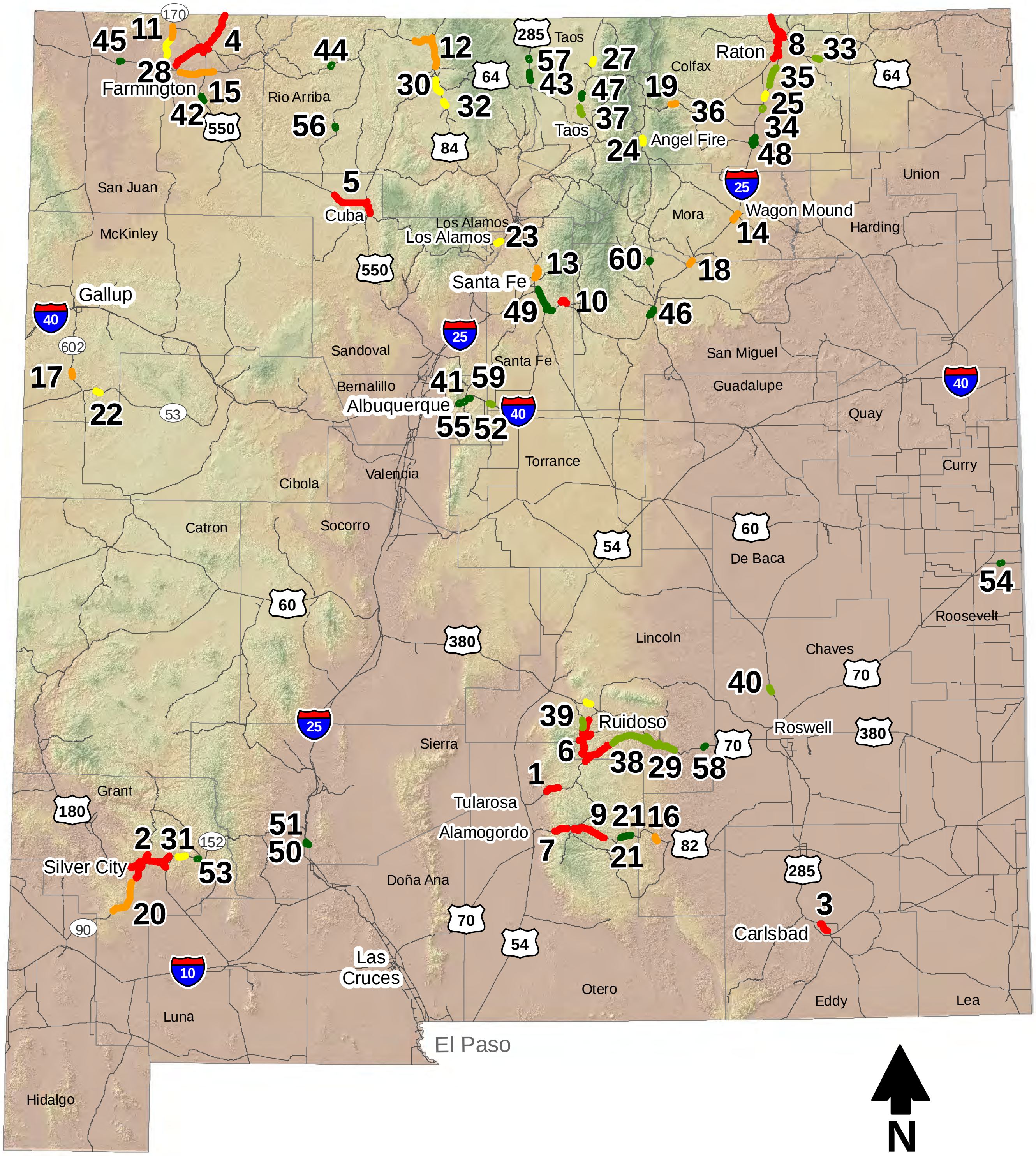
Appendix B

Assessment of Public Interest and Concern

Assessment of Public Interest and Concern	Very Low (Level 1)	Low (Level 2)	Moderate (Level 3)	High (Level 4)	Very High (Level 5)
1. What is the anticipated level of conflict, concern, controversy, or opportunity on the issue of wildlife vehicle collisions/conflicts, wildlife linkages, and Action Plan to identify mitigation priorities, and creating wildlife crossing structures?					
2. How significant ate the potential impacts to the public?					
3. How much do the major stakeholders care about these issues and projects already implemented in New Mexico and elsewhere?					
4. What degree of involvement does the public appear to desire?					
5. What is the potential for public impact on the recommendations in the Action Plan?					
6. How significant are the possible benefits of involving the public?					
7. How serious are the potential ramifications of NOT involving the public?					
8. What level of public participation does NMDOT expect?					
9. What is the possibility that the media will become interested?					
10. What is the probable level of difficulty in completing the Action Plan?					
TOTALS					

Appendix C

Hotspots Identified Statewide



Explanation

Ranked OHSA 1-mile analysis

- 1 - 10
- 11 - 20
- 21 - 30
- 31 - 40
- 41 - 60

NMDOT WILDLIFE CORRIDORS ACTION PLAN

Optimized Hot Spot Analysis (OHSA) 1-mile Distance with 1-Mile Road Segments

DBS&A
Daniel B. Stephens & Associates, Inc.
10/5/2021 DB19.1389

S:\PROJECTS\DB19.1389_WILDLIFE_CORRIDORS_ACTION_PLAN\GIS\MXDS\FIGURES_SEPTEMBER2021\HOT_SPOT_RESULTS_TOP60.MXD

List of WVC Hotspots Identified in New Mexico

(as shown on preceding map)

Rank	Mean Crashes per Mile	Length (miles)	Name	Location	Count	Fatalities	Injuries	Pronghorn	Bear	Cougar	Deer	Elk
1	17.600078945	5.00	US 70 Bent – Sacramento Mtns	US 70	88	0	4	0	0	0	18	70
2	17.054418032	27.62	US 180 SR 90 Silver City	NM 180 , NM 90	471	0	16	0	2	1	455	13
3	16.500074011	4.00	US 285 North Carlsbad – Pecos River	US 285	66	0	1	0	0	0	66	0
4	13.413977892	33.77	NM 516 and US 550 Farmington to Aztec to CO	NM 516 , US 550	453	0	17	1	4	0	446	2
5	12.058877619	17.00	US 550 North of Cuba	US 550	205	0	10	0	4	0	81	120
6	10.848533503	33.00	US 70 and NM 48 Ruidoso Sacramento Mtns.	US 70 , NM 48	358	0	9	0	4	1	256	97
7	10.800000000	5.00	US 82 West of Cloudcroft	US 82	54	0	2	0	0	1	13	40
8	10.576169301	26.47	I-25 North Raton to Colorado Border	I-25	280	0	14	3	49	3	183	42
9	10.307738543	13.00	US 82 East of Cloudcroft	US 82	134	0	7	0	3	0	46	85
10	9.500042612	4.00	I-25 Glorieta	I-25	38	0	0	0	6	0	30	2
11	9.500042612	4.00	SR 170 South of La Plata	NM 170	38	0	0	0	1	0	37	0
12	8.823568990	17.00	US 64-US 84 South Chama	US 64 , NM 17	150	0	2	0	7	1	106	36
13	8.809205397	4.77	US 84 North of Santa Fe	US 84	42	0	3	0	2	0	35	5
14	8.333370713	3.00	I-25 South of Wagon Mound	I-25	25	0	3	0	5	0	14	6
15	8.083369591	12.00	US 64 East of Farmington	US 64	97	0	3	0	0	0	96	1
16	8.000035884	2.00	US 82 East of Otero/Chaves County line	US 82	16	0	0	0	0	0	16	0
17	8.000035884	2.00	SR 602 South of Gallup at Rio Nutria	SR 602	16	0	5	0	0	0	7	9
18	8.000035884	2.00	I-25 South of Watrous	I-25	16	0	3	0	1	0	11	4
19	8.000035884	2.00	US 64 between Eagle Nest and Cimarron	US 64	16	0	0	0	2	0	5	9
20	7.785746541	14.00	SR 90 South of Tyrone	NM 90	109	0	6	0	0	0	109	0
21	7.500033641	2.00	US 380 West of Capitan	US 380	15	0	0	0	0	0	5	10
22	7.500033641	2.00	SR 53 Pescado	SR 53	15	0	0	1	0	0	4	10
23	7.500033641	2.00	NM 502 West of Rio Grande	NM 502	15	0	1	0	0	0	14	1
24	7.500033641	2.00	NM 434 Angel Fire	NM 434	15	0	1	0	0	0	8	7
25	7.500033641	2.00	I-25 South of Raton	I-25	15	0	2	0	0	1	8	6
26	7.500033641	2.00			15	0	1	0	1	0	1	13
27	7.500033641	6.00			45	0	3	0	1	0	44	0
28	7.067123056	5.38			38	0	2	0	0	0	25	13
29	7.000031398	3.00			21	0	0	0	1	1	19	0
30	7.000031398	2.00			14	0	4	0	0	0	6	8
31	7.000031398	2.00			14	0	3	0	5	0	2	7
32	7.000028000	1.00			7	0	0	0	0	0	7	0
33	6.878690390	22.53			155	0	11	0	2	0	140	13
34	6.616751339	7.41			49	0	5	2	4	1	21	21
35	6.500029156	2.00			13	0	2	0	0	1	4	8
36	6.333361741	3.00			19	0	4	0	0	0	19	0
37	6.250028034	4.00			25	0	0	0	0	0	9	16
38	6.000026913	3.00			18	0	2	0	0	0	10	8
39	6.000026913	2.00			12	0	0	0	0	0	11	1
40	6.000026913	2.00			12	0	0	0	0	0	12	0
41	6.000026913	2.00			12	0	1	0	0	0	9	3
42	6.000026913	3.00			18	0	2	1	0	0	4	13
43	6.000026913	1.00			6	0	0	0	0	0	3	3
44	6.000026913	1.00			6	0	0	0	0	0	6	0

List of WVC Hotspots Identified in New Mexico

(as shown on preceding map)

Rank	Mean Crashes per Mile	Length (miles)	Name	Location	Count	Fatalities	Injuries	Pronghorn	Bear	Cougar	Deer	Elk
45	5.750019344	4.00	US 82 east of Mayhill	US 82	23	0	0	0	0	0	13	10
46	5.513103106	3.63			20	0	9	0	5	0	5	10
47	5.500024670	2.00			11	0	0	0	0	0	5	6
48	4.988053781	7.62			38	0	1	0	1	2	35	0
49	4.958926514	17.54			87	0	8	1	1	0	80	5
50	4.000017942	1.00			4	0	0	0	0	0	4	0
51	4.000017942	1.00			4	0	0	0	0	0	4	0
52	4.000017942	1.00			4	0		0	3	0	0	1
53	3.000013457	1.00			3	0	0	0	0	0	3	0
54	3.000013457	1.00			3	0	0	0	0	0	3	0
55	3.000013456	1.00			3	0		0	3	0	0	0
56	3.000013456	1.00			3	0	0	0	0	0	3	0
57	3.000013456	1.00			3	0	0	0	0	0	0	3
58	2.000008971	1.00			2	0	0	0	0	0	2	0
59	1.000004485	1.00			1			0	1	0	0	0
60	1.000004486	1.00			1	0	0	0	0	0	1	0

Appendix D

Types of Wildlife Mitigation

Appendix D. Types of Wildlife Mitigation

This appendix describes different types of wildlife mitigation actions available to modify driver or wildlife behavior as an additional resource for New Mexico wildlife and highway planners, maintenance personnel, and engineers. The appendix is not meant to represent an all-inclusive guide to mitigation actions, but it briefly introduces all the available options and mentions relevant or recent supporting studies. For more details on mitigation options, see the 2008 FHWA report to U.S. Congress (Huijser et al., 2008 or FHWA, 2008). The types of mitigation actions are summarized in Table D-1.

Table D-1. Overview of wildlife mitigation strategies to reduce WVCs (adapted from Cramer et al., 2014 and 2016). Blue highlighted text is hyperlinked to section.

Measure	Difficulty in Effort and Time to Deployment	Effectiveness	Use Across U.S.	Cost to Agency
Actions that Target Wildlife				
Retrofit – Modify Existing infrastructure				
Place fence to existing structures	Moderate	High	Common	Moderate
Retrofit culverts and bridges	Low	Moderate	Common	Low
Adapt fences and gates	Low to Moderate	High	Common	Low
Facilitate wildlife movement across road	Low	High	Low	Low
Make Roadside Less Attractive to Wildlife				
Supplemental feeding/salt/water at a distance from road	Low	Unknown	Low	Low
Deter Wildlife from Entering Road				
Place exclusion fence and deterrents	Moderate	Moderate	Low - Moderate	Moderate-High

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Table D-1 (cont.)

Measure	Difficulty in Effort and Time to Deployment	Effectiveness	Use Across U.S.	Cost to Agency
Exclude Wildlife from Road and Provide Wildlife Crossing Structures, Fence, Escape Ramps, Guards				
Wildlife crossing structures, fence, fence end treatments, escape ramps, gates, guards,	High	High	High	High
Reduce Wildlife Populations				
Sharpshooting deer	Low-Moderate	Moderate-High	Moderate	Low
Experimental, Ineffective, and Inconclusive Methods Targeting Wildlife				
Vegetation management	Low	Low-Moderate	Moderate & Unknown	Low
Devices intended to elicit behavioral response through wildlife senses: tags, whistles	Low	Unknown	Low	Low
Reflectors and Noise	Low-Moderate	Inconclusive	Low	Low-Moderate
Predator Urine	Low	Inconclusive	Low	Low
Painted White Lines	Low	Low	Low	Low
Actions that Target Drivers				
Public Education and Awareness Campaigns				
Public awareness campaigns	Moderate	Largely Unknown	High	Low
Signage				
Static driver warning signs	Low	Low	High	Low
Static signs with lights	Low	Low	High	Low
Variable message boards	Low	Low-Moderate	High	Low
Speed Reduction Zones				
Wildlife crossing zones	Low - Moderate	Low- Moderate	Low	Low
Animal Detection Driver Warning Systems				
Animal detection driver warning systems, no exclusion fence	Moderate-High	Low - Moderate	Low	High

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Table D-1 (cont.)

Measure	Difficulty in Effort and Time to Deployment	Effectiveness	Use Across U.S.	Cost to Agency
Animal detection driver warning system with exclusion fence, crosswalks or fence ends	Moderate - High	Moderate - High	Low	High
Ineffective, Inconclusive, or Experimental Driver Methods				
Traffic calming	Moderate	Low - Moderate	High	Moderate
Reduce roadside vegetation	Low	Unknown to Low	Unknown	Low
Wildlife crosswalks and animal activated crosswalks	Moderate	Low	Low	Low-Moderate
Roadside lighting	Moderate	Unknown	High	Moderate-High
In road lighting – solar pucks	Moderate	Unknown	Low	Moderate
On-vehicle lighting	Low	Unknown	Low	Low
Driver phone applications	Low	Unknown	Moderate	Low
In vehicle warning systems	High	Unknown	Low	Moderate
Self-driving vehicles	Low	Unknown	Low	Low

D.1 Actions that Target Wildlife

D.1.1 Retrofit Existing Structures

Objective: Many existing culverts and bridges may allow wildlife to pass beneath roads with small modifications at a lower cost and on shorter time frames than needed for new wildlife crossing structures. In this context, retrofit is defined as an action to existing infrastructure that helps to encourage wildlife movement and thus makes the existing culvert or bridge functional for wildlife connectivity. See the Washington DOT Passage Assessment System (PAS) for how to evaluate existing infrastructure for potential retrofitting for all taxa of wildlife (Kintsch and Cramer, 2011). Retrofits include placing wildlife exclusion fence to existing structures, adapting culverts and bridges for wildlife movement, cleaning and clearing debris within and beneath structures, and other small adjustments.

Options: The options are classified in four categories:

- Fence placement to exclude animals from the road surface and encourage animals to use existing structures to move beneath or above roads
- Retrofit of culverts and areas under bridge to encourage wildlife movement
- Adapt fences and gates to facilitate wildlife movement beneath the road
- Adapt fence to facilitate wildlife movement across the road.

D.1.1.1 Place Fence to Existing Structures

Most DOTs place 8-foot-high fence along the right-of-way to channel ungulates and other wildlife to existing bridges and culverts so animals can move through them to pass beneath highways. Amphibian and reptile fence can be placed along the right-of-way fence to guide turtles, snakes, salamanders, tortoises, and other small animals to use existing culverts and bridges.

New Mexico has implemented multiple projects involving the retrofitting of existing bridges, culverts, and fences, deterring wildlife movements over roads and instead directing animals to use structures below the road (e.g., Figure D-1).

Figure D-1. Bridge under I-40 that wildlife use near Edgewood, New Mexico. Mule deer and other wildlife are directed to the area under the bridge for movement beneath I-40 (photo credit: M. Watson and J. Hirsch).

Arizona used a similar approach to reduce elk-vehicle collisions along I-17. Gagnon et al. (2015) documented a 97 percent reduction in elk-vehicle collisions in a road section where an area between existing bridges that were placed originally for water flow had right-of-way fence extended upward to 8 feet high. Use of the structures by elk increased by as much as

217 percent. Monitoring of several of the completed or planned New Mexico retrofits are currently being conducted by Arizona Game and Fish Department (AZGFD) and New Mexico Department of Transportation (NMDOT) Research Bureau (Figure D-2).

Figure D-2. Mule deer using areas under bridges in New Mexico after wildlife exclusion fence was placed along I-40 in Tijeras Canyon (photo credit: AZGFD and NMDOT).

D.1.1.2 Retrofit Modifications to Culverts and Areas Under Bridges

If culverts and areas under bridges are more like nearby natural conditions, wildlife will have more of a tendency to use them. The most common methods to make culverts and areas under bridges more suitable for wildlife use are as follow (e.g., Figures D-3 through D-6):

- Cleaning of culverts so wildlife can better use them
- Placement of natural substrate in culverts to mimic natural soil-like conditions
- Placement of a shelf to allow small animals to move above water
- Addition of crusher fines or other materials onto existing riprap rocks to create a 5 to 20 feet wide pathway through the boulder field that would facilitate wildlife and human movement
- Placement of a natural substrate path alongside asphalt pavement to facilitate safe wildlife passage underneath bridged interchanges
- Placement of stumps and logs and natural vegetation under bridges and in wildlife crossing structures including overpasses, to promote small animal movement along the passage
- Modification of pedestrian underpasses and overpasses for use by wildlife

Figure D-3. Small mammal shelf placed in a Montana culvert facilitated movement of raccoons and other wildlife (photo credit: P. Cramer and Montana DOT).

Figure D-4. Tijeras Canyon retrofit of public school interchange under I-40; no known wildlife use (photo credit: J. Gagnon, AZGFD).

Figure D-5. New Mexico I-25 Raton Interchange where retrofit fence was added and existing pathways were available and used by wildlife (photo credit: J. Gagnon, AZGFD).

Figure D-6. Mule deer using the pathway under the Lincoln Street Bridge, New Mexico (photo credit: AZGFD and NMDOT).

D.1.1.3 Adapt Fences and Gates

It is important to remove or modify fences and gates that are located at the entrances of culverts and bridges. Fences and gates near the entrances of these structures can impede wildlife movement (e.g., Figures D-7 through D-9).

Figure D-7. Gate located at concrete box culvert contained livestock within a pasture (left), but it also prevented mule deer passage (0 deer successful crossings). When the gate was removed and a right-of-way fence installed 40 feet from the culvert entrance, it greatly facilitated deer movement through the culvert (887 deer successful crossings, right) (photo credit: AZGFD and NMDOT).

Figure D-8. Mule deer hesitate at a rancher-placed barbed wire fence at NMDOT bridge. NMDOT maintenance pulled this fence away from pathway to allow wildlife movement (photo credit: NMDGF).

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Figure D-9. Fence placed at entrance of concrete box culvert under US 550 near Aztec, New Mexico (left) (only four mule deer successfully crossed), and NMDOT adapted fence placed away from concrete box culvert entrance to enhance mule deer movement while containing cattle (right) (741 successful mule deer crossings) (photo credits: J. Gagnon, AZGFD).

D.1.1.4 Facilitate Wildlife Movement across Road

There are some places where wildlife movements are predictably limited in space and time, where wildlife crossing structures are not yet an option, and where annual average daily traffic (AADT) is still well below 2,000 vehicles per day during times of wildlife movement. In these areas, where there may be sheet flow of hundreds to thousands of animals, laying down right-of-way fence during movement periods (typically migrations) is an option to facilitate faster herd movements across the road. This is possible when livestock are not in the area.

Facilitating wildlife movement can also include temporary road closing, temporary dynamic signs, or reduced speed limits during peak movement times, and other actions.

It should be noted that these actions may not reduce WVCs, but rather facilitate wildlife movement and connectivity across the road.

Fences are laid down in New Mexico on USFS lands along SR 17 north of Chama, and BLM lands on the Rio Grande Del Norte National Monument along US 285 (Figure D-10). The fences are then placed back to upright positions during periods when cattle are in the area.

Figure D-10. Lay-down fence in erect setting on the Rio Grande Del Norte National Monument, Tres Piedras, New Mexico (photo credit: P. Cramer).

D.1.2 Make the Roadside Less Attractive to Wildlife

Objective: Draw wildlife away from roads and roadside habitat by providing resources away from the road. It is important that wildlife professionals judge the reasons why animals may be coming to the road surface, foraging in the road right-of-way, or crossing the road to access resources. There may be different incentives and motivations for wildlife on different sides of the road. For example, while access to water on one side of the road may be an apparent motivator for wildlife to cross the road, other factors of heterogeneous habitat features may be drawing animals across the road. It is important to assess animals' motivation for various resources to find the potential actions to reduce movement near or across the road.

Potential measures include the following (e.g., Figure D-11):

- Provide supplemental feeding (intercept feeding) and salt-mineral sources at locations away from road (Wood and Wolfe, 1988; Grossman et al., 2011).
- Use road deicing agents that do not attract wildlife and/or replace the use of sodium chloride roadway salt with products such as ethylene glycol, calcium chloride, or other acceptable alternatives (Fraser and Thomas, 1982).
- Plant right-of-way with native vegetation that is unpalatable and of low nutritional value to wildlife (Mastro, 2008).

- Remove roadkill carcasses promptly to avoid attracting eagles and other scavengers (Grubb and Lopez, 2018).
- Place water resources such as water guzzlers or water catchments away from the road to attract thirsty animals there and to keep them on one side of the road.

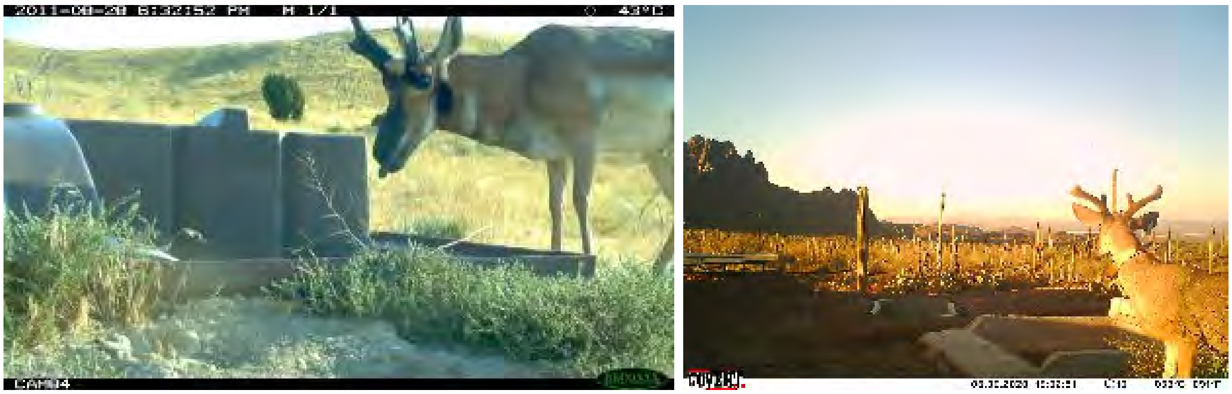

Figure D-11. Pronghorn at a Water Guzzler in Utah (left) (photo credit: R. Larson, Bringham Young University) and mule deer at water guzzler in Arizona (right) (photo credit: AZGFD).

D.1.3 Deter Wildlife from Entering Road

Objective: Keep wildlife off the road but do not provide any wildlife passage. This is done by erecting wildlife exclusion fence with no options for wildlife to move beneath or over the road to access both sides. Wild ungulate exclusion fence is typically eight feet high, metal fence material that is supported with metal or wooden poles, T-posts, or combinations of these supports. It is placed along the right-of-way fence line along roads and highways. It can also be of woven or welded wire, V-mesh wire, chain link, electrified strands of wire or rope embedded with conductive material such as copper, or a combination of these materials. In some instances, smaller-gauge mesh can be included to simultaneously address smaller wildlife species or options that use smaller openings at the bottom to exclude small wildlife and graduate to large openings at the top to exclude large wildlife (van der Ree et al., 2015).

Exclusionary fence can be an effective tool to reduce WVCs (Clevenger et al., 2001). However, the use of fence as a standalone measure to reduce wildlife-vehicle collisions is not recommended in most instances, as it can be detrimental to some wildlife populations (Jaeger and Fahrig, 2004). Additionally, if wildlife have an incentive to access a specific location, such as a preferred food source or migration route, and an option for crossing is not provided, it can lead to animals attempting to finding ways under, over, or through the fence and, in turn, increased fence maintenance efforts. Early attempts to block deer access to roads with fence without connectivity options were unsuccessful, and in most cases this practice has been largely discontinued (Falk, 1978; Feldhamer, 1986). Any time exclusionary fence is used, with or without wildlife crossing opportunities, it should include wildlife guards at turnouts and driveways to deter wildlife from entering the right-of-way, along with escape ramps that allow animals entrapped within fenced areas to safely exit the roadway (see sections on escape ramps and guards for more details).

D.1.4 Exclude Wildlife from Road using Fence and Provide Wildlife Crossing Structures, Escape Ramps, and Game Guards (Double Cattle Guards)

Objective: Wildlife exclusion fences placed to guide animals to wildlife crossing structures substantially decrease WVCs, and are an important part of providing wildlife connectivity. These structures and fence are also concurrently placed with escape ramps to allow trapped wildlife to escape and game guards to keep wildlife from entering the roadway at turnouts and driveways.

New Mexico installed three wildlife crossing culverts in 2004 for mule deer on US 550 near Aztec (Figures D-12 and D-13). Camera monitoring conducted by AZGFD and NMDOT documented more than 6,000 successful mule deer crossings movements at these culverts from 2017 to 2020 (Gagnon and Loberger, 2020).

Figure D-12. US 550 original corrugated metal culvert (left), replaced with a wildlife crossing concrete box culvert (right) in the Aztec Project (photo credit: NMDGF).

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Figure D-13. Mule deer successfully moved through the US 550 wildlife crossing culverts (photo credit: AZGFD and NMDOT).

D.1.4.1 Wildlife Crossing Structures

There are two different methods to get wildlife over and under the road, with variations on the types of infrastructure that can be used. With overpasses, wild animals move above the road and traffic. With underpasses, they move beneath the road.

D.1.4.1.1 Overpasses

Overpasses are proven to work for all ungulates found in New Mexico, and have been used by mountain lions, and bears to a lesser degree. Overpasses have worked for desert bighorn sheep in Arizona (Gagnon et al., 2017) and Nevada (Gagnon et al., 2020), Rocky Mountain bighorn sheep in Colorado (Kintsch et al., 2021), pronghorn in Wyoming (Sawyer et al., 2016) and Nevada (Simpson et al., 2016), elk in Utah (Cramer, 2012 and 2014) and Colorado (Kintsch et al., 2021), and mule deer in Arizona (Gagnon et al., 2020), Utah (Cramer, 2012 and 2014), Colorado (Kintsch et al., 2021), Wyoming (Sawyer et al., 2012 and 2016), Nevada (Simpson et al., 2016), and Montana (Hujiser et al., 2017).

Overpasses are typically the most expensive option of all wildlife crossing structures, but can be the best option for certain landscapes, types of roads, and specific ungulate species (Figures D-14 through D-19). In particular, bighorn sheep species and pronghorn have proven that overpasses are the most viable option for facilitating movement of entire herds of mixed genders and ages (Gagnon et al., 2017; Kintsch et al., 2021).

Figure D-14. Moose used the Colorado SH 9 overpass the first fall after completion (left). The overpass was created with pre-fabricated arches (photo credit: J. Richert, Blue Valley Ranch). Bighorn sheep use a Colorado SR 9 overpass (right) (photo credit: Eco-Resolutions, CDOT, and CPW).

Figure D-15. Mule deer use Arizona SR 77 overpass (photo credit: AZGFD).

Figure D-16. Arizona SR 77 wildlife overpass, 150 feet wide (photo credit: AZGFD).

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Figure D-17. Desert bighorn sheep use US 93 overpasses in Arizona (photo credit: AZGFD).

Figure D-18. rizona US 93 desert bighorn overpass (photo credit: AZGFD).

Figure D-19. Mule deer and elk use the first overpass built in North America over I-15 in Utah (photo credit: P. Cramer, UDOT and UDWR).

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D.1.4.1.2 Bridged Underpasses

Bridges are commonly used as wildlife underpasses, in part because studies have shown that mule deer, elk, and other ungulates have higher success rates moving through these types of structures than most culverts (Cramer, 2012, 2014a, 2014b, and 2015; Dodd et al., 2007; Gagnon et al., 2011; Simpson et al., 2016). When a river or wetland is involved, bridges can be the most logical choice, helping to avoid wetland building permits, providing human movement below the road, and allowing for natural terrestrial and aquatic wildlife movement (Figures D-20 through D-23).

Figure D-20. In Utah, mule deer use wildlife crossing bridge at the Weber River, under I-80 (photo credit: P. Cramer, UDOT, UDWR).

Figure D-21. In Arizona, SR 260 wildlife crossing bridges were found to facilitate over 6,000 successful elk crossing movements (Gagnon et al., 2011) (photo credit: AZGFD).

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Figure D-22. In Montana, black bear and white-tailed deer used bridged wildlife crossing structures with and without water features (photo credit: P. Cramer and Montana DOT).

Figure D-23. In New Mexico, elk used the US 550 Bridge near Cuba (left), and cougar used the bridge under I-40 in Tijeras Canyon (right) (photo credit: AZGFD and NMDOT).

D.1.4.1.3 Arch Underpasses

These structures are created with pre-fabricated concrete arches that are typically about 6 feet wide, with the arches placed on a concrete foundation. The prefabrication of underpasses with these arches, and with overpasses created in the same way, help reduce the traffic detours and congestion associated with large infrastructure placement in the road. They allow for a high amount of vertical and horizontal space to accommodate wildlife. Mule deer success rates at these structures have been over 90 percent in Utah (Cramer, 2014a and 2014b) (Figure D-24), Colorado (Kintsch et al., 2021), and other states. However, they are still a limited option for elk movements. While elk have been present at the locations monitored at the Utah and Colorado studies, years of research and dozens of elk approaches at these structures have either been limited to several dozen successful passages by elk, or higher numbers after the initial five years post construction (Kintsch et al., 2021).

Figure D-24. Mule deer used the arch underpass under I-70 in Utah (photo credit: P. Cramer, UDOT, and UDWR).

The diversity of wildlife species in New Mexico will have different preferences for types of structures. For example, in Arizona along SR 77, both an overpass and an underpass wildlife crossing structure were installed within close proximity to each other Figures D-25 and D-26). More than 10,000 times mule deer and other wildlife used these structures in nearly equal numbers. When given the choice, mule deer primarily selected the overpass, while a large variety of other species, including coyote, bobcat, javelina, and multiple other species preferred the arch underpass (Gagnon et al., 2020b).

Figure D-25. Arch wildlife underpass on Arizona's six-lane SR 77. Wildlife have used it over 5,000 times to pass beneath the highway (photo credit: J. Gagnon).

Figure D-26. Bobcat, mule deer, and javelina were just a few of many species documented using the arched underpass on Arizona's SR 77 (photo credit: AZGFD).

In Colorado, the full diversity of ungulate and carnivore species present in the area were documented using the five arch underpass structures on SR 9, including mule deer, limited numbers of elk, moose, single bighorn sheep, single pronghorn, black bear, coyote, bobcat, and medium sized mammals (Kintsch et al., 2021) (Figure D-27).

Figure D-27. Black bear used an arch underpass under Colorado's SR 9 (photo credit: Eco-Resolutions, CDOT, and CPW).

D.1.4.1.4 Concrete Box Culvert Underpasses

Concrete box culverts have been used to accommodate wildlife of all sizes and movement capabilities (Sparks and Gates, 2012) (Figures D-28 through D-30). As long as the culverts are less than 200 feet long and are at least 13 feet high and wide, mule deer may use them over time as they adapt to them. For example, from 2017 to 2019, researchers with AZGFD documented more than 6,000 mule deer successful movement through box culvert wildlife underpasses installed along US 550 near Aztec, New Mexico (Gagnon and Loberger, 2020). Concrete box culverts are not recommended for elk, bighorn sheep, and pronghorn; these species have rarely used this type of structure in numbers greater than singular or several animals. Carnivores, such as mountain lion and black bear, have used these structures regularly in Montana (Cramer and Hamlin, 2018), Utah (Cramer, 2012 and 2014), and Colorado (Kintsch et al., 2021). In New Mexico, Gagnon et al. (2020c) documented black bear use of existing concrete box culverts.

Figure D-28. In Utah, once wildlife exclusion fence was placed along this USFS road that encompassed a pair of concrete box culverts, mule deer began using these to pass beneath I-70, with hundreds of successful mule deer movements through the pair of culverts each year (Cramer, 2012 and 2014) (photo credit: P. Cramer, UDOT, and UDWR).

Figure D-29. Cougars use ranch operations concrete box culvert under I-70 in Utah (photo credit: P. Cramer, UDOT, and UDWR).

Figure D-30. In New Mexico, black bear have regularly used existing box culverts to cross under I-25 near Raton (photo credit: AZGFD, NMDOT).

D.1.4.1.5 Corrugated Steel Culverts

Corrugated steel culverts, also known as squash pipes, or corrugated metal pipes (CMPs) are used by departments of transportation to accommodate wildlife across the western U.S. As long as they are high, wide, and short enough, mule deer will use them (Cramer, 2012 and 2014; Cramer and Hamlin, 2019a, 2019b, and 2019c), as will multiple wildlife species (Clevenger, 2001b; Cramer and Hamlin, 2019a) (Figures D-31 and D-32). However, elk, bighorn sheep, and pronghorn will typically not use them. Smaller wildlife and carnivores have been proven to use these culverts as well.

Figure D-31. In Colorado on SR 9, a black bear exits an existing corrugated steel 6-foot by 6-foot culvert (photo credit: ECO-Resolutions, CDOT, and CPW).

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Figure D-32. In Utah, mule deer use a large corrugated steel culvert underpass in Deer Creek State Park under US 189 (photo credit: P. Cramer, UDOT).

D.1.4.1.6 Wildlife Exclusion Fences

Wild ungulate exclusion fence is used to prevent wildlife in general, access to the road area. It is described in better detail in the previous section on deterring wildlife from entering the road. There are field fences with welded wire to deter ungulates, mesh fence to deter smaller animals, and Electrobraid fence, or a combination of these types of fences to deter large mammals (Figure D-33).

Figure D-33. Traditional field fence 8 feet high (top left), woven wire mesh fence for smaller wildlife (top right), standalone electrified braid fence (bottom left), and combination of electrified braid and standard right of way fence to limit elk access to Arizona's SR 260 (bottom right) (photo credit: AZGFD).

Wildlife also needs to access wildlife crossing structures and existing culverts and bridges. If there is a need to keep domestic livestock out of the structures, it is important to place rail fence 18 inches above the ground (Figure D-34) and back at the right-of-way line of fence to accommodate wildlife trying to use the structure while deterring livestock from entering the crossing. Wildlife friendly fence options are detailed in two manuals from Montana and Wyoming (Paige, 2008; Paige, 2012).

Figure D-34. Utah wildlife rail fence at a wildlife crossing structure under I-15 (photo credit: P. Cramer).

Fence may also need to be placed to deter motorized vehicles, particularly off-highway vehicles (OHVs), while still allowing wildlife access to the area. See Arizona's approach to this challenge in Figure D-35.

Figure D-35. Arizona placed a steel rail fence at a wildlife underpass structure to deter motorized vehicle use (photo credit: AZGFD).

D.1.4.1.7 Fence End Treatments

The fence ends typically have end runs by wild animals that either did not find structures to move beneath the road or that will not use those structures. Over time, after fence placement and existing crossing structures become more highly used by wild animals, there is typically a reduction in numbers of animals that move around fence ends, as long as the wildlife crossing structures or existing structure are maintained to promote wildlife movement (Cramer and Hamlin, 2019a).

There have been concerns by state DOTs that the wild animals that move around fence ends will move back into the fenced part of the road. In Utah (Cramer and Hamlin, 2019a) and Colorado (Cramer and Hamlin, 2021; Kintsch et al., 2021), research revealed that approximately 10 percent of the animals detected by cameras at fence ends move back into fenced areas, while 90 percent move to the other side of the road or escape out of the fenced areas. In Arizona, the rate into the fenced area was 19 percent (Gagnon et al., 2010). Therefore, fence end treatments across roads with deterrents such as electric pavement may not be necessary if the 10 to 19 percent generalization is acceptable. It is a judgment call that will need to be made by the transportation agency professionals evaluating the situation.

Fences can also be angled toward the road at the fence ends to deter animals that move around the ends from moving into the fence right-of-way.

Fence ends can be placed at natural breaks in the landscape that are difficult for wildlife to maneuver, such as steep cliffs and rock walls or human-dominated areas, or attached to bridge abutments and culvert bases.

There are fence end treatments that can help prevent animals from entering the fenced right-of-way at the natural areas up to the pavement. These include an experimental Enviro-grid that is used to secure erosion-prone slopes (Cramer and Hamlin, 2021) but may not be effective. Another right-of-way treatment is boulders. Boulder fence is a wide stretch of riprap boulders extending out from the pavement that in theory cannot be traversed by hooved animals and are likely completely ineffective for padded animals. In Arizona, boulder fence was used along SR 260, and over time ungulates and livestock learned to negotiate it leading to regular occurrences of wildlife in the right-of-way at these locations. In 2015, standard 8-foot woven wire fence was placed on the backside of the boulders, and incidence of animals in the roadway was significantly reduced. It is not recommended as a standalone measure or over an extended stretch of roadway, and may increase the barrier effect for many species and present a potential safety hazard for drivers.

Animal detection systems placed at fence ends alert motorists of the presence of wildlife providing the opportunity to avoid collisions at these locations. See the section on animal detection systems driver warning systems for details.

D.1.4.1.8 Right-of-Way Escape Mechanisms

In the event that animals are trapped within the right-of-way, options to allow them to escape are needed. Options include escape ramps, one-way gates, and slope jumps (lowered sections of fence on a slope). To date, the only effective escape mechanisms are escape ramps (sometimes referred to as "jumpouts").

Escape ramps are mounds of earth placed in the right-of-way along the exclusion fence to provide an area animals trapped in the right of way can use to jump out of the area. Escape ramps should be placed with wildlife biologist input to maximize use by trapped wildlife. In Utah and Colorado, the standard is four escape ramps per mile of wildlife exclusion fence. Experiments with various ramp designs have found that the most effective designs include the following (Figures D-36 through D-39):

- Integration into the topography so that animals encounter them without having to climb a steep slope.
- If integration into the topography is not possible, then provide ramp access with no steeper than 3:1 slopes (Kintsch et al., 2021) and preferably 4:1 or even less steep (Gagnon et al., 2020b). A nominal 4-foot-wide flat area at the top of the ramp to facilitate jumping out into the wild area.
- In Colorado (Kintsch et al., 2021) and Utah (Cramer and Hamlin, 2019b), researchers recommend no center fences, while Arizona does not have this preference.
- A minimum ramp opening of 10 feet at the top.
- In Utah, Cramer and Hamlin (2019b) found that placement of ramp at a slight angle (approximately 150 degrees), or at an inflection point in the fence to draw the animals inward and over the ramp to the wild side worked best.
- The landing pad on the wild side should be flat and clear of vegetation, rocks, and debris.
- The height of the ramp will depend on species; for example, a ramp height of 6 feet is recommended for elk, but a ramp for deer should be in the 5 to 6 feet range (Kintsch et al., 2021). If there are elk present in the same area as mule deer, ramps should conservatively be placed at 6 feet high due to the safety concerns caused by larger bodied elk (Gagnon et al., 2020c). Bighorn sheep require a crossbar set at 18 to 20 inches above the lip of the ramp to reduce entry into the right-of-way while still allowing them to go over or under the ramp to exit (Gagnon et al., 2017 and 2020c).

- There are several different escape ramp designs. There can be one, two, or even three ramps tied together at an opening in the fence location. These multiple ramp entries improve the chances that wildlife will find and use them.

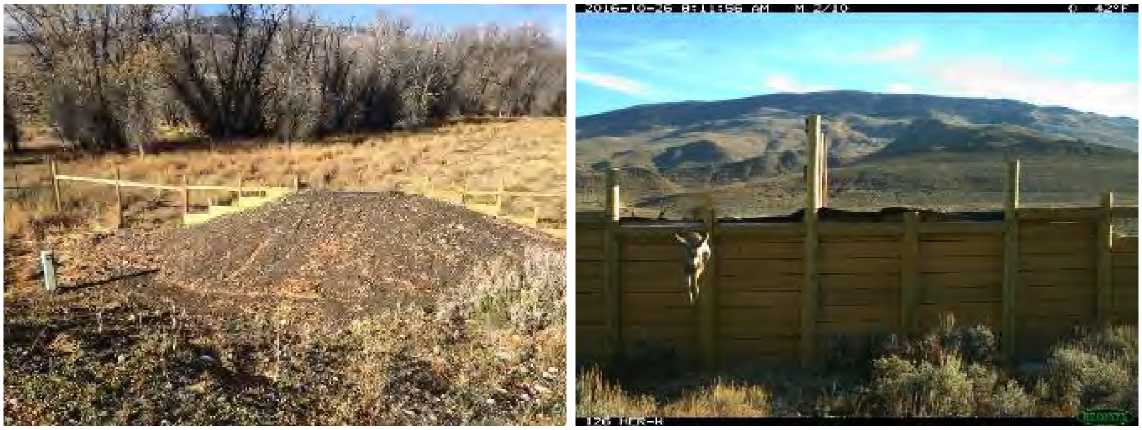

Figure D-36. Colorado SH 9 most successful escape ramp type with a 3:1 slope and no center fence (left) (photo credit: P. Cramer). Mule deer using escape ramp with center fence in Colorado, SR 9 (right) (photo credit: CDOT, CPW, Eco-Resolutions).

Figure D-37. Angle of escape ramp in fence along Utah's US 189 (left). Red fox on Utah escape ramp on US 189 (right). Ramp is at approximately a 150 degree angle to fence line (photo credit: P. Cramer, UDOT).

Figure D-38. A Utah high migration escape ramp on US 91 (left). Three sides provide three escape opportunities (photo credit: P. Cramer). Mule deer uses a high migration escape ramp in Utah, US 91 (right) (photo credit: P. Cramer, UDOT).

Figure D-39. Elk use escape ramp (left) and desert bighorn sheep use a 6-foot escape ramp (right), both in Arizona. The bar on the desert bighorn ramp was placed higher than 6 feet (photo credit: AZGFD and AZDOT).

D.1.4.1.9 Gates, Guards, and Electrified Barriers

When using fence to exclude wildlife from roads, there must also be provisions for preventing wildlife from entering the roadway through open turnouts, driveways, and lateral roads. Options include gates, game guards (double cattle guards), and electrified barriers.

For lateral access roads with low traffic volumes, 8-foot-high chain link gates should be included. Educational signs (Figure D-40) can help alert motorists, recreationists, and land users of the risks of leaving gates open. Although gates are cost effective, there is the risk that gates will be left open and allow wildlife to enter the roadway. Gates that automatically close using internal spring mechanisms should be a consideration in design to minimize the chances of gates being left open. If a project budget allows, other robust measures besides gates should be used.

Figure D-40. Educational signs on gates in wildlife fence in Utah (left) and Arizona (right) (photo credits: P. Cramer, J. Gagnon).

In situations where gates are not feasible, guards should be used to allow vehicle access and limit wildlife access. Single cattle guards are the typical guards placed to keep cattle from entering roads. Paired single cattle guards are typically called game guards, or double cattle guards, and are used for deterring wildlife from entering roadways at egress and ingress places along wildlife exclusion fences. These game guards (double cattle guards) should have a more rounded or pointed top surface to help reduce wildlife with hooves from using the bars to walk across and accessing the roadway (Figure D-41).

Figure D-41. Utah double cattle guards with appropriate side fences and aprons, no mid-guard support, rounded top bars (left) (photo credit: P. Cramer). Mule deer ponders a Utah guard on US 89 and was deterred (photo credit: P. Cramer, UDOT, UDWR).

The game guards (paired cattle guards) should be continuous bars, with no concrete support between the two, as mule deer photographed in studies in Utah, Montana, Colorado, and Arizona have demonstrated an ability to use that middle strip as a launch point. Grate style wildlife guards have been successfully used to limit mule deer and white-tailed deer access to roads in Montana (Allen et al., 2013), Utah (Flower, 2016), and Florida (Peterson et al., 2003). The sides of all guard types typically have concrete supports for the vault below. Those concrete side supports need to be fenced over and not available to mule deer and other wildlife to walk on to enter the road right-of-way. The aprons that attach to the posts and cover the concrete lips also need fence placed under them so animals do not use the area beneath the aprons to access the road. Or, the fence can be placed directly to the guard edge, and the aprons placed on either side. The best in road wildlife deterrents are not 100 percent effective, and some animals move over the guards and onto the road. However, Cramer and Flower (2017) found double cattle guards (game guards) to be 85 to 90 percent successful in deterring mule deer efforts to breach them. At every guard location, there need to be escape ramps within several hundred feet of the guard to allow animals that have breached them who become caught in the right-of-way a nearby escape mechanism. In recent projects in Utah (Cramer and Hamlin, 2019a, 2019b, and 2019c) and Colorado (Kintsch et al., 2021; Cramer and Hamlin, 2021), all roads, driveways, and vehicle entrance and exit ramp entrances have at least one escape ramp placed nearby.

Figure D-42. Elk breaches double cattle guard in Arizona (photo credit: AZGFD and AZDOT).

Figure D-43. Wildlife guard in Utah, US 91 (left). Mule deer breached the guard by walking on the outer lip of the vault (right) (photo credits: P. Cramer, UDWR).

Figure D-44. Desert bighorn sheep breach a single cattle guard by using support lip in Arizona (left). The guard was adapted to a double cattle guard and the vault lip was covered with fence (right). Monitoring Found no bighorn sheep breaches after retrofit (photo credit: AZGFD, AZDOT).

Figure D-45. Colorado SH 9 round bar double cattle guard (left) (photo credit: P. Cramer). How mule deer can use the support beams to breach the guard (right) (photo credit: CDOT, CPW, and ECO-Resolutions).

Figure D-46. In New Mexico, US 550 Cuba double-width game (cattle) guard with perpendicular fence and beveled vault edges (photo credit: AZGFD).

Electrified barriers or wildlife guards (also known as game and double cattle guards) at the road surface hold promise as a potential to provide vehicular access while excluding wildlife from the right-of-way (Figure D-47). They function by providing a shock to the animal when they attempt to walk on the alternating charged and grounded sections. A powerful enough energizer must be used to deliver a shock to hooved animals when standing on asphalt. Electrified guard or barriers are particularly effective on padded feet animals such as bears. Electrified components should be Underwriter Laboratory (UL) approved to ensure they will provide a shock but are not unsafe to humans or animals. Appropriately designed electrified barriers should be at least 12 feet wide and use sturdy and proven designs that not only are effective on wildlife but hold up to extreme environmental and traffic conditions (Gagnon et al., 2020b).

Figure D-47. Electrified barriers installed along SR 260 in Arizona (left) and along US 550 in New Mexico (right) to keep elk and deer out of the right-of-way (photo credit: AZGFD).

Use of experimental untested designs along roads can increase the risk of failure and need for replacement over a relatively short time period. Personnel trained in the maintenance of electrified components (e.g., signs and lights) should be used for repairs and maintenance. Fault switches that relay loss of power to maintenance personnel can be included in the design. Although the electrified barriers/guards are safe for those with shoes on, temporary push button shut offs can allow pets and horses across them. Gates can also be used to allow passage to pedestrians with small children or strollers, their pets, and equestrians. However, there is a risk of gates being left open unless there is a spring mechanism to automatically close them.

Gagnon et al. (2020b) recommend that in areas where electrified guards are preferred over standard double cattle guards, consider either a wide stand-alone electrified guard or a combination of electrified and non-electrified guards, such as one panel of electric placed with an adjacent game guard.

Early research of these electrified barriers or guards revealed shortcomings in the designs and components (Cramer and Flower, 2017; Cramer and Hamlin, 2017), which in turn helped to improve later designs. AZDOT installed electrified barriers along SR 260 after evaluation of these structures in a controlled test site demonstrated effectiveness in deterring elk and withstanding extreme heat and freezing conditions. The electrified barrier was installed to keep elk and deer from entering the right of way as they cross at the end of the fence where an animal detection system warns motorists of their presence. Traffic volume on SR 260 ranged from approximately 4,000 to 20,000 vehicles per day, including heavy semi-truck traffic. In spite of these volumes and weights, the electric pavement remained intact after three years. Similar electrified barriers were installed in New Mexico along US 550 with the same goal as the guard in Arizona; to act as a fence end treatment.

Continued research on the effectiveness of electrified guards will help determine if these are a viable option and in what circumstances.

D.1.5 Reduce Wildlife Populations

Objective: Reduce deer population sizes in areas near roads with high incidence of WVCs to reduce the likelihood of deer-vehicle collisions.

This approach engages sharpshooters to cull deer populations in suburban areas, or increase hunter tags in hunting units with high wildlife populations near roads. Hunting is recognized as an effective means of reducing a deer population; however, the subsequent impacts on WVCs is uncertain, particularly in rural areas; at least one study documented a decrease in deer-vehicle collisions following deer population culling targeting reproductive-age females (Muller et al. 2014). Kilgo (2020) documented as high as a 50.8 percent reduction in deer-vehicle collisions using sharpshooters at select times during the year. The impacts of culling on population size are temporary and increased harvesting must be implemented annually for long-term impacts to population size. Targeted harvesting to control population size is best done in conjunction with public education and outreach, particularly where population management is being conducted near suburban areas. It is the responsibility of the state wildlife agency to create and oversee these programs.

D.1.6 Experimental, Ineffective, and Inconclusive Methods Targeting Wildlife

D.1.6.1 Vegetation Management

Objective: Make the roadside vegetation less attractive to wildlife.

Vegetation management can be used to reduce the presence of highly palatable grasses and plants in the right-of-way. Low nutritional species of plants can be planted in the right-of-way to prevent attracting ungulates that come to graze on the plants. Cutting vegetation to keep it short for lines of sight of drivers can also make the plants less attractive for wild animals. This also applies to small mammals. In dry and desert-like ecosystems, the small amount of precipitation that falls on the road drains off to supply the right-of-way with greater amounts of moisture than nearby landscapes, thus providing opportunity for vegetative growth that attracts not only ungulates, but small mammals that are then hunted at night by terrestrial wildlife and owls. Vegetation management can be an important part of mitigating roads for wildlife. However, the Federal Highways study on mowing practices related to deer-vehicle collisions (Normandeau and Associates, 2012) found inconsistent results with changes in vegetation practices and reduction of deer-vehicle collisions.

D.1.6.2 Devices Intended to Elicit Behavioral Response Through Wildlife Senses

Several studies have attempted to measure if different devices can elicit a behavior from wildlife, primarily deer, through visual, auditory, and olfactory senses that would cause them to avoid roads. To date, many of these studies have shown mixed results, generally ineffective or inconclusive but in some instances warrant further investigation.

To use vision as a warning cue to deer of oncoming vehicles, standalone wildlife warning reflectors that cause a beam or reflection directed toward animals when cars pass have been tested on several occasions, and results have been largely ineffective or inconclusive (Brieger, 2016; Rytwinski et al., 2016). D'Angelo et al. (2006) and Jared et al. (2017) found wildlife warning reflectors completely ineffective and not even visible to the deer eye. This method is not a viable measure to deter deer from the road.

Fence tags are small, playing card sized reflectors that fasten onto wire fences and are meant to elicit a vigilant response behavior from ungulates as they reflect light and flutter in the wind. Fence tags gather sunlight during the day and re-emit absorbed light overnight. This "glow-in-the-dark" function does not require passing cars for activation, continuously alerting animals to the presence of the fence and associated roadway reducing their desire to cross the right-of-way fence, thus reducing ungulate-vehicle collisions. Fence tags have been used to effectively reduce sage grouse collisions with fences but are considered untested along roads. AZGFD is testing fence tags along roads in Arizona; results should be available in 2022.

To stimulate auditory response of deer as vehicles approach, several methods have been attempted including "deer whistles," which, contrary to popular belief, are not effective in reducing deer-vehicle collisions even at varying decibel (dB) levels (Romin and Dalton, 1992; Valitski et al., 2009). Acoustic road markings have been tested to determine deer response to vehicles passing by and deer showed relatively quick habituation (Ujvári et al., 2004). This measure is considered ineffective.

The combination of auditory and visual stimulus may have potential for deterring road crossings by wildlife. Optical and acoustic sensors attached to posts by the roadside pick up the sudden increase in light from a car headlight, trigger an alarm, which then emits a strobe LED light toward where the deer are coming from and a high-pitched sonar signal between 4 kHz and 8 kHz. A gray literature study found that these devices reduce accidents with red and roe deer in Italy by 62 to 70 percent. UDOT conducted a study on these devices, and found that results were inconclusive. Like other devices, animals can habituate to them. Additional research on these devices may be warranted. At this time, they are not recommended.

There are companies that produce urine or urine-like compounds of wolves, coyotes, and bobcat as a purported deterrent for prey species. These products are not proven to work along roadsides to deter deer and other animals. Andreassen et al. (2005) observed "questionable" beneficial results on the use of scent to reduce moose-train collisions. If they had some efficacy, the urine would have to be sprayed every week to keep the scent present. Urine products are not recommended and are currently considered inconclusive.

Some states paint parallel white lines on the road surface to mimic cattle guards as a low cost alternative to true cattle guards, with the intention of repelling animals from walking over the surface to access highways. Cramer (2012 and 2014) and Gagnon (2020c) found that these painted lines do not deter wild animals. In Utah, Cramer (2014) documented elk, moose, and mule deer walking over painted white lines to access and escape I-80 over 200 times. In Arizona, Gagnon et al. (2020c) tested painted stripes against various wildlife crossing guard options and painted stripes repelled only 9 percent of the 647 attempted crossings by elk, which was only slightly better than a control of asphalt that repelled only 4 percent of the 862 attempted crossings by elk. Although the painted stripes appeared to mildly confuse elk on the first day, over a couple of days the painted stripes became even less effective. Painted white lines are not recommended as a deterrent for wildlife.

Figure D-48. Elk move over painted lines mimicking cattle guard in Utah along I-80 (photo credit: P. Cramer, UDOT, UDWR).

D.2 Actions that Target Drivers

D.2.1 Public Education and Awareness Campaigns

Objective: Public education and awareness campaigns are used to alert the public and, in particular, the driving public, about the potential hazard of WVCs and, in some cases the countermeasures being implemented to reduce the likelihood of WVCs.

Public education and awareness campaigns typically communicate the scope of the WVC problem and the impacts to wildlife and ecosystems; and may provide driver safety tips. These types of public outreach efforts have been conducted across the country and may target a particular time frame (rut or migration) or species, or may provide more general awareness.

CDOT has a seasonal campaign to watch for wildlife (CDOT, 2016). The British Columbia Ministry of Transportation (British Columbia Ministry of Transportation, 2020) continually keeps motorists abreast of seasonal warnings on various social media platforms https://twitter.com/TranBC/status/1270121868226371585 and different aspects of wildlife collisions https://www2.gov.bc.ca/gov/content/transportation/driving-and-cycling/traveller-information/routes-and-driving-conditions/wildlife.

D.2.2 Signage

Objective: Driver warnings and caution signs are used to alert drivers to the potential for wildlife on the road in areas with high WVC rates. Signage includes static signs, seasonal or temporary signs, and variable message boards.

D.2.2.1 Static Signs and Signs with Lights

Typical, non-location-specific warning signs, usually with words or a silhouette of an animal such as a deer, have been widely (over-) used across the county and although may help in the very short term (Found and Boyce, 2011), and are generally recognized as having no long-term impact on driver speeds and their ability to respond to an animal in the roadway. Features that add to a sign's distinctiveness (e.g., flashing lights, flagging, animation, unique graphics) attract more attention from drivers and may perform better at reducing vehicle speeds and motorist awareness; however, their effect on reducing WVCs remains moderate to ineffective (Pojar et al., 1975; Sullivan et al., 2004). Similarly, signage that is posted only seasonally when wildlife is most active or that indicates caution over a limited distance elicits a moderately increased response from drivers and influences vehicle speed more than signs that are posted year-round (Sullivan et al., 2004).

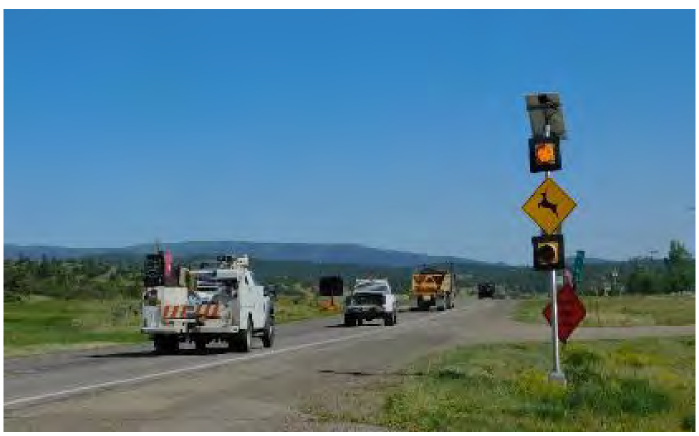

Figure D-49. Warning sign with flashing yellow lights in Chama, New Mexico (photo credit: P. Cramer).

Sielecki (2017) proposed and tested a Wildlife Hazard Rating System (WildHAZ®) that provides drivers with a more consistent and comprehensive warning about deer hazards. The sign changes the color and flashing pattern of deer silhouette signs depending on daily or seasonal crash likelihood in certain geographic areas that could potentially provide speed reductions during high risk periods (Figure D-50). These enhanced signs could cause motorists to increase vigilance during high risk WVC periods.

Figure D-50. Variations of deer-vehicle collision warning signs with flashing border intended to alert motorists during peak potential crash periods. color and flash pattern can be changed as needed (from Sielecki, 2017).

D.2.2.2 Variable Message Boards

The electronic variable message board or variable message sign (VMS) can be used in specific areas where a problem of wildlife on the road is short in duration and predictable. The wording on the sign can be changed to suit the situation, and can be programmed daily, sometimes from remote locations. NMDGF has purchased two such signs for placement on New Mexico roads. They are moved seasonally to warn drivers of elk on the road near Bent, in the Sacramento Mountains, and near Questa to warn drivers of bighorn sheep on the road. The signs can be general or very specific to detail the problem. However, DOTs and FHWA have specific criteria for the number of lines displayed in a message, display interval and other factors that must be followed. Hardy et al. (2006) found that portable message signs were more effective than permanent signs in eliciting a driver response. Recent research by Donaldson and Kweon (2018) indicated deer carcass removals were significantly lower and motorist speeds were reduced when variable message boards were present. Variable message signs provide a temporary option to potentially reduce collisions. Additional research to corroborate their effectiveness is warranted.

Figure D-51. M. Watson of NMDGF installs driver warning variable message board with NMDOT maintenance personnel (photo credit: NMDGF).

Figure D-52. Variable message board in Montana on US 191 outside of Yellowstone National Park, giving specific reasons why motorists should be careful of wildlife (photo credit: P. Cramer).

D.2.3 Speed Reduction Zones

Objective: Speed reduction zones are road segments with reduced speed limits to both reduce wildlife-vehicle collisions and protect wildlife. They are based on seasonal or night-time reductions, or with physical traffic calming measures such as more narrow lane widths or mimics of narrower lanes with white stripes that come inward to reduce vehicle speeds in areas with high wildlife-vehicle collision rates. On low speed, low volume, and more suburban/urban roads, temporary speed bumps, bulb-outs, or roundabouts can be implemented.

Research was inconclusive on the effectiveness of speed reduction zones in reducing wildlife-vehicle collisions. Although it is generally recognized that drivers are better able to avoid WVCs at slower vehicle speeds, speeds would have to be reduced to 45 mph or less to achieve a notable reduction in wildlife-vehicle collisions (Nichols et al., 2014). A test of seasonal and/or nighttime wildlife crossing zones in Colorado determined them to be ineffective at reducing WVCs, although no concurrent population studies were conducted. Roadway design may have a greater influence on vehicle operating speed than the posted speed limits.

Figure D-53. Wildlife signs (photo credit: CDOT).

D.2.4 Animal Detection Driver Warning Systems

Animal detection systems consist of sensors along either side of a road segment that detect wildlife movement and send a signal to flashing warning signs alerting drivers that an animal is currently present within the right-of way and possibly entering the road. These systems may use full light spectrum cameras, infrared light beams, laser, radar, LiDAR, thermographic cameras, vibration, or electromagnetic/buried cable fields to sense wildlife activity. Radio-collared animals have also been used to activate warning signs. In-vehicle sensors and warning systems are also being developed and may ultimately provide a reliable, targeted driver warning system as their development continues; however, widespread deployment and use may take several generations.

Until relatively recently, various technologies used to detect wildlife for purposes of activating roadside warning systems have shown mixed or inconclusive results. Early tests of animal detection technology held up fairly well in controlled test sites, but did not meet expectations when implemented in a field setting. Huijser et al. (2009) evaluated nine detection technologies, and five of those technologies met recommended performance requirements; yet, even those systems lacked suitable robustness for field settings. Historically, many detection systems evaluated in field settings rarely met desired outcomes due to the maintenance needs and the lack of robustness of the systems or high levels of false positives or negatives (Huijser and McGown, 2003).

More recently, advances in radar, LiDAR, electromagnetic, and thermal technology and research have provided promising results even in field settings. However, in many instances these should still be considered experimental until additional systems have been successfully deployed. Radar based systems showed promising results in Idaho (Huijser et al., 2017) and British Columbia (Len Sielecki, personal communication), and additional research and deployments are warranted. Chen et al. (2019) successfully used LiDAR technology to detect animals in Nevada in field settings. Overall, electromagnetic technology has not met expectations, and has been discontinued in Colorado (Huijser et al., 2012). However recent research in Virginia by Druta and Alden (2019) has identified the advances of this technology in the animal detection realm with successful field deployments. Arizona successfully implemented thermal imaging technology along SR 260 beginning in 2007 and upgraded to more advanced thermal imaging technology in 2020 to increase accuracy and robustness (Gagnon et al., 2019).

Motorist response to signs activated by animal detection systems is a crucial component to their success. The signs must be properly located, spaced, and draw enough attention to the signs to elicit a response from motorists to give them the opportunity to reduce reaction time and either avoid a collision altogether or hit the animal at a slower speed reducing the potential for injury (Huijser et al., 2009). The effectiveness of the signs overall is dependent on the accuracy of the detection technology to activate them. If signs are constantly activated, drivers eventually become complacent. When signs are not activated, drivers will be inattentive. In both cases, potential for WVCs is increased. Assuming the signs are activated properly, their ability to get the drivers' attention is important and can include flashing lights, LEDs, or VMS signs. Grace et al. (2015) used driving simulators to find that drivers responded more to picture based animal detection system signs than word based signs, although both significantly reduced the probability of a crash.

In Arizona, a combination of static, VMS, and flashing lights on a static elk silhouette sign were used to help reduce accidents with elk and consistently reduce motorist speeds and braking behavior for nine years (Figure D-54) (Gagnon et al., 2019).

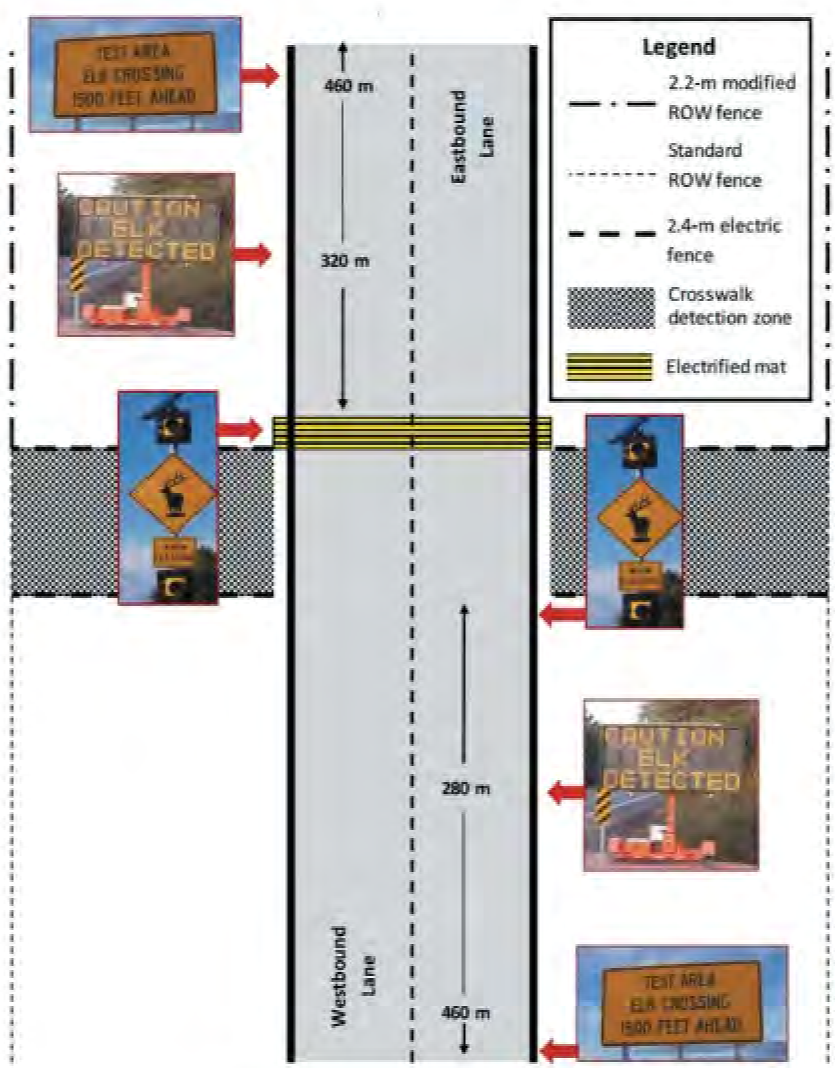

Figure D-54. Combination of signage used to successfully reduce speed and increase braking response of motorists along SR 260 in Arizona (from Gagnon et al., 2019).

There are three kinds of situations where animal detection driver warning systems are placed: (1) along stretches of road where there are no wildlife exclusion fences, (2) at wildlife-exclusion fence ends, and (3) where the wildlife-exclusion fence funnels wildlife to a specific crosswalk area over the road. The first two of the three placement types are discussed below. The placement of driver warning systems at animal crosswalks has not had across the board success, and this third method is presented in the next section, "Ineffective, Inconclusive, or Experimental Approaches to Target Driver Response."

D.2.4.1 Animal Detection Systems No Wildlife Exclusion Fence

The use of standalone animal detection systems that cover long stretches of road is an important option under some circumstances. This option may be desired in areas with multiple lateral access roads that would require multiple game guards if there were fences, where 8-foot high fence is not wanted, such as along adjacent private land, or where the terrain does not allow for fence construction. Implementing detection technologies over long stretches of road without fences is one of the most complex situations to overcome, as the capabilities of the detection technology is pushed to its limits. Depending on the technology, several detectors may need to be linked together to cover the needed distance, which can lead to a higher risk of equipment failure. Additionally, the potential for false positives or negatives increases as distance covered increases. Last, being able to properly locate and design the signs in a manner that gets the attention of drivers at the appropriate time increases in difficulty or expense as distance increases.

In some instances, areas of a mile or more may need to be covered; in these instances, a radar based system may be the best option because it uses the least number of components versus linking together shorter distance technologies to achieve the same result. A radar-based system was successfully implemented at two locations in British Columbia (Len Sielecki, personal communication) (see the Highway 3 webpage: https://www.tranbc.ca/2015/10/21/on-the-case-for-safety-wildlife-detection-systems-on-highway-3/, and thermal camera images at: https://www.tranbc.ca/2016/07/27/behind-the-scenes-bc-wildlife-trucks-saved-from-collision/). These systems can provide a potential option under the appropriate circumstances.

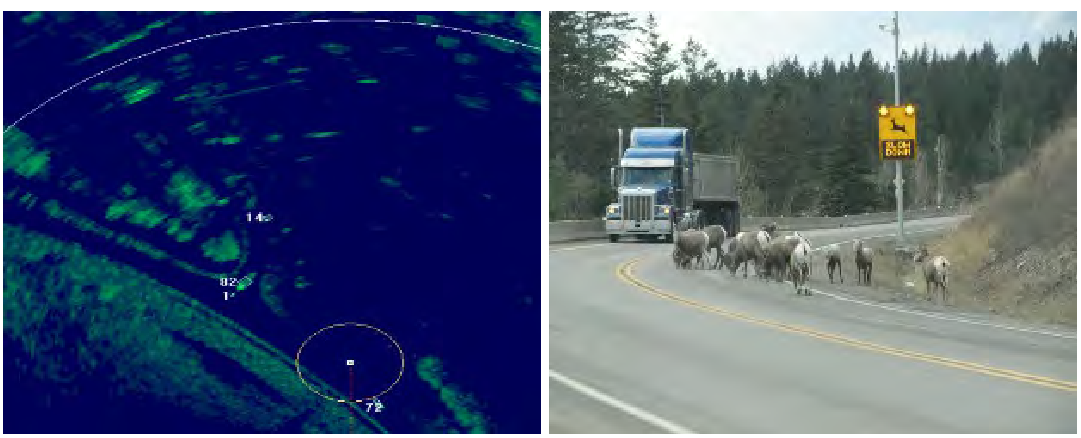

Figure D-55. Radar scatter plot (left) and semi slowing down for bighorn sheep (right) detected by a radar system in British Columbia (photos courtesy of CrossTek, LLC).

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D.2.4.2 Animal Detection Systems with Wildlife Exclusion Fence

Fences are a time-proven method for keeping many wildlife species off roads and when combined with appropriately designed and located wildlife crossing structures provide a successful system for mitigation of roads on wildlife. At some point, fences used to exclude animals and guide them to wildlife crossings needs to end, and can lead to animal end-run events, or concentrated wildlife crossings at the ends of fences. In these instances, animal detection systems can be used to alert motorists of wildlife presence as they cross at these fence termini. A good example of a detection system that addresses an end run situation was implemented in Arizona along SR 260 in 2007. The SR 260 system used thermal imaging technology to detect wildlife approaching the road at the end of the fence. This system combined with the exclusionary fences reduced accidents with elk by 97 percent and continually reduced motorist speeds for nine years. In 2019-2020, this system was upgraded to a more robust and accurate FLIR based thermal system (Gagnon et al., 2019).

Figure D-56. Screen capture of thermal camera image of elk cow and calf and motorist warning sign on Arizona SR 260 (photo credit: AZGFD and CrossTek, LLC).

NMDOT collaborated with AZGFD and placed a similar wildlife activated FLIR based thermal sensor system with motorist warning signs along US 550 south of Cuba, New Mexico. These systems were part of a retrofit of existing bridges to guide wildlife under the road. The project was completed in 2019; both driver behavior and wildlife use of the structures and fence ends are being monitored by AZGFD and NMDOT.

Figure D-57. Wildlife activated driver warning system on US 550, New Mexico (photo credit: AZGFD).

Figure D-58. Driver warning signs and electrified barrier at fence end on US 550, New Mexico (photo credit: AZGFD).

D.2.5 Ineffective, Inconclusive, or Experimental Methods to Target Driver Response

There are methods to improve driver awareness of roadway hazards, including the presence of wildlife. Some of these have proven to work in more human dominated settings, such as traffic calming actions. Other methods have little to no research to back their use for reducing WVCs. New technologies are also a way to help affect drivers to slow in caution in areas where WVCs are more likely. These approaches are presented below.

Objective: The goal of these treatments is to help keep drivers more alert to the dangers of WVCs. This can be done with illumination, traffic calming methods, opening lines of sight with a reduction of vegetation, telling drivers exactly where wildlife will be, and leaving it all to the smart car.

D.2.5.1 Traffic Calming

There are methods to reduce driver speeds. These include the following:

- Installation of a median with vegetation in two lane roads
- Traffic calming striping to reduce the driver's perceived width of the roadway, which is done by bringing the painted white line on the right edge of the road inward several inches or feet (Kahn and Kahn Goedecke, 2011)
- Road speed tables, including temporary speed tables that could be placed during specific wildlife-vehicle collision periods
- Speed bumps or rumble strips

D.2.5.2 Reduce Roadside Vegetation

Roadside vegetation can be trimmed or eliminated in areas where wildlife is known to cross the road and become involved in vehicle collisions. This would be especially important in areas where the road has abundant vertical and horizontal curves, or vegetation that grows adjacent to the driving lanes. In this type of roadway condition, motorists have a difficult time responding to hazards including wildlife hazards. It is also important to mow vegetation within the right-of-way to help keep a visual landscape where drivers can see wildlife moving into the roadway. In South Dakota, the Pierre Area maintenance crews experimented with double pass mowing (i.e., mowing a wider swath along the right-of-way) during the fall months to provide better sight distances for drivers, which coincided with lower wildlife-vehicle collision rates, although a direct correlation cannot be confirmed. The effectiveness of road treatments to improve sight-distances for drivers with a resulting decrease in wildlife-vehicle collisions are difficult to quantify and inconclusive. A recently mowed right-of-way may be more appealing to deer, resulting in the unintended consequence of attracting deer to the roadside. Fall regrowth may be less palatable than spring regrowth, and mowing can be timed accordingly. In addition, vegetation clearing may increase the barrier effect of the roadway for some species. Meisingset et al. (2014) recommend targeting vegetation clearing to short WVC hotspot segments in the late fall when vegetation regrowth has ceased. Targeted clearings may be most effective when used in conjunction with seasonal speed limit reductions through these hotspot segments.

D.2.5.3 Wildlife Crosswalks and Animal Activated Crosswalks

Wildlife crosswalks are an area where animals are allowed to cross roads at a discrete location that is defined by an area that warns drivers of the potential for wildlife presence as they approach that location. This method was used in Utah along US 40 south of Park City. Although animals were able to cross at this location there was no significant reduction in accidents, in part due to vehicle speeds over 50 miles per hour, and the size of the four-lane divided highway the animals had to cross (Lehnert and Bissonette, 1997). These inconclusive results were primarily due to the lack of motorist response to the static warning signs. This method should be considered ineffective until further research is conducted.

Crosswalks would be an unfair location for wildlife to become involved in motor vehicle collisions unless there are only two lanes of traffic, the speeds are below 55 miles per hour, the area is rural, and AADT is 2,000 vehicles per day or less for diurnal periods and less than 8,000 vehicles per day for species that are nocturnal/crepuscular. Otherwise, motorists cannot stop in time for an animal, and animals cannot find a break in the traffic to cross safely.

An animal activated crosswalk could in theory function like an at-grade version of a wildlife crossing in instances where traffic volumes are low enough to allow wildlife to cross the road. An animal activated crosswalk was attempted along Highway 333 in Tijeras Canyon New Mexico in 2007. This crosswalk was put in place to allow wildlife an opportunity to cross Highway 333 and access the bridges to the south that were retrofitted with exclusion fencing to cross under I-40, which parallels Highway 333. Because the detection system failed to operate after a short period of time, the signs were no longer activated by wildlife and stayed on all night. This site essentially became a non-animal activated crosswalk and occasional WVCs still occur.

AZGFD and NMDOT have been monitoring this crosswalk since 2017, and have documented more than 250 times wildlife successfully crossed at this location (Gagnon and Loberger, 2020). NMDGF and NMDOT are working together to incorporate a new detection system similar to that located along US 550 in New Mexico and SR 260 in Arizona. Two mule deer bucks were recorded by still cameras crossing the NM 333 crosswalk in Tijeras Canyon, and approximately 45 minutes later were documented using an existing bridge retrofitted with fencing, showing complete connectivity across two major roadways.

This method should be considered untested. Additional research is needed.

Figure D-59. Tijeras Canyon Safe Passage Project electrified concrete barriers at NM 333 wildlife crosswalk (photo credit: AZGFD).

Figure D-60. Two mule deer bucks were recorded entering the NM 333 Crosswalk (left) and exiting the area to the south by using the existing bridges, as recorded by AZGFD monitoring cameras (photo credit: AZGFD and NMDOT).

D.2.5.4 Roadside Lighting

In theory, street lighting may help drivers and wildlife to see one another in semi-developed rural areas. However, Reed and Woodward (1981) found highway lighting was not effective at reducing deer-vehicle collisions. This method should be considered ineffective until further research is conducted.

D.2.5.5 In Road Lighting with Solar Pucks

Raised pavement markers (RPMs), can be adapted to provide lighting at the road level, and are known as solar pucks, or internally-illuminated raised pavement marks (IIRMMs). These markers "enhance delineation and driver awareness, especially in low light conditions" (FHWA, 2009). Their added purpose on rural roads would be to provide lights along the white line on the right side of the lane, and in the center strip that would illuminate if a large animal such as an elk, were positioned across one of these lines of light; thus, a driver would be better able to evaluate the animal's presence. This potential use is not tested and further research is needed.

Figure D-61. Solar pucks installed in pavement of I-70 in the mountains outside of Denver (photo credit: Fox Denver, KDVR.com).

D.2.5.6 On-Vehicle Lighting

Vehicle lights can illuminate roads allowing motorists to see wildlife alongside or crossing the roads (Mastro et al., 2010). However, deer and other wildlife are known to "freeze" or act erratically when vehicle lights shine on them and can contribute to collisions. Although sample sizes are relatively low, recent research by DeVault et al. (2020) showed that rear-facing lights mounted to the front of a vehicle and aimed toward the vehicle to illuminate the front of the vehicle versus shining directly outward caused more deer to move out of the way of the vehicle versus freezing.

This method should be considered inconclusive but additional research is warranted.

D.2.5.7 Driver Phone Applications

Smart phone applications, such as WAZE, inform drivers of immediate road conditions in real-time. NMDOT could install driver warning public messages for a specific stretch of road during specific times of year when wildlife movements make the risk of WVCs highest. In turn, drivers could warn one another of wildlife in the road. These applications are more heavily used in the eastern U.S. These methods of warning drivers have not been tested for efficacy at reducing WVCs.

D.2.5.8 In Vehicle Warning Systems

Volvo and other vehicle manufacturers are experimenting with infrared cameras on the vehicles feeding images to an on-board computer that then warns drivers of animals in the road and may even brake the car (Volvo's system is called Pilot Assist II) (Adams, 2017). The Volvo Pilot Assist II can detect large animals from a distance of 200 meters (656 feet) via radar and camera components and alerts the driver with a loud warning and flashing dashboard lights (Cheng, 2017). These in-vehicle systems have not been tested for efficacy in reducing collisions with wildlife. It may take several years for these systems to become used in high enough numbers to test their efficacy and safety.

D.2.5.9 Self-Driving Vehicles

Driverless vehicles are being developed with the above onboard camera systems that detect wildlife from the approximate size of a raccoon or a human toddler, and automatically brake or avoid hitting the animal or human. The combined work of citizens reporting wildlife on or near the road through smart phone applications, known wildlife-vehicle conflict areas programmed onto vehicle computers, and sensors in high wildlife-vehicle crash areas that could warn the vehicles of animals entering the roadway (another type of animal detection driver warning system) could all be used to create a more wildlife-friendly smart car. These systems are being developed, and should become common enough in the near future to measure their efficacy in reducing WVCs.

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Appendix E

Project Recommendation Tables

Appendix E. Project Recommendation Tables

This appendix includes the following tables of mitigation recommendations for each project:

Table E-1. Final project recommendations for the US 550 North of Cuba WVC hotspot.

Site Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 550 MP 80.5 Northwest Fence End			Fence end	Northwest fence and location of fence end were decided in conjunction with a Jicarilla Apache Nation wildlife biologist. They can tie into an existing cattle guard on Tribal road turnout. This is an alternative to fence end MP 79.0 to the southeast.
US 550 MP 80.3 New Wildlife Overpass	Hillsides above road, about 30 feet above		Overpass	Good cuts to both sides. The road is bordered by Jicarilla Apache Nation lands. Elk and deer signs in the area. In the event that the five recommended overpasses cannot all be installed, this location could be deprioritized, as it would likely be used less than others.
US 550 MP 79.0			Fence end	Alternative northwest fence end. Located on Jicarilla Apache Nation lands. Opportunities exist to extend the fence farther west to encompass the entire hotspot if needed, but this location works as a logical fence end without need for additional overpasses. Either use this location or MP 80.5 as fence end.
US 550 MP 79.0 Wildlife Underpass Culvert	Road approximately 10′ above landscape	Single cell concrete box culvert 6′ x 6′ x 80′	Retrofit Culvert Underpass	Retrofitting of the existing structure is needed to benefit medium-sized carnivores. This would entail placement of wildlife exclusion fence. Otherwise, it could be replaced by a larger box or arch culvert if needed.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-1 (cont.)

Site Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 550 MP 77.0 New Wildlife Overpass	Hillsides above road, about 20 feet above		Overpass	Continental Divide Overpass location. Third-ranked overpass location for this WVC hotspot. It has only one side of slope and needs fill on the other side. It represents the location where Jicarilla collared elk remained on the north side of US 550, and where overwintering occurred. The right-of-way is wide, providing an opportunity to possibly expand the parking area and add a kiosk about wildlife crossings. BLM-managed lands border the road on both sides.
US 550 MP 75.7 New Wildlife Overpass	Hillsides above road, about 20 feet above		Overpass	Not a lot of cut to work with, but MP 75 to MP 77 does not present a lot of overpass, underpass opportunities.
US 550 MP 75.5 New Wildlife Overpass	About 15' from road to top of cut		Overpass	Among the possible locations for considering a wildlife overpass. A possible challenge faced is that there is 4-foot five-strand right-of-way fencing on both sides. Barbed wire fence low embankment on each side about 15 feet in height or the highway cuts through a ridge. Did not rank among the top 4 overpasses.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-1 (cont.)

Site Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 550 MP 75.3 New Wildlife Underpass Culvert	Road approximately 8′ to bottom of fill	Single cell corrugated metal pipe 5′ high x 5′ wide x 100′ long	Culvert Underpass	Replace existing culvert with larger culvert to accommodate small to medium sized mammalian carnivores. The existing culvert is a hindrance to wildlife movement other than for small animals. The existing structure is a small round concrete culvert about 5 feet in diameter that could be enlarged for more use by both small and medium-sized mammals, although there is probably no potential benefit for ungulates at this location.
US 550 MP 74.8 New Wildlife Underpass Bridge	About 50′ from road to bottom of fill	Single cell corrugated metal pipe culvert = 3′ x 3′ x 120′	Span Bridge Underpass	Great spot for a good-sized underpass, with big valley drainage on both sides. The new structure will need to accommodate elk.
US 550 MP 74.3 New Wildlife Underpass Bridge	Road About 10′ above bottom of fill	Two cell concrete box culvert: each box = 10′ x 10′ x 120′	Span Bridge Underpass	Major drainages are present. Retrofit: additional vegetation and articulated concrete blocks at the end of the spill way to bring the outflow area up to concrete spillway.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-1 (cont.)

Site Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 550 MP 73.0 New Wildlife Underpass Bridge	About 20′ from road grade to bottom of fill	Single cell concrete box culvert: 8′ x 8′ x 100′	Span Bridge Underpass	Open span underpass to accommodate elk, similar to underpasses on AZ SR 260 that have proven effective for the species. Current box poses hindrances to wildlife movement. The location is in a valley. Animals can come down on the east side of road.
US 550 MP 72.4 New Wildlife Overpass	About 50′ from top of ridge line to road		Overpass	Seems like a very good location for an overpass with good embankments on both sides of US 550; pretty deep cut soft soil. Surrounding vegetation is pinyon juniper woodland.
US 550 MP 71.8 New Wildlife Underpass Culvert	About 10′ from road to bottom of culvert	Two cell concrete box culvert, each chamber 10′ x 10′ x 120′	Culvert Underpass	Place fence to this culvert to guide deer to use it. Located on private land. Replace culvert with a concrete box culvert or precast arch in upcoming projects. Can be used by deer in the meantime.
US 550 MP 70.2 New Wildlife Overpass	About 40′ from road to top of cut		Overpass	The top choice for an overpass in this hotspot. The target species is elk. Look at ridge north south, the animals may be running. Public land on both sides of the road: National Forest lands on the south side. BLM land on the north side.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-1 (cont.)

Site Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 550 MP 70.0 New Wildlife Overpass	About 35′ from road to bottom of fill	Single cell corrugated metal pipe culvert 2′ x 2′ x 150′	Overpass	Current corrugated metal pipe silted in. Location may be an alternative to overpass at MP 70.2.
US 550 MP 68.5 New Wildlife Overpass	About 40′ from road to bottom of fill		Overpass	Second-ranked overpass location. For elk. Open on both sides of the road, good overpass location, land ownership is National Forest on both sides. Paved road just south needs cattle guards, but not a hindrance. Given presence of agriculture fields to the north and the ridge line, a lot of deer and elk probably move in through this location right by the 70 mph speed limit sign.
US 550 MP 67.5 New Wildlife Underpass Bridge	Road is 40 feet above bottom of fill	Three cell corrugated metal pipe culvert, each cell: 8′ x 8′ x 120′	Span Bridge Underpass	Replace existing concrete box culvert by new span bridge to accommodate elk. Culvert area has plenty of overburden (approximately 15 or 20 feet).
US 550 MP 67.0 New Wildlife Underpass Bridge	About 30′ from road to top of cut	None	Culvert or Bridge Underpass	Suitable for an underpass as there have been few elk crashes here. Human disturbance, possible private land concerns.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-1 (cont.)

Site Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 550 MP 66.5 New Wildlife Underpass Bridge	About 14′ from road to bottom of fill	Two cell corrugated metal pipe culvert 12′ x 12′ x 100′	Span Bridge Underpass	New span bridge to accommodate elk. Human residential development nearby. If the span bridge is not placed here, build an overpass at MP 65.8.
US 550 MP 65.8 New Wildlife Overpass	Hillsides about 100 feet above road		Overpass	Fourth choice overpass. Steep cliff on the east side, National Forest lands on both sides (maintenance yard on west). The surrounding vegetation is all natural. If not an overpass, then place a span bridge here, similar to the one on AZ SR 260.
US 550 MP 65.1 Fence End Southeast			Fence end	Southeast fence end. Los Pinos road and cattle guard. Housing nearby, good place to end the fence.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-2. Final project recommendations for the US 180 and NM 90 Silver City WVC hotspot.

Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 180 West of Silver City				
US 180 MP 106.8 New Wildlife Underpass	Road is about 8′ above landscape	Three cell concrete box culvert, 8′ x 10′ x 100′ each	Culvert or Bridge Underpass	Steep slope, over 30′ from culvert to bottom of wash, 8′ drop like a mine shaft within the end of the culvert. Need to consider flow of water in re-design. Potential fence end
US 180 MP 107.7 Fence End			Fence end	West fence end. Replace existing fence with game fence and run back up Rogers Drive.
US 180 MP 107.8 New Wildlife Underpass Culvert	Road is about 30′ above landscape	Single cell corrugated metal pipe, 8′ x 8′ x 100′	Culvert Underpass	Good site for larger underpass. Nice valley, plenty of fill and space to work with. Replace with larger structure and use as west fence end.
US 180 MP 108.1 New Wildlife Overpass	Road is about 30′ below landscape		Overpass	Good fill on both sides, good arch overpass location. Continental Divide option 1. Neighborhood development to north side of road, may be difficult to navigate.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-2 (cont.)

Site Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 180 MP 109.4 New Wildlife Overpass	Road is about 30′ below landscape		Overpass	Good fill on both sides, good arch overpass location. Continental Divide option 2. Neighborhood development to north side of road but single large parcel nearby that may provide refuge for crossing wildlife. Spacing between adjacent structures more conducive to wildlife use than option 1.
US 180 MP 110.3 New Wildlife Underpass Culvert	Road is about 20′ above landscape	Single cell corrugated metal pipe, 8′ x 8′ x 40′	Culvert Underpass	Immediate retrofit: fence covers mouth of structure, remove fence. Possibly replace with larger culvert for deer, nice short structure length.
US 180 MP 110.6 New Wildlife Underpass Culvert	Road is about 15′ above landscape	Single cell corrugated metal pipe, 5′ x 5′ x 50′	Culvert Underpass	Small barn just south of culvert opening. Mobile home park adjacent and more residential further south. Marginal project that may be able to replace concrete metal pipe with box culvert to facilitate deer movement. No obvious signs of deer. Potential for connectivity to nearby open space via drainage.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-2 (cont.)

Site Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 180 MP 110.8 Retrofit Culvert	Road is about 25′ above landscape	Single cell concrete box culvert, 10′ x 10′ x 60′	Retrofit Culvert	Place wildlife exclusion fence to both ends of the culverts. Existing box culvert in minor drainage, deer tracks indicate current use. Utility conduit passes through culvert but buried on both sides.
US 180 MP 111.9 New Wildlife Underpass	Road is about 30′ above landscape	Two cell corrugated metal pipe 3′ x 3′ x 80′ each	Culvert Underpass	Corrugated metal culvert in minor drainage with lots of deer signs in area. Culvert angled. Medium human disturbance. Replace with large box culvert or arched passage to allow deer movement. Will take some contouring to southeast side of road which is heavily eroded.
US 180 MP 112 New Wildlife Underpass	Road is about 12′ above landscape	Single cell corrugated metal pipe, 3′ x 3′ x 50′	Culvert Underpass	Corrugated metal culvert in minor drainage with lots of deer sign in area. Culvert angled. Medium human disturbance. Replace with large box culvert or arched passage to allow deer movement. Exposed utility line outside drainage.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-2 (cont.)

Site Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 180 MP 112 New Wildlife Overpass	Road is about 30′ below landscape		Overpass	Game trails in area. Adjacent cuts offer a few different location options. Cut higher to west, about 30′ to west and 15′ to east. Next to university campus.
US 180 MP 112.5 Retrofit Bridge	Road is about 25′ above landscape	Trafficked underpass bridge, 13′ x 20′ x 80′	Retrofit Bridge	Place wildlife exclusion fence to both ends of the culvert. Existing bridge is road traveling under US 180. Not any room on sides of road to allow safe wildlife passage but appears to be low traffic.
US 180 MP 112.5 Fence End			Fence end	East Fence end at existing interchange underpass.
US 180 Silver City Section				
US 180 MP 115.4 Fence end			Fence end	West fence end, tie into existing-new structure here.
US 180 MP 115.4 New Wildlife Underpass Culvert	Road is about 25′ above landscape	Single cell concrete box culvert, 6′ x 4′ x 150′	Culvert Underpass	Water pipe in culvert, high human disturbance. New culvert would be for deer.
US 180 MP 115.6 Retrofit Culvert	Road is about 13′ above landscape	Three cell concrete box culvert, 12′ x 10′ x 100′ each	Retrofit Culvert	Place wildlife exclusion fence to both ends of the culvert. Human disturbance, water line in culvert and cased in concrete.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-2 (cont.)

Site Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 180 MP 115.9 Retrofit Culvert	Road is about 25′ above landscape	Single cell concrete box culvert, 7′ x 5′ x 150′	Retrofit Culvert	Place wildlife exclusion fence to both ends of the culvert. Human disturbance. Sediment buildup within CBC. Utility conduit in culvert.
US 180 MP 116.5 Retrofit Culvert	Road is about 13′ above landscape	Single cell concrete box culvert, 7′ x 6′ x 125′	Retrofit Culvert	Remove fence across entrance, retrofit existing box culvert with wildlife exclusion fence on both ends. Sediment buildup within CBC. Clean out debris and sediment.
US 180 MP 116.8 Retrofit Culvert	Road is about 12′ above landscape	Two cell concrete box culvert, 9′ x 10′ x 125′ each	Retrofit Culvert	Retrofit by placing wildlife exclusion fence to both ends of culvert, and remove sediment buildup within CBC. Only 9′ high on one end. Later, replace the culvert. with single large box culvert
US 180 MP 117.5 Fence end	Transition from natural area to developed		Fence end	Arenas Valley Rd.Could be used as eastern fence end for small section of mitigation project.
US 180 MP 117.8 New Wildlife Underpass	Road is about 12′ above landscape	six cell concrete box culvert, 7′ x 10′ x 125′ each	Culvert or Bridge Underpass	Replace with taller bridge or larger box culvert(s). Surrounded by medium development.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-2 (cont.)

Site Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 180 MP 118.1 New Wildlife Underpass	Road is about 15′ above landscape	Two cell concrete box culvert, 10′ x 10′ x 170′ each	Culvert Underpass	Replace with larger box culvert Current box culvert under repair. Added median atrium CMP and several crack repairs. Human disturbance.
US 180 MP 119.0 Fence end			Fence end	West fence end
US 180 MP 119 Retrofit Culvert	Road is about 25′ above landscape	Single cell concrete box culvert, 12′ x 10′ x 170′	Retrofit Culvert	Retrofit by placing wildlife exclusion fence to both ends of culvert. Human disturbance. Game trails coming to location.
US 180 MP 119.2 New Wildlife Overpass	Road is about 20 below landscape		Overpass	Construction of overpass would need easement with private landowners. Good cuts to each side. Important for elk in the area, which have been involved in WVCs nearby.
US 180 MP 119.8 Retrofit Culvert	Road is about 25′ above landscape	Five cell concrete box culvert, 12′ x 10′ x 125′ each	Retrofit Culvert	Retrofit by placing wildlife exclusion fence to both ends of the culvert. Residential development.
US 180 MP 119.8 Fence End			Fence end	East fence end.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-2 (cont.)

Site Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 180 MP 120.8 New Wildlife Underpass Culvert	Road is about 20′ above landscape	Eight cell concrete box culvert, 12′ x 10′ x 100′ each	Culvert Underpass	Replace with 2-3 larger box culverts. Add wing fence. Large wash and good crossing location and opportunity. Human disturbance.
US 180 MP 122.2 Retrofit Culvert	Road is about 12′ above landscape	Three cell concrete box culvert, 9′ x 9′ x 100′ each	Retrofit Culvert	Retrofit by placing wildlife exclusion fence to both ends of the culvert, just as wing fencing. Deer tracks through box. Waterline present in box. Human disturbance, residential. Larger box would increase deer use at this high collision area. Burry waterline and remove infrastructure to clear westbound structure approach.
NM 90				
NM 90 MP 41.4 Retrofit Bridge	Road is about 30′ above landscape	Bridge, 250′ in length (width as animal moves under), 40′ high	Retrofit Bridge	Add wing fencing to both ends of culvert. Large maintenance yard near bridge but not in channel. Deer adapted to suburban world would adapt to this bridge for movement below highway. Wing fence off of every corner of the bridge.
NM 90 MP 40.1 Fence End			Fence end	Northern fence end tied into new bridge.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-2 (cont.)

Site Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
NM 90 MP 40.1 New Wildlife Underpass Bridge	Road is about 20′ above landscape	Single cell corrugated metal pipe, 4′ x 4′ x 200′	Bridge Underpass	Development nearby. Potential fence end. Lots of overburden to accommodate a larger structure.
NM 90 MP 39.7 New Wildlife Underpass Culvert	Road is about 25′ above landscape	Single cell corrugated metal pipe, 3′ x 3′ x 200′	Culvert Underpass	Very promising, better option for area. No development at location on either side.
NM 90 MP 39.2 New Wildlife Underpass Bridge	Road is about 25′ above landscape		Bridge or Culvert Underpass	Good site to construct crossing structure. Bridge preferable. Or Arch Culvert.
NM 90 MP 37.8 New Wildlife Underpass Culvert	Road is about 12′ above landscape	Five cell concrete box culvert, 7′ x 7′ x 200′ each	Culvert Underpass	Deer likely using current structure on occasion. 2′ erosion created step at downstream outlet. Replace with arch culvert.
NM 90 MP 37.3 Retrofit Culvert	Road is about 12′ above landscape	Four cell concrete box culvert, 8′ x 12′ x 150′ each	Retrofit Culvert	Place wildlife exclusion fence on both ends of the culvert. Deer use. Wild area, road along north side with some businesses.
NM 90 MP 37.2 Retrofit Culvert	Road is about 5′ above landscape	13 cell concrete box culvert, 3′ x 4′ x 125′ each	Retrofit Culvert	Place wildlife exclusion fence on both ends of the culvert. Businesses all around. Clean out middle 6 cells.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-2 (cont.)

Site Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
NM 90 MP 36.1 New Wildlife Underpass Culvert	Road is about 10′ above landscape	Single cell concrete box culvert, 6′ x 10 x 125′	Culvert Underpass	Will likely require additional lateral excavation. Potential fence end. Few options exist at the south end of the hotspot along NM 90 to upsize structures. May be only opportunity to do so.
NM 90 MP 36.1 Fence end			Fence end south	Fence extends northward from here
NM 90 MP 35.6 New Wildlife Underpass Culvert	Road is about 8′ above landscape	Single cell corrugated metal pipe, 5′ x 3′ x 150′	Culvert Underpass	Not much fill to work with but might be workable for a CBC if needed in this area. Replace with larger box culvert.
NM 90 MP 35 New Wildlife Underpass Culvert	Road is about 6′ above landscape	Four cell concrete box culvert, 3′ x 5′ x 100′ each	Culvert Underpass	Culvert low to ground, all cells filled in with sand. Completely replace for wildlife. Just 1 mile to the south is WVC hotspot 14. Replace with larger box culvert.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-2 (cont.)

Site Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
NM 15				
NM 15 MP 3 New Wildlife Underpass Culvert	Road is about 20′ above landscape		Culvert Underpass	Relatively flat road in surrounding areas. Decently slope down from right-of-way to both sides. Closer to 15' on west side. Potential to install box culvert suitable for deer, maybe even as a fence end location with fence running south. Potential fence end
NM 152				
NM 152 MP 1.4 New Wildlife Underpass	Road is about 15′ above landscape	Single cell concrete box culvert, 10′ x 10′ x 120′	Culvert Underpass & Add Wing Fence	Large box culvert in steeply banked ephemeral streambed. Slight dogleg or bend in the culvert. Appears frequently used by deer (other tracks also present) but may benefit from installing a straight-shot box culvert or arched culvert with natural bottom. Wing fence to funnel wildlife to culvert may suffice since it is being used. May have to cut back stream bank, at least on west side.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-2 (cont.)

Site Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
NM 152 MP 2.9 New Wildlife Overpass	Road is about 30’ below landscape		Overpass	East side embankment approximately 30', west side approximately 15'. Good location for overpass placement. Blind corners to both sides, overhead powerline. Some deer tracks present.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-3. Final project recommendations for the US 70 and NM 48 Ruidoso WVC hotspot.

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
Ruidoso Downs to Mescalero Apache Tribal Lands, US 70 MP 258 – 269				
Note: As one moves from west to east on this road (and up in milepost [MP] numbers), the town of Ruidoso Downs is the heavily human populated area with wild land and wildlife connectivity opportunities for mitigation largely west and east of the town. The eastern end of this US 70 stretch has the best opportunities for enhancing habitat connectivity and in terms of feasibility as it is found on Mescalero Apache Tribal Lands.				
US 70 MP 255.9 New Wildlife underpass bridge	Road about 10 feet above landscape	Double chambered concrete box culvert 7′ x 10′ x 136′, total width 21′	Bridge Underpass	Place a bridge for water conveyance. A wildlife trail is present and comes down to the area on the downstream side. Deer pellets were found on the upstream side. The existing structure is too much of a tunnel for wildlife. Thus the probability of use by mule deer is low. Elk occur in the area, but the culvert does not have the necessary height for them. MP 257.2 has more WVC crashes. Potential fence end for west. Mescalero Apache Tribal land.
US 70 MP 256.5 New Wildlife Underpass Culvert	Road about 12 feet above landscape	Pair of corrugated metal culverts 3′ x 3′ x 130′, total width 9′	Culvert Underpass	North side has hill slopes, with sign of elk. Replace with a culvert large enough for mule deer. Mescalero Apache Tribal land
US 70 MP 257.1 Wing Fence Retrofit			Retrofit Add Wing Fence	MP 257.1 is west fence end on Mescalero Apache Tribal land, MP 257.3 is the East fence end.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-3 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 70 MP 257.2 New Wildlife Underpass Bridge	Road about 14′ above landscape	Three cell concrete box culvert 10′ x 10′ x 100,′ total width=32′	Bridge Underpass	Only priority for Mescalero Apache Tribal land in this hotspot. Replace the culvert with a bridge. It is a priority for elk. The existing culvert conveys water, so that a new bridge would allow water flow and the passage of elk, mule deer, and other wildlife. There is a home about 200′ downstream from the culvert. Mescalero Apache Tribal data show crashes occurring near this location. Add wing fences, going just past the driveway to the west and placing a guard in the driveway. To the east, add a wing fence to driveways. The area will experience end runs the structure is not upgraded. Increased human activity has been noted at the lake to the north over the years, due to casino and recreation opportunities. Increased human activity may affect wildlife.
US 70 M 257.5 New Wildlife Crossing Bridge	Road about 9′ above landscape	Single cell concrete box culvert 3′ x 7′ x 130′	Bridge Underpass	Lack of height of road bed at this site, may preclude structures. There is a home on the downstream side of the culvert, a garage building on the north side.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-3 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 70 MP 258 Wildlife detection system first, then a New wildlife crossing bridge	Road about 11′ above landscape	Single cell concrete box culvert 5′ x 8′ x 170′	Wildlife Detection System first, then Bridge Underpass	Possibly install a wildlife detection – driver warning system here since structure options are limited. Then plan for a bridge in future projects. The existing culvert is a tunnel, too long for ungulates. Some housing is present nearby. Mescalero Apache Tribal WVC data show crashes occurring near this location at MP 259. Thus, this location might still represent a good opportunity to reduce the number of crashes, extend fence out in both directions. Mescalero Apache Tribal land.
US 70 MP 263 - 69.5 Town of Ruidoso Downs				
Wildlife crashes through town, but only MP 263.2 has any opportunity for providing a wildlife crossing structure.				
US 70 MP 263.1 Wing Fence Retrofit			Retrofit with Wing Fence	MP 263.1 would be the west fence end on MP 263.2 bridge, and on to the MP 263.3 on the east side.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-3 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 70 MP 263.2 New Wildlife Underpass Bridge	Road about 50 above landscape	Single cell corrugated metal pipe, approximately 3′ x 3′ over 400′ long	Bridge Underpass	This riparian corridor north to south through Ruidoso Downs would be a good location for a new culvert/bridge to provide mule deer habitat connectivity. Right now it is a drainage area with a very small (3′) culvert. Every WVC crash near this location is likely the result of animals following riparian corridor before going over the road at this location. The existing culvert is full of shallow water. It extends diagonally across the road and would need to be 300-400′ long if it were to be replaced. In the future, when NMDOT when replacing the culvert, place a bridge. Fence can only extend from this future structure a few feet, too many driveways and homes. This riparian area should stay protected from development over the years, making it the perfect in town corridor for wildlife. A new structure would have a lot of logistical and expense concerns. There is also homeless people activity. Also grassy fields associated with church and other nearby locations may have been partial cause of accidents. It's a good spot for mitigation, but difficult in reality. As a possible retrofit, the floodplain forest contains Chinese elm, which is an invasive non-native. Replace with native willows. Water may sheet flow through this area. Possibility as a wetland mitigation credits site.
US 70 MP 265.9 Fence end			Fence end	West fence end. Extends from here eastward.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-3 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 70 MP 266.05 New Wildlife Bridge	Road about 15′ above landscape	Single cell concrete box culvert 6′ x 8′ x 150′	Bridge Underpass	Place a bridge or culvert to accommodate deer, perhaps elk. There is an open wildlife corridor both sides of the road at this location, there is a natural draw in landscape. The USFS owns land at a distance, on both sides of the road. Existing culvert may accommodate medium-sized animals. If there will be an overpass at MP 266.1, which is preferred, this will be useful for smaller species or predators, likely not deer. If the overpass is not selected this needs to be an open span bridge wide enough for elk, the same requirements to place conservation easements for open space from USFS land to USFS land is essential.
US 70 MP 266.1 New Wildlife Overpass	Road about 35′ below road cut/ embankment		Overpass	THE priority overpass for US 70. Undeveloped land on both sides, The USFS owns land at a distance, on both sides of the road. The private land connecting the FS lands would need to be left open or conserved. The north side would need additional fill. This is an important alternative because the bulk of mule deer and elk collisions are between MP 264-266 and this is the only opportunity we have with all the businesses and homes in this stretch of US 70. At this site, one side of US 70 looks like a NMDOT staging area, possibly widened ROW, relatively. This may be enough land to cover an overpass without additional ROW acquisition. The west fence end at 265.9.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-3 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 70 MP 266.6 Retrofit Bridge and Future New Wildlife Underpass Bridge	Road about 12’ from landscape	Bridge 10-15’ x 30’ each section x 150’. Total width 90’.	Retrofit with Wing Fence and New Bridge Underpass	Retrofit existing bridge by adding fence to both ends to guide elk. The existing bridge has 3 sections between support columns. There is water present but more terrestrial dry land than water, so ample opportunity for wildlife movement. Center section is about 15’ high. In future build a higher, wider bridge (that could also accommodate higher water flows with climate change). Retrofit also should include thinning of vegetation for wildlife to find this, remove fence blocking entrance. Note - If overpass at MP 266.1 is constructed the need to replace this structure will lessen and could function as is. It is an ok structure as is. Possibility as a wetland mitigation site.
US 70 MP 267.9 New Wildlife Underpass Bridge	Road is about 30’ above landscape	Single cell corrugated metal pipe 10’ x 10’ x 215’	Bridge Underpass	Priority - Replace with bridge suitable for elk. IMPORTANT- This is on USFS land, both sides There is field fence across entrance of existing culvert, it needs to be removed immediately. Slight bend in culvert. Existing culvert is much too long and small for ungulates. It has some concrete on the bottom. There is a natural draw or maybe an arroyo on the landscape that could lead wildlife to this structure.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-3 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 70 MP 268 New Wildlife Underpass Bridge	Road is about 15′ above landscape	Three cells, 2 kinds, 1 box culvert: 8′ x 8′ x 75′ and 2 corrugated metal pipe culverts 3′ x 3′ x 75′. Total width of the two, which are surrounded by concrete ends = 20′	Bridge Underpass	Create a suitable bridge for elk. Heavily used wildlife trail to the east. This is an open valley. Currently fenced off by rancher on downstream side. Immediately have fence removed. The area is high value for wildlife. Extend wing fence to the east. The straight shot of the road here is potential line of site for motorists to see wildlife. Not hard fast fence end.
US 70 MP 268.4 Fence End			Fence end	East Fence end, extend out from bridge by ½ mile.
Ruidoso NM 48 MP 0 – 9				
NM 48 MP 6.8 South Fence End	Road level with landscape		Fence end	Potential South Fence End A straight away, cross roads, good sight distance, signs or animal detection system. Near the junction with Alpine Village and University. Not selected or prioritized, but here for possible other solutions.
NM 48 MP 6.8 New Wildlife Underpass Culvert	Road about 40′ above landscape		Culvert Underpass	Install 25′ wide arched culvert or other structure. Unfortunately, homes all along both sides of road near here.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-3 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
NM 48 MP 7.2 New Wildlife Overpass	Road is about 20’ below hillsides		Overpass	Homes on east side, and slightly away from road on west side.
NM 48 MP 8.1 New Wildlife Underpass Culvert	Road is about 30’ above landscape	Single cell corrugated metal pipe with concrete at ends 12’ x 12’ x 200’	Culvert Underpass	Replace this culvert with larger one for wildlife. There are residences all along on either side of this site, but it is on a vegetated ridge. Field crew saw 5 deer approach culvert but were repelled by observers. Residential deer adapted to homes and businesses.
NM 48 MP 8.5 Wing Fence Retrofit			Retrofit with Wing Fence	Wing fence begins at MP 8.5 and is to guide wildlife to the MP 8.6 bridge, and then extend out from bridge to MP 8.7.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-3 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
NM 48 MP 8.6 Eagle Creek Retrofit Culvert, Future New Wildlife Underpass Bridge	Road is about 6′ above landscape	Seven cell concrete box culvert 5′ x 10′ 70′; 80′ total width	Retrofit with Wing Fence then Bridge Underpass	Place short wing fence on either side of existing 8 chambered bridge/multiple box culvert (see below for details). Look at NMDOT as-built records, and see if this is 8′ box culvert chamber; if so, excavate the fill out of the 2 most center culverts to get height back. Then excavate the outer ones 1-2′. Restoring a creek with a deep area in the center, and more shallow on the ends. This retrofit could be temporary, until it could be replaced with a longer, higher bridge that could accommodate wildlife. Would have to raise the level of the road. This bridged water leads to reservoir, so should always contain some water and not be developed. This is not wild area; there are homes, baseball fields, mine operation, and lots of human activity, yet the structure is there for water and could help wildlife under the road. Elk and deer have adapted to people and are ever present at homes and golf courses. Possibly add a wildlife detection system at fence ends. Below lake to the east is a candidate wetland restoration area for NMDOT. Wing fence along drainage on the southwest side. Southeast side, fence to access road. NE side, to the building. NW side fence to driveway or wall of existing business. Candidate for wetland mitigation credit project. Potentially downstream of the lake, place low height check dams. Integrate this area as a wetland and wildlife project. Also add habitat restoration.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-3 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
NM 220 MP 0-3.2				
NM 220 MP 0.2 New Wildlife Underpass Bridge	Road is about 12′ above landscape	Five cell corrugated metal pipes, each 2′ x 3′ x 100′	Bridge Underpass	Second priority bridge on this road. 5 squash pipes could be replaced with a low bridge. Could help wildlife get to NM 48 MP 10.4 future crossing structure. Team idea here was to have an elk underpass on NM 220 that would work in tandem via fencing with an elk underpass at NM 48 MP 10.3.
NM 220 MP 0.8 Wing Fence Retrofit			Retrofit with Wing Fence	Wing Fence for bridge on MP 0.9. MP 0.8 is the west fence end, and MP 0.9 is the east fence end.
NM 220 MP 0.9 New Wildlife Underpass Bridge	Road is about 20′ above landscape	Two cell corrugated metal pipes 3′ x 3′ x 200′ each, total of 10′ wide	Bridge Underpass	First priority bridge on NM 220. There is enough depth to the fill below the road to insert an arch culvert or bridge. The current culverts' entrances are beyond NMDOT right-of-way. Homes nearby, but not close as in south NM 48. Wing Fence, 0.1 mile in each direction.
NM 220 MP 1.1 Wildlife Overpass	Road is about 20′ below landscape		Overpass	Escarpments on both sides of the road. Private land, home immediately on south side. Not a priority with homes nearby and private land.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-3 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
NM 220 MP 2.9 Wildlife Overpass	Road is about 40′ below landscape		Overpass	Escarpment on both sides of road, wildlife trails along fence. There are some residences, spaced out, not as densely populated, and tourist attractions. Ft. Stanton Veterans Memorial. As there are homes nearby, this is not a priority location. Also, not where worst number of crashes were. AADT is less than 200 vehicles per day; not defensible to place structure.
NM 220 MP 3.2 East Fence End	Road is about 20′ above landscape	Single cell corrugated metal pipe 2′ x 2′ x 80′ crushed and buried under fill	Fence end	East fence end. Only consider placing fence along this road if there are wildlife crossing structures. Otherwise, AADT is low enough, elk and other wildlife can get over. Lots of elk sign.
Alto-Angus to Lincoln National Forest NM 48 – MP 9 – 17, NM 220 MP 0-3				
NM 48 MP 10.3 New Wildlife Underpass Bridge	Road is about 18′ above landscape	Two cell corrugated metal pipes 12′ x 10′ x 90′; total width 25′	Culvert or Bridge Underpass	A good opportunity to place a bridge or large culvert for wildlife. Homes nearby, but nowhere near the density as NM 48 farther south. With the pair of culverts and natural drainage. Not as many elk crashes here, but their numbers may be increasing. Homes may be an obstacle; however, there are quite a few drainages in this area, lots of topography potentially to work with.
NM 48 MP 10.4 New Wildlife Underpass Bridge	Road is about 8′ above landscape	Single cell corrugated metal culvert 4′ x 4′ x 80′	Bridge or Culvert Underpass	Place a new bridge or culvert here. Home on east side. Connect this potential crossing structure with NM 220 MP 0.2 culvert crossing structure. Potentially fence south to MP 10.3 structure. Drainage here.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-3 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
NM 48 MP 11.4 New Wildlife Underpass Culvert	Road is about 40′ above landscape	Single cell corrugated metal pipe 3′ x 3′ x 100′	Culvert Underpass	The metal pipe is filled, and drainage is not happening. There may be an opportunity to incorporate a wildlife crossing into a project that needs to be done anyway. Upgrading this pipe to a better drainage culvert would be a wildlife crossing opportunity. Truck storage yard at upstream side. Few houses in the area. Into a project that needs to be done anyway.
NM 48 MP 11.8 Fence end			Fence end	South fence to MP 11.9 new wildlife underpass bridge and northward to MP 17.1.
NM 48 MP 11.9 New Wildlife Underpass Bridge	Road is about 75′ above landscape		Bridge Underpass	Secondary priority bridge in this segment of hotspot. Make bridge high and wide enough to accommodate elk. There was an elk trail with lots of fresh elk sign, paralleling southbound lanes 25′ below highway. Lots of topography, few homes, recent fire, it has potential. Also within area with most deer and elk crashes. AADT = 10,169 vehicles per day. In deer hotspot. Fence, start 0.1 mile from south at MP 11.8, and then come from north from MP 13 overpass, have to place double cattle guards in driveways.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-3 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
NM 48 MP 12.5 New Wildlife Underpass Bridge	Road is about 15’ above landscape	Single cell corrugated metal pipe 3’ x 3’ x 50’	Bridge Underpass	This may be a good priority location for a bridge: – little to no human development at the road, looks like it is on a ridge, near both mule deer and elk collision hotspots, and then Rio Bonito Valley drops down from here. There are opportunities here. Need to consider the home development to the northwest of the road, possibly blocking wildlife movement to this spot.
NM 48 MP 12.9 Retrofit Bridge	Road is about 30’ above landscape	Bridge 20’ x 60’ x 40’	Retrofit Bridge	Very Important – Priority - existing bridge, retrofit by placing fence to it. Stream running beneath bridge, terrestrial pathways. Fresh elk tracks present, riprap present, near a commercial area, riparian corridor is narrow. This is in a deer collision hotspot. Good fence end location. On west side, work the fence northward to turn out and down NM 37 to MP 0.3 culvert then back up to north on NM 48, so animals are funneled to use Bonito Creek crossing. On east side, bring fence to the Copper Canyon development gate. Potential for wetland mitigation credit.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-3 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
NM 48 MP 13.1 Wildlife Overpass	Road is about 20′ below landscape		Overpass	Number 1 priority overpass location in this segment. Great hill cuts on both sides. Hill has deer paths on both sides. Deer sign. Road cut is high on west side, about 15′ on east side. Lots of signs deer are crossing the highway here. Area has the correct topography. However, it is privately owned, and the area would require a pretty sized swath of open space across the private land to maintain a wildlife corridor. Place fence from here north up all the way to MP 17.3. Take fence south to the Copper Canyon gate and then to MP 12.9 bridge.
NM 37 MP 0.3 Retrofit Culvert	Road is about 15′ above landscape	Two cell corrugated metal pipe culverts 4′ x 4′x 45′, total width 12′	Retrofit fence to this culvert, then Culvert Underpass	Retrofit with fence from along NM 48. Deer are coming down to the creek. Give them access to Bonito Creek at NM 37, and chance to follow fence to bridge at MP 12.9. Take NM 48 fence and come up from the south and down from the north to this road to this culvert location. In future, replace with arch culvert.
NM 48 MP 13.8 Wildlife Underpass Bridge	Road is about 22′ above landscape	Single cell concrete box culvert 8′ x 6′ x 100′	Bridge Underpass	Secondary priority bridge, needed for spacing between the MP 13.1 overpass and the MP 15.8 bridge. Make this an elk underpass. It is in the elk hotspot area. Contour drainage to be more gradual, too steep right now. There is a building 100 yards to the northeast. Bring wildlife exclusion fence to this future bridge.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-3 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
NM 48 MP 15.4 New Wildlife Underpass Bridge	Road is level with landscape in this flat area	Single cell corrugated metal pipe 4′ x 4′ x 45′	Underpass Bridge or Culvert	Land is so flat, not a candidate for wildlife crossing structures. It would be easier to build a wildlife overpass than raise road for an underpass. Listed here for potential inclusion in future project.
NM 48 MP 15.8 New Wildlife Underpass Bridge	Road is about 20′ above landscape	Single cell crushed corrugated metal pipe 2′ x 2′ x 80′	Bridge Underpass	Priority Bridge. Replace small pipe with a single span bridge and add elk fencing. Lots of elk sign. It is in an elk heavy WVC area, State land to the east, not adjacent. Appears to be a natural draw or arroyo. It needs to be a bridge if we are accommodating the elk. Perfect elk habitat. Take the fence from MP 13 at overpass to this structure.
NM 48 MP 16.2 New Wildlife Underpass Bridge	Road is about 15′ above landscape	Single cell crushed corrugated metal pipe 2′ x 2′ x 40′	Bridge Underpass	Four ungulate carcasses tossed in front of culvert, possibly road kill dump site. In elk crash area, would need to slightly raise the road to get a bridge in for elk. Also there is a possible overpass site, nearby. Not a priority, just a report of what is there.
NM 48 MP 16.5 New Wildlife Overpass	Road is about 10′ below cut in landscape		Overpass	Potential overpass site. At this site, the road cuts through a hillside. It is possible to excavate the road farther down and drop the road to a lower elevation, and build up existing embankment on both sides for an overpass. Private land. Just one home to the southeast.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-3 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
NM 48 MP 16.76 Extend Fence & West Fence End			Extend Fence & Fence end	West Fence End Private landowner already has an elk exclusion fence heading north from this site. If NMDOT was to “use” this, it could be the north terminus of the west side of road fence coming from the south. Private area encompasses pasture and houses on west side of the road and ends up at the large box culvert at MP 17.2. The “fence end” only for the west side.
NM 48 MP 17.1 Retrofit to Fence			Fence	There is an elk proof fence around a pasture on the east side of the road here. NMDOT could tie into this if they wanted to use private fence. The MP 17.2 culvert would have fence extending south to this location, to guide wildlife to use the culvert.
NM 48 MP 17.2 Retrofit Culvert	Road is about 30’ above landscape	Single cell concrete box culvert 20’ x 20’ x 40’	Retrofit - Redesign Existing Fence	The private landowner fence could potentially block east side of this culvert, although it is about 15’ up in the air. Redesign a NMDOT fence to allow wildlife to get to wild area on east side. The existing culvert is a good structure for mule deer. Probably not feasible for elk. If possible, add natural substrate, although this is along an arroyo and water moves through. It is a very new structure. When road is rebuilt, place a larger structure – a bridge, for elk. Fence to the north 0.1 mile, to MP 17.3.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

Table E-3 (cont.)

Site Number/ Mile Post/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure	Type of Mitigation Recommended	Comments
NM 48 MP 17.3 Fence End			Fence end	North Fence end. NMDOT place wildlife exclusion fence as a wing fence for 0.1 mile to guide wildlife to culvert. Note: USFS land is at MP 17.35. There could be potential partnership at more northern structures.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-4. Final project recommendations for the I-25 Glorieta Pass WVC hotspot.

Recommendation Site Number/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
I-25 MP 294.1 Phase II Fence End		Standard cattle guard at access road	Fence end	The fence end would be placed during a Phase II: extend fence southwest from hotspot to end here. Tie fence end into existing cattle guard at an access road.
I-25 MP 294.2 Fence end		Three cell concrete box culvert 12′ x 8′ x 120′	Fence end	End fence at triple cell box culvert. A cougar roadkill was recorded at this location.
I-25 MP 294.2 New Wildlife Underpass Culvert	Road is about 25′ above landscape	Three cell concrete box culvert 12′ x 8′ x 120′ each cell	Culvert Underpass	Phase II arch culvert.
I-25 MP 295.2 New Wildlife Underpass Bridge	Road is about 80′ above landscape	Two cell concrete box culvert 15′ x 25′ x 200′.	Span bridge Underpass	Phase II. No fence in front of the riparian area. Loose mid-level fence. Replace with single-span bridge. Possible low human disturbance at Grasshopper Canyon trailhead parking lot nearby.
I-25 MP 297.1 Phase I Fence end		Trafficked underpass	Fence end	West fence end Phase I: MP 297 Valencia interchange-exit. Tie fencing to existing underpass. Install game guards on access roads as needed.
I-25 MP 297.1 Retrofit Bridge		Bridge about 12′ x 10′ x 60′	Retrofit Bridge	The Phase I west fence end would begin here and extend eastward. Wildlife or double cattle guards would need to be installed on all entrance and exit ramps here.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-4 (cont.)

Recommendation Site Number/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
I-25 MP 297.7 Retrofit Culvert	About 15′ from road to bottom of fill	One cell concrete box culvert 10′ x 8′ x 120′	Retrofit Culvert	Retrofit with wildlife exclusion fence for Phase I: Existing box culvert too narrow for wildlife, with a concrete bottom. Phase II – replace.
I-25 MP 297.8 New Wildlife Overpass	About 30′ from road to top of cut		Overpass	Phase I. Parallel rail line. Suitable topography to place overpass. Elk and mule deer would use it.
I-25 MP 297.9 Retrofit Culvert	About 20′ from road to bottom of fill	Two cell concrete box culvert, 5.5′ x 8′ x 120′ each cell	Retrofit Existing Culvert	Retrofit with wildlife exclusion fence, and clean out sand and debris from bottom for Phase I. Sandy bottom has bear and cougar tracks. At southeast end, sediment filled-in so it is only 5′ high.
I-25 MP 298.6 New Wildlife Underpass Culvert	Side slope		Culvert Underpass	Phase I. No existing structure present but enough overburden present to install a strategically placed, sizable underpass for large mammals. Potential source of collisions at camp (water source).
I-25 MP 299 Retrofit Culvert	About 20′ from road to bottom of fill	One cell concrete box culvert 5′ x 5′ x 300′	Retrofit Culvert	Place wildlife exclusion fence to the culvert for Phase I. Long structure, concrete bottom, human disturbance, parallel rail line. This culvert has minimal value for prey species, but may be used by carnivores and smaller mammals.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-4 (cont.)

Recommendation Site Number/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
I-25 MP 299.9 New Wildlife Underpass Culvert	About 30′ from road to bottom of fill	One cell concrete box culvert 8′ x 7′ x 200′	Culvert Underpass	Existing culvert has concrete floor, but there are signs of use by small mammals. Residential development nearby. Make new culvert into two structures for opposing lanes of traffic and create an open atrium to add light and encourage use.
I-25 MP 300 Phase I Fence End			Fence end	Phase I East fence end.
I-25 MP 300 Retrofit Culvert	About 20′ from road to bottom of fill	Single cell concrete box culvert 7′ x 5′ x 200′	Retrofit Culvert	Place wildlife exclusion fence to culvert to encourage small mammal and bear use, but residential human disturbance nearby, so may have limited utility for wildlife.
I-25 MP 301.4 Retrofit Culvert		Single cell concrete box culvert 21′ x 14′ x 53′	Retrofit Underpass	Phase II fence end. Tie fence in to vehicle underpasses under northbound and southbound lanes of I-25. Connect using wildlife exclusion fence.
I-25 MP 301.4 Fence end		Single cell concrete box culvert 21′ x 14′ x 53′	Fence end	East/north fence end Phase II fence end. Extend the fence 100′ beyond culvert. Connect northbound and southbound lanes with fence along roadway (La Joya Rd).

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-5. Final project recommendations for the US 70 Bent WVC hotspot.

Milepost/ Structure or Cut	Type of Area	Approximate Dimensions of Existing Infrastructure	Type of Mitigation Recommended	Comments
US 70 MP 237.5 Fence End			Fence end	Western fence end, tie to bridge.
US 70 MP 237.5 Retrofit Existing Bridge	Area beneath bridge	Pair of bridges, 25′ high x 125 wide x 200′ long 2 opposing lanes′ bridges w 70′ atrium	Retrofit Bridge	Retrofit bridge with fence. Add wildlife exclusion fencing to the existing structure. Natural substrate slopes are present along the stream. This is the existing structure with the highest potential to pass elk beneath it with just the addition of wildlife fencing. Retrofitting would be easy. Other advantages include the presence of well-developed vegetation and the large amount of water flowing down the creek and likely attracting wildlife. Big open area. Very similar to Tijeras Canyon Mid Bridge and East Bridge.
US 70 MP 238.8 New Wildlife Underpass Bridge	Approx. 40′ from road to bottom of fill	Single cell concrete box culvert 15′ high x 8′ wide x 150′ long	Bridge Underpass	Possible underpass if the arroyo were to be graded back on the north and south sides to allow animals to access the underpass. Otherwise the arroyo is likely too deep to accommodate elk. Replace current culvert. Plenty of overburden to place a bridge. The replacement underpass has to be a bridge to accommodate elk under 150′ of highway. The 38 elk-vehicle crashes recorded along a 0.75-mile road segment starting at MP 39 represent the largest cluster of elk crashes in this WVC hotspot, and possibly in a single 1.5 mile stretch in the whole state. Either this location or MP 239.4, the next location, needs to accommodate elk. With a 40′ height from road to bottom of fill, this area would have a bridge with openness under it to accommodate elk herds. However, the land was being cleared in 2020 and may now be developed, in which case this location would become unsuitable for building a wildlife crossing structure.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-5 (cont.)

Milepost/ Structure or Cut	Type of Area	Approximate Dimensions of Existing Infrastructure	Type of Mitigation Recommended	Comments
US 70 MP 239.4 New Wildlife Underpass Culvert	About 15′ from road to bottom of fill	Single cell concrete box culvert 8′ high x 8′ wide x 200′ long	Culvert Underpass	Place an arch culvert here if the bridge is built at MP 238.8. If no bridge is possible at MP 238.8, then build a bridge here instead of a culvert. The bridge would need to accommodate elk with proper spacing of crossing structures for the species' needs.
US 70 MP 239.9 New Wildlife Overpass	About 70′ from top of cut to road		Overpass	Steep cut only on one side of the road, need to fill in on the other side, where the land appears to be owned by NMDOT, with fill piled for construction activities, although there is also a church behind it. The construction staging area and church may hinder wildlife movement, especially in the case of elk, which avoid human infrastructure more than mule deer. However, it appears that there is very little human disturbance at this location on most days. The adjacent open space/drainage to the east and lower probability of future development must be weighed against the likelihood of development in other areas along US 70. Proceed with caution at this location. The road is 4 lanes wide. Easement far back with room to sculpt an overpass. Drainage running parallel to the ridge with the road cut. The church is located on the southwestern corner of the area on the southeastern side of the road. Land managed by the BLM is found on the north side, 250′ from US 70. There is also an underpass option here in the drainage immediately east of the church. The underpass option is not kept as the location primarily offers the only opportunity of building an overpass for the entire hotspot.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-5 (cont.)

Milepost/ Structure or Cut	Type of Area	Approximate Dimensions of Existing Infrastructure	Type of Mitigation Recommended	Comments
US 70 MP 240.5 Orchard-Cause	Possible cause of WVCs			Existing 8′ woven wire fence for 0.1 mile around an apple orchard.
US 70 MP 241 New Wildlife Underpass Bridge	About 15′ from road to bottom of culvert	Single cell corrugated metal pipe 5′ high x 5′ wide x 200′ long	Span Bridge Underpass	Replace the existing concrete box culvert with a bridge for deer. Possible human disturbance at this site and the presence of dogs on a property to the southwest potentially prohibit wildlife movement. Big perpendicular metal culvert and fence within 30 feet of entrance. Because the east bound side opens to a pasture with horses, buy-in from the land owner will be needed. Because the crossing measures 200′ in length at this location, the new structure needs to be a span bridge with enough space beneath it to encourage ungulate use.
US 70 MP 241.4 New Wildlife Underpass Bridge	About 12′ from road to bottom of culvert	Single cell concrete box culvert 7′ high x 8′ wide x 200′ long	Span Bridge Underpass	Replace the culvert with a bridge. The 200′ length of the existing culvert likely deters many animals from using it to cross the road. The new structure has to offer lots of room beneath it to encourage ungulate use. Address eastbound outlet erosion issue, as the culvert has a 3′ drop at opening. Make any replacement culvert larger: the existing culvert may work for deer, but not elk. Human disturbance exists at this location (small power transfer station ~ 200′ away) and together with the residential development may be a problem.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-5 (cont.)

Milepost/ Structure or Cut	Type of Area	Approximate Dimensions of Existing Infrastructure	Type of Mitigation Recommended	Comments
US 70 MP 241.6 New Wildlife Underpass Culvert	About 12′ from road to bottom of culvert	Single cell concrete box culvert 7′ high x 8′ wide x 200′ long	Culvert Underpass	Replace concrete box culvert with a larger culvert – preferably a large arch culvert. Flare wing walls to open entrance. Big perpendicular metal culvert carrying water within 15′ of entrance. May work for deer, but not for elk. Human disturbance may present a challenge.
US 70 MP 241.8 New Wildlife Underpass Culvert	About <10′ from road to bottom of culvert	Single cell corrugated metal pipe 6′ high x 6′ wide x 200′ long	Culvert Underpass	Large concrete box culvert at least 12′ x 12′ could be built at this location. However, this is not a priority, unless other, nearby recommended mitigation does not work. Natural bottom in culvert, which is filling with sediment. There is an eastbound lateral access road/driveway with overgrown vegetation; it appears abandoned. A new CBC would be good for deer but not for elk. The sediment issue detected at the current culvert would need to be addressed immediately, and in the new culvert. There may not be enough available fill, will not prioritize.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-5 (cont.)

Milepost/ Structure or Cut	Type of Area	Approximate Dimensions of Existing Infrastructure	Type of Mitigation Recommended	Comments
US 70 MP 242.5 New Wildlife Underpass Bridge	About 10’ from road to bottom of culvert	Bridge with four chambers each 10’ high x 10’ wide x 200’ long	Span Bridge Underpass	Replace the four-chambered culvert with a bridge to span the water flow and allow for upland terrestrial passage, even during the 200-year flood events, to anticipate future increased flows resulting from climate change. An upstream wetland and water flowing under the bridge hinder wildlife movement. The new bridge could provide upland terrestrial passage and keep animals out of the water when moving beneath the road. This location could serve as an eastern fence end, as collisions east of here appear reduced and areas to the east become more urbanized. This is on Mescalero Apache land, so NMDOT would need to work with Tribal staff on the proposed bridge replacement and on wildlife movement, and on any possible fence end at any place east of MP 241.4.
US 70 MP 243.8 New Wildlife Underpass Bridge	About 20’ from road to bottom of bridge	Bridge with three chambers, each 8’ high x 10’ wide x 200’ long	Span Bridge Underpass	Replace the culvert with a bridge to span the water flow and allow for upland terrestrial passage, even during the 200-year flood events, to anticipate future increased flows resulting from climate change. A wetland upstream of this location, water flowing through the culvert, a steep drop within the culvert, and a sharp bend all hinder local wildlife movement. The stream has flows in November. This location could serve as an optional eastern fence end. This location is on Mescalero Tribal land. The hotspot was not extended here because NMDOT has not received crash data from the Mescalero Apache Tribe in the past. However, the Mescalero Apache Conservation Office provided ample evidence of wildlife crashes in this area for this research.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-5 (cont.)

Milepost/ Structure or Cut	Type of Area	Approximate Dimensions of Existing Infrastructure	Type of Mitigation Recommended	Comments
US 70 MP 243.8 Fence End			Fence end	Eastern fence end. Need to work with the Mescalero Apache Tribe. The large number of lateral access roads between MP 242.5 and MP 243.8 along with the lower number of collisions east of MP 242.5 make MP 242.5 a logical fence terminus. Addition of Mescalero Apache crash data and collaboration with the Tribe could change the recommendation to MP 243.8.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-6. Final project recommendations for the Chama wildlife corridor.

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 84 From Colorado Border South to Junction with US 64				
US 84 MP 288 New Wildlife Overpass	Road below hillsides		Overpass on Border	Could partner with CDOT and others for an overpass.
US 84 MP 287.4 Fenced End	Meadows and hills	Single cell culvert about 5′ x 5′ x 175′	Fence end	North fence end, Tie into existing culvert if any of the overpasses and bridges from MP 285 to 287.3 are constructed. If not, this is too far away from priority overpass at MP 284.9 to extend the fence.
US 84 MP 287.3 New Wildlife Overpass	Road below hillsides		Overpass	Overpass at slight angle or add fill on one side or the other.
US 84 MP 287.2 New Wildlife Underpass Bridge	Road above landscape		Bridge Underpass	Road is above landscape. Good site for single span bridge or for large box or arch culvert.
US 84 MP 287.0 New Wildlife Underpass Bridge	Road is about 60′ above landscape		Bridge Underpass	Large pond to the east.
US 84 MP 286.1 New Wildlife Overpass	Road below landscape, about 22′ road cuts		Overpass	Decent sloping landscape to both sides might make for more natural-looking land bridge. Good overpass location with decent fence end locations to the north.
US 84 MP 286.1 Fence End			Fence end	North Fence end for the MP 28.49 underpass to the south.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-6 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 84 MP 284.9 New Wildlife Underpass Bridge	Road about 25′ above natural draw with water	Two culverts, 5′ high, 12′ total between them for width, 60′ long	Bridge Underpass	Arch culvert with natural bottom or single span bridge. Could replace with large box, arch culvert, or single span bridge. May have to cut bank back to allow access. Water flowing, deeply incised banks. West side has a 7′ plunge from culverts.
US 84 MP 284 New Wildlife Overpass	Cut slopes are about 30′ above the road		Overpass	Good overpass location, water source on west side. Fresh elk tracks, visible in right-of-way. Privately owned lands on both sides. GPS collars on mule deer show them crossing the road here.
US 84 MP 283.4 New Wildlife Overpass	Cut slopes are about 20′ above the road		Overpass	Private land, water on the east side.
US 84 MP 283.3 New Wildlife Underpass Culvert	Road is about 12′ above landscape	Two cell corrugated metal pipe culverts, each 5′ x 5′x 60′	Culvert Underpass	Holding water on both sides.
US 84 MP 283.0 New Wildlife Overpass	Road is about 15′ below landscape cuts		Overpass	Private lands on both sides.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-6 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 84 MP 283.0 South Fence End			Fence End	South fence end.
US 84 MP 282.9 New Wildlife Underpass Bridge	Road is about 16′ above landscape	Single cell concrete box culvert 7′ x 7′ x 75′	Bridge Underpass	Arch culvert or bridge. Challenge: privately owned land on both sides, landowner fences on existing culvert. Water source on east side.
US 84 MP 282.8 New Wildlife Overpass	Road is about 25′ below landscape		Overpass	Potential overpass location, hill taller on west side by 25′, 6′ on east side, wooded west side, open meadow east side, water sources east side, apparently all privately owned.
Intersection of US 84 and US 64 East to Chama				
The MPs are for US 64, even though the two highways are one at this segment.				
US 64 MP 149 Fence end			Fence end	West fence end.
US 64 MP 149.5 New Wildlife Underpass Bridge	Road is about 16′ above landscape	Single cell corrugated metal pipe 18′ x 18′ x 75′	Bridge Underpass	Must accommodate elk. NMDGF Humphries WMA on southwestern side. Bridge or larger arch culvert to accommodate elk. Highly recommend span bridge, similar to what has worked in AZ, SR 260 for elk.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-6 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 64 MP 150.6 New Wildlife Overpass	Road location is unknown with respect to landscape		Overpass	Second choice overpass for location in this segment, on Humphries WMA land.
US 64 MP 151.8 New Wildlife Overpass	Road is about 20′ above landscape		Overpass	Top overpass location for this segment. Make sure it is within the Humphries WMA.
US 64 MP 151.9 New Wildlife Underpass Bridge	Road is about 30′ above landscape	Single cell corrugated metal pipe 4′ x 4′ x 70′	Bridge Underpass	Span bridge to accommodate elk if the MP 151.8 overpass cannot be built. Within or adjacent to Humphries WMA. Elk droppings and tracks in right-of-way.
US 64 MP 153.5 New Wildlife Underpass Culvert	Road is about 20′ above landscape		Culvert Underpass	Replace current culvert with a small concrete box culvert. Height of road is not high enough for an underpass to accommodate elk.
US 64 MP 153.6 New Wildlife Overpass	Road is about 20′ below the landscape		Overpass	Not much cut, private land. Observed, old elk tracks. Video of this location was recorded.
US 64 MP 153.9 New Wildlife Underpass Culvert	Road is about 5′ above landscape	Single cell corrugated metal pipe 2′ x 2′ x 70′	Bridge Underpass	Small animal crossing. Game fence, cannot upsize culvert.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-6 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 64 MP 154.5 New Wildlife Underpass Culvert	Road is about 20′ above landscape	Single cell corrugated metal pipe 2′ x 2′ x 80′	Culvert Underpass	Possible replacement opportunity but may not be feasible. Human disturbance.
US 64 MP 154.6 Fence End	Road is just a few feet above landscape	Single cell concrete box culvert ~ 4′ x 4′ x 75′, crumbling	Fence end	Proposed wildlife fence end, when looking at the hotspot. Data collected in October 2020.
US 64 MP 154.6 New Wildlife Overpass	Road is about 16′ below landscape		Overpass	Open rangeland; stock pond south of the road; both sides under private landownership; little to no human activity; 30 foot cut/ridge on north side of road; but level ground (at-grade) on south side of road; overhead powerline along north side of road; proposed overpass. This location is a priority based on Jicarilla Apache Tribe data on mule deer and elk movements, and crashes involving these animals. It is just inside the west boundary of the Chama WVC hotspot. Place overpass between MP 154.6 and 154.9.
US 64 MP 154.9 New Wildlife Overpass	Road is about 15′ below landscape		Overpass	Small Overpass Private land on both sides of the roadway; light human use adjacent to area; stock ponds and open rangeland adjacent to site on both sides of the road; near the edge of a WVC hotspot.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-6 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 64 MP 155.0 New Wildlife Underpass Culvert	Road is about 20′ above landscape	Single cell corrugated metal pipe 3′ x 3′ x 150′	Culvert Underpass	Private land.
US 64 MP 155.5 New Wildlife Underpass Culvert	Road is about 25′ above landscape	Single cell corrugated metal pipe 4′ x 4′ x 120′	Culvert Underpass	This would be a good site for an enlarged concrete box culvert. Plenty of overburden and there is a natural drainage funneling down to the crossing with a small dam upstream to the north. It looks like a water tank has been built, so the location holds both a water source and good habitat on both sides of the highway. An open meadow is present on the south side.
US 64 MP 156.2 New Wildlife Underpass Bridge	Road is about 20′ above landscape	Single cell corrugated metal pipe 2′ x 2′ x 120′	Bridge Underpass	Replace the corrugated metal culvert with a span bridge. Small dam immediately upstream presumed to be for water tank. Important for mule deer movement and a preferred place suggested by NMDGF and the Jicarilla Apache Nation to enhance road permeability.
US 64 MP 156.9 New Wildlife Underpass Culvert	Road is about 12′ -15′ above landscape	Single cell corrugated metal pipe 3′ x 3′ x 100′	Culvert Underpass	Place a large concrete box culvert or arch culvert. Structure replacement might require some excavation. Overburden is fairly limited (12 to 15 feet). Less overburden on north side (probably 10 feet or less).

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-6 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 64 MP 157.2 New Wildlife Underpass Bridge	Road is about 20′ above landscape	Three cell corrugated metal pipes, each 8′ x 8′x 100′	Bridge Underpass	About 8 feet of overburden. Culvert will need a U.S. Army Corps of Engineers 404 permit, as this is a major drainage wetland. So bridge may be more appealing to NMDOT, and certainly better choice for elk. This is in the hotspot.
US 64 MP 157.5 New Wildlife Underpass culvert	Road is about 10′ above landscape	Single cell corrugated metal pipe 2′ x 2′ x 120′	Culvert Underpass	Not much overburden here, very small culvert.
US 64 MP 160.0 New Wildlife Underpass Culvert	Road is about 7′ above landscape	Two cell corrugated metal pipes 3′ x 3′ x 60′	Culvert Underpass	Water and coyote willow present. Little overburden available. There is room for minor culvert upgrade; possible fence end.
US 64 MP 160.0			Fence end	East fence end.
US 64 MP 161.0 Retrofit Existing Bridge	Road is about 20′ from water and landscape below	Existing bridge, 3 sections, each 20′ x 40′ x 75′	Retrofit with Wing Fence	Retrofit with fence to existing bridge. Good, large bridge with three sections between the pilings, but right in Chama. It is a concrete pile bridge with peers. Add short amount of fence as a retrofit to guide animals. Spring runoff flows may erode installed substrate; the bigger issue is the river substrate itself; no installed riprap. Need a specific site visit for alternatives for substrate beneath the existing bridge.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-6 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
Chama US 84/US 64 Southward				
US 64 MP 161 Fence End			Fence end	
US 64 MP 161.5 Retrofit Bridge	Road is about 25′ above landscape and water	Existing three cell bridge of concrete box culverts, each 15′ x 30′ x 50′	Retrofit with Wing Fence	This bridge is over the Rio Chama. Rocky substrate is not good for mule deer passage. Getting an amendable substrate for mule deer and elk passage may be a challenge. Fence needed on both ends of the bridge to guide wildlife to it. Needs of smaller animals should be considered: make the fence graduated at the bottom.
US 64 MP 162.5 New Wildlife Underpass Culvert	Road about 10′ above landscape and water	Bridge of six cells of concrete box culverts, 5′ x 5′ x 75′ each, about 55′ in width	Culvert Underpass	The structure is pretty low with not much for overburden (approximately 3′). Replacement with a larger structure may require excavation.
US 64 MP 164.0 New Wildlife Underpass Bridge	Road is about 9′ above landscape and water	Single cell concrete box culvert 10′ x 10′ x 50′	Bridge Underpass	Replace current box culvert. Would need to be upsized for deer and elk. This culvert is undersized and is full of water wall-to-wall. Would need to be widened and potentially deepened for deer and elk passage. Not much overburden.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-6 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 64 MP 165.0 New Wildlife Underpass Culvert	Road is about 8′ above landscape	Six cell concrete box culverts, 5′ x 5′ x 66′ each, about 40′ in width	Culvert Underpass	When replacing culverts, install larger culvert. Natural drainage, lots of cover, and bear tracks present. Private outfitter ranch, adjacent to Jicarilla Apache Tribal land. Little room for expanding the concrete box culvert.
US 64 MP 165.9 New Wildlife Underpass Bridge	Road is about 12′ above landscape	Single cell corrugated metal pipe 7.5′ x 7.5′ x 170′	Bridge Underpass	The Jicarilla Apache Nation owns land on both sides and would be open to placing a road-crossing structure on their land in this high mule deer use area. The river is not far, on the west side of the road.
US 64 MP 166.4 New Wildlife Underpass Culvert	Road is about 20′ above landscape	Four cell concrete box culvert, each 15′ high, 70′ long, total width 55′	Culvert Underpass	Concrete box culvert. Perennial stream, but the streambed is cobbled. Restore streambed, replace existing multi-chambered culvert with one large culvert.
US 64 MP 166.6 New Wildlife Overpass	Road is about 30′ below hillside cuts		Overpass	Top overpass location south of Chama. It lies adjacent to private land and residences. Riparian area nearby.
US 64 MP 167.8 New Wildlife Underpass Culvert	Road is about 12′ above landscape	Single cell corrugated metal pipe 8′ x 8′ x 118′	Culvert Underpass	Replace the existing culvert with a concrete box culvert or corrugated metal pipe that mule deer will use.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-6 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 64 MP 168.2 New Wildlife Underpass Bridge	Road is about 15′ above landscape	Single cell corrugated metal pipe about 3′ x 3′ x 100′	Bridge Underpass	Span bridge or culvert. Top choice for a structure south of Chama. It is also adjacent to some wet meadows that probably represent the main attractant for wildlife and part of the collision problem. Fair amount of overburden. Jicarilla Apache Tribal data show mule deer often found on the road between MP 167-168.
US 64 MP 168.5 Possible source of Collisions				Agricultural as a source to bring in ungulates
US 64 MP 169.0 New Wildlife Underpass Culvert	Road is about 20′ above landscape	Two cell corrugated metal culverts about 5′ x 5′ x 100′	Culvert Underpass	Replace existing culvert and its two corrugated metal pipes with a concrete box culvert, if possible. Light to moderate human activity but adjacent to open rangeland on both sides of the road. Riparian corridor and private lands on both sides of the road; about 2,300 feet east of Jicarilla Apache Nation ownership. Good place to upsize to concrete box culvert; could possibly make the new structure large enough to accommodate elk. Concrete box culverts/bridges are not the only option. Arched culverts should be considered (easier to obtain a 404 permit with arched culvert).

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-6 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 64 MP 169.2 New Wildlife Underpass Culvert	Road is about 25′ above landscape	One cell corrugated metal pipe 10′ x 10′ x 110′	Culvert Underpass	Replace with a concrete box culvert. Deer and elk carcasses, perennial stream. Undersized structure.
US 64 MP 170.0 – junction of NM 512 New Wildlife Underpass Culvert	Road is about 20′ above landscape	One cell corrugated metal pipe 5′ x 5′ x 120′	Culvert Underpass	Replace with a concrete box culvert. Adjacent to a residence; existing wire-enclosed riprap at culvert outfall; near road junction; downstream from stock pond; private ownership on both sides of road. Should not be prioritized (busy intersection).
US 64 MP 171.0 Fence End and Retrofit Rio Brazos Bridge	Road is about 25′ above landscape and river	Bridge, with 2 sets of pillar supports, at least 10′ high	Fence end	Retrofit area under the existing bridge. Add crusher fines to wire-enclosed riprap to facilitate movement of wildlife. Periods of high flows may increase the difficulty of movements for wildlife under the bridge. US 64 Brazos River bridge, just north of MP 171, recorded as a fence end. Just south of the hotspot. With the human development south if it, it would be a good fence end from the north. Move the fence just 0.2 mile south of the existing fence end.
US 64 MP 171 Fence end			Fence end	South fence end.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-6 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 64 MP 177.5 New Wildlife Overpass	Road is about 60′ below cuts		Overpass	Steep cuts above the road. Could place an overpass, but nearby homes might deter wildlife movement. Not included as a priority.
US 64/84 South of Tierra Amarilla				
US 64 MP 174.5 Fence End	Existing 5-chambered culvert		Fence end	Tie north fence end into existing 5-chambered culvert.
US 64 MP 174.5 New Wildlife Bridge Underpass Tierra Amarilla Creek	Road is about 18′ above landscape	Five cells concrete box culvert 8′ x 10′ x 50′ each	Bridge Underpass	Tierra Amarilla Creek. Replace with bridge. Possibly channelize the stream to decrease the footprint of the proposed structure. The current stream channel is becoming filled with sediment. Single span bridge would work best to cross the stream. However, right now the road may be too low for a span girder bridge. Single span bridge about 50′ long over the stream. From hydrology standpoint, much better for the stream to flow under a bridge instead of through a 5-chambered culvert. Current culvert is falling apart on top and bottom sides with concrete crumbling.
US 64 MP 175.0 New Wildlife Underpass Culvert	Road is about 15′ above landscape	Single cell concrete box culvert 5′ x 7′ x 75′	Culvert Underpass	Replace with arch underpass with tie-in fence.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-6 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 84 MP 254.0 New Wildlife Overpass	Road is about 8′ below cut		Overpass	Second best choice for an overpass, tied with MP 253.4. Road is narrow here. Probably would need significant fill.
US 84 MP 253.4 New Wildlife Overpass	Road is about 40′ below cuts		Overpass	Also the second-best choice for an overpass, tied with MP 254. Steep slope on the west side. Good road cuts. Steep slope on west side had a ridge coming up to it. Slopes are a bit offset. East side might need some fill. Wildlife trails coming up from west side. Potentially one of the best overpass locations and local wildlife evidently used to steep terrain. Land is private along this road section, but larger ranches are predominant.
US 84 MP 252.8 New Wildlife Underpass Bridge	Road is about 10′ above landscape	One cell corrugated metal pipe 2′ x 2′ x 70′	Bridge Underpass	Arch culvert or span bridge for carnivores.
US 84 MP 250.8 Wildlife Overpass	Road is about 15′ below cut	None	Overpass	Private land. Cut to west is set back. Would have to add fill or lengthen the proposed overpass. Better cut slope on the east side. One of the better overpass locations.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-6 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 84 MP 250.5 New Wildlife Underpass Culvert	Road is about 18’ above landscape	Single cell corrugated metal pipe 4’ x 4’ x 100’	Culvert Underpass	Replace with a large box culvert or arch culvert. Several other drainages present in the area share similar characteristics so there are probably a couple other options nearby that are not listed in the table because they could not be seen from the road. Elk droppings. Possible structure for carnivores. Not enough overburden to make a new structure large enough for mule deer.
US 84 MP 250.0 New Wildlife Underpass Bridge	Road is about 20’ above landscape	Single cell corrugated metal pipe 7’ x 7’ x 120’	Bridge Underpass	Somewhat deeply incised drainage. Some deer sign nearby. This location is suitable for carnivores and mule deer. Existing culvert has a slope with fill that needs to be cleared out on west end. Might need to cut back some areas of embankment to allow ungulate access to channel.
US 84 MP 249.7 New Wildlife Overpass	Road is about 30’ below cut		Overpass	Top overpass location south of Tierra Amarilla. Good location for overpass with cuts on both sides. Telemetry data show mule deer migratory movements are here. Probably private land.
US 84 MP 249.6 New Wildlife Underpass Culvert	Road is about 25’ above landscape	One cell corrugated metal pipe 3’ x 3’ x 100’	Culvert Underpass	For deer and elk. Good location for a crossing structure, elk sign nearby.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-6 (cont.)

Site Number/ Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 84 MP 249.4 New Wildlife Underpass Bridge	Road is about 30’ above landscape	One cell corrugated metal pipe 3’ x 3’ x 120’	Bridge Underpass	There is ample room/overburden to work with. Elk tracks present with deer and elk droppings. Tie fence end to the future arch culvert or bridge.
US 84 MP 249.4 Fence End			Fence End	South fence end. Tie fence end to culvert or span bridge to be placed here. The road flattens out south of here and the topography becomes homogeneous.
US 84 MP 244.0 New Wildlife overpass			Overpass	Small cuts on both sides of highway. Ridge of ponderosa pine, with some Rocky Mountain juniper mixed in. Other recommended locations lack the same topography. This ridge may help animals move in the future under the influence of climate change that would alter ecosystems in lower elevations.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-7. Final project recommendations for the Rio Grande Del Norte wildlife corridor.

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 285 MP 385.3 New Wildlife Underpass Culvert	Road is about 10′ above landscape	One cell corrugated metal pipe, 2′ x 2′ x 60′	Culvert Underpass	The structure in place is a small corrugated metal pipe, but 10′ overburden is present. Would likely only be large enough for carnivores but maybe deer as well. Located close to town.
US 285 MP 385.5 Potential Fence end			Fence end	Potential south fence end
US 285 MP 385.5 New Wildlife Underpass Culvert	Road is about 16′ above landscape	One cell concrete box culvert, 8′ x 8′ x 60′	Culvert Underpass	May be suitable for deer as-is, but there is enough overburden to replace the concrete box culvert with a larger road-crossing structure.
US 285 MP 385.8 New Wildlife Underpass Culvert	Road is about 10′ above landscape	One cell concrete box culvert, 5′ x 5′ x 50′	Culvert Underpass	Replace with larger box culvert; remove fence. Deer tracks are present in the area, but none in the culvert. Possible medium-sized mammal tracks in the culvert. Fence only blocking the east side.
US 285 MP 386.1 New Wildlife Underpass Culvert	Road is about 8′ above landscape	One cell concrete box culvert, 3′ x 6′ x 60′	Culvert Underpass	Replace with larger box or small arch culvert Would have to probably focus on carnivores, not enough overhead room for deer.
US 285 MP 386.4 Potential Fence end			Fence end	South fence end potential. Tie into existing culvert. Phase III
US 285 MP 386.4 Retrofit Culvert	Unknown	Unknown structure	Fence end	Potential Fence end for Phase III. Structure overlooked during field reconnaissance. Likely too small to pass ungulates, but should be reevaluated in the future.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-7 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 285 MP 386.7 New Wildlife Underpass Culvert	Road is about 8′ above landscape	One cell concrete box culvert, 3′ x 3′ x 60′	Culvert Underpass	Replace with larger box or small arch culvert during Phase III. Would have to probably focus on carnivores, not enough overhead room for deer.
US 285 MP 387.5 New Wildlife Underpass Culvert	Road is about 7′ above landscape	Two cell concrete box culvert, 3′ x 4′ x 60′ each	Culvert Underpass	Replace with larger box or small arch culvert Phase III. Would have to probably focus on carnivores, not enough overhead room for deer.
US 285 MP 388.2 New Wildlife Underpass Culvert	Road is about 12′ above landscape	One cell concrete box culvert, 4′ x 6′ x 60′	Culvert Underpass	Replace with arch culvert as part of Phase III. Elk carcass found nearby. Elk droppings and tracks abundant in the area. Existing culvert in bad shape.
US 285 MP 388.4 Retrofit Culvert	Road is about 10′ above landscape	Three cell concrete box culvert, 7′ x 5′ x 60′ each	Retrofit Culvert	Place wildlife exclusion fence to culvert as part of Phase III. Elk carcasses found. Lots of deer and elk tracks.
US 285 MP 388.8 New Wildlife Underpass Culvert	Road is about 6′ above landscape	Two cell concrete box culvert, 4′ x 4′ x 60′ each	Culvert Underpass	Replace with larger box culvert (Phase III). Little overburden to work with.
US 285 MP 389.7 New Wildlife Underpass Bridge	Road is about 15′ above landscape	Four cell concrete box culvert, 10′ x 10′ x 60′ each	Bridge Underpass	Replace with bridge (Phase III). Currently used by livestock. The proposed bridge is more conducive to elk use. Fence blocking entrance.
US 285 MP 389.7 Fence End			Fence end	Potential north fence end for Phase III.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-7 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 285 MP 389.8 New Wildlife Underpass Culvert	Road is about 8′ above landscape	Two cell concrete box culvert, 3′ x 6′ x 50′ each	Culvert Underpass	Replace with larger box or small arch culvert (Phase III). Residential property to the east. Would have to probably focus on carnivores, not enough overhead room for deer.
US 285 MP 390.0 New Wildlife Underpass Culvert	Road is about 6′ above landscape	One cell concrete box culvert, 4′ x 6′ x 55′	Culvert Underpass	Replace with larger box culvert. Very little overburden to work with. Culvert in poor condition and partially silted in.
US 285 MP 390.5 Retrofit Culvert	Road is about 8′ above landscape	One cell concrete box culvert, 5′ x 5′ x 50′	Retrofit Culvert	Remove fence. Storage yard for trucks, trailers, and earthmoving equipment. Fence blocking the entrance.
US 285 MP 390.6 New Wildlife Underpass Culvert	Road is about 15′ above landscape	One cell concrete box culvert, 10′ x 10′ x 60′ each	Culvert Underpass	Replace with arch culvert or span bridge; Fence blocking the entrance, should be immediately removed. Unidentified animal tracks in the area but not in the culvert. Deer bones present.
US 285 MP 390.8 New Wildlife Underpass Culvert	Road is about 7′ above landscape	One cell concrete box culvert, 5′ x 4′ x 50′	Culvert Underpass	Replace with larger box or small arch culvert; remove fence. Old mine site. Fence blocking the entrance. Culvert in very poor condition.
US 285 MP 391.7 US 285 At-grade Animal Detection Driver Warning System	Road is about even with landscape		Animal Activated Detection System	Some residential and commercial land here. Appears defunct. Roadway is flat and open, offering good visibility. Would likely need animal detection system capable of covering large area.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-7 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 285 MP 391.8 New Wildlife Underpass Culvert	Road is about 8′ above landscape	One cell concrete box culvert, 6′ x 4′ x 50′	Culvert Underpass	Replace with larger box culvert; remove fence. Fence blocking the entrance. Elk tracks in the area. Near water source.
US 285 MP 392.1 Fence End	Turnout for mine		Fence end	Potential Fence end Phase I. South fence end at existing cattle guard on turn out (east side). Find logical end point to west side.
US 285 MP 392.8 New Wildlife Overpass	Road is about 30′ below landscape		Overpass	Phase I. Elk tracks and droppings present. Basalt substrate. Potentially public land, but land ownership will have to be examined more closely.
US 285 MP 395.4 New Wildlife Underpass Bridge	Road is about 12′ above landscape	Five cell concrete box culvert, 5′ x 6′ x 75′	Bridge Underpass	Replace with span bridge (Phase I). Immediately remove the fence blocking the entrance. Elk carcass found. A span bridge may require raising the road.
US 285 MP 395.6 New Wildlife Overpass	Road is about 30′ below landscape		Overpass	Phase I. Should be a priority overpass location. Just south of San Antonio Mountain. Telemetry data identifies animal crossings in the area. A natural ridge comes down to the road on the east side. The topography is flat on the west side.
US 285 MP 396.6 Fence End	Turnouts		Fence end	Potential fence end Phase I. North Fence end at existing cattle guard on turn outs to both sides of the road.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-7 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 285 MP 398.0 At-grade Animal Activated Detection Driver Warning System	Unknown		Animal Activated Detection System	Phase II. Milepost location estimated based on initial assessment of gap between Phases I and II. Doppler radar-type ADS can cover a large distance. Estimate one to 1.5 miles of system. Will need reevaluation by installer. Type and location to be determined.
US 285 MP 400.2 At-grade Animal Activated Detection Driver Warning System	Unknown		Animal Activated Detection System	Phase II. Milepost location estimated based on initial assessment of the gap between Phases I and II. Doppler radar-type ADS can cover a large distance. Estimate one to 1.5 miles of system. Will need reevaluation by installer. Type and location to be determined.
US 285 MP 398.3 New Wildlife Underpass Culvert	Road is about 12′ above landscape	One cell concrete box culvert, 2′ x 2′ x 60′	Culvert Underpass	Replace with arch culvert. Laydown fence present. Higher to the west with only 6′ to culvert. Culvert blocked with round pipe. Might be able to excavate the west side leading to the culvert.
US 285 MP 401.0 Fence End	Turnouts		Fence end	Potential fence end Phase II. South fence end at existing cattle guard on turnouts to both sides of the road.
US 285 MP 401.2 New Wildlife Underpass Bridge	Road is about 10′ above landscape	Six cell concrete box culvert, 3′ x 3′ x 60′ each	Bridge Underpass	Phase II. Elk droppings and tracks present. Culverts blocked with round pipe. A bridge is necessary for elk herd movement.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-7 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 285 MP 401.5 Retrofit Culvert	Road is about 6′ above landscape	One cell concrete box culvert, 5′ x 6′ x 60′	Retrofit Fence	Repair fence soon. Fence tied into both sides, needs repair. Elk droppings present.
US 285 MP 401.9 New Wildlife Overpass	Road is about 10′ below landscape		Overpass	Phase II. Would need additional fill to east side, possibly both sides. Important wildlife migration area.
US 285 MP 402.1 New Wildlife Underpass Culvert	Road is about 8′ above landscape	Two cell concrete box culvert, 3′ x 6′ x 100′ each	Culvert Underpass	Replace with larger box or small arch culvert. Signs of pooling water. Not a lot of room to work with.
US 285 MP 402.5 New Wildlife Underpass Culvert	Road is about 7′ above landscape	Two cell concrete box culvert, 4′ x 7′ x 80′ each	Culvert Underpass	Replace with larger box or small arch culvert. Little overburden to work with.
US 285 MP 403.4 New Wildlife Underpass Bridge	Road is about 10′ above landscape	Three cell concrete box culvert, 7′ x 5′ x 70′ each	Bridge Underpass	Replace with bridge (Phase II). The fence blocking the entrance can be removed immediately. Deer carcass found.
US 285 MP 403.6 New Wildlife Underpass Culvert	Road is about 12′ above landscape	One cell concrete box culvert, 3′ x 3′ x 100′	Culvert Underpass	Replace with arch culvert. Slight curve noted in the existing culvert but can still see through. Less overburden on the west side, ~9′.
US 285 MP 403.8 New Wildlife Underpass Culvert	Road is about 9′ above landscape	One cell concrete box culvert, 3′ x 3′ x 70′	Culvert Underpass	Replace with box or small arch culvert. Only about 4′ overburden.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-7 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 285 MP 404.2 New Wildlife Overpass	Road is about 4′ below landscape		Overpass	Phase II. Good location for pronghorn overpass. Will need substantial fill on both sides.
US 285 MP 404.6 New Wildlife Overpass	Road is about 6′ below landscape		Overpass	Cut slightly higher on the west side. Will need fill on both sides.
US 285 MP 405.0 Fence End	Turnout	No structure	Fence end	Potential fence end Phase II. North fence end, place at existing cattle guard on turn out (east side). Find logical end point to west side.
US 285 MP 405.6 New Wildlife Underpass Culvert	Road is about 7′ above landscape	Two cell concrete box culvert, 4′ x 4′ x 70′ each	Culvert Underpass	Replace with box or small arch culvert. Elk droppings abundant. Round concrete culverts.
US 285 MP 405.8 New Wildlife Overpass	Road is about 6′ below landscape		Overpass	Lower on the west side. Fill needed on both sides.
US 285 MP 407.2 New Wildlife Overpass	Road is about 8′ below landscape		Overpass	The east side has a lower cut. Likely need additional fill on both sides.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

Table E-8. Final project recommendations for the Pronghorn Triangle wildlife corridor.

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
I-25 MP 428 - 451				
I-25 MP 428.4 Retrofit Culvert	Road is about 6′ above landscape	Two Cell Concrete Box Culvert, 3′ x 6′ x 150′ each	Retrofit Culvert	Retrofit existing box culvert; potential fence end. 5′ atrium present. Railroad adjacent, has bridge.
I-25 MP 428.9 Fence End			Fence end	South fence end
I-25 MP 428.9 Retrofit Culvert	Road is about 16′ above landscape	One Cell Concrete Box Culvert, 14′ x 24′ x 150′	Retrofit Culvert	Tie fence to culvert. Vehicle underpass, minor farm road. Railroad adjacent, at-grade crossing. Work with landowner.
I-25 MP 430.2 Retrofit Bridge	Road is about 25′ above landscape	Bridge, 25′ x 40′ x 150′	Retrofit Bridge	Tie fence to culvert. 60′ atrium present. Separate north- and south-bound bridges. Water present. Railroad adjacent, has bridge. Work with landowner.
I-25 MP 431.8 Retrofit Bridge, Fence End	Road is about 5′ above landscape	One Cell Concrete Box Culvert, 25′ x 75′ x 150′	Retrofit Bridge	Tie fence to culvert. 0′ atrium present. Clear vegetation to open-up crossing location. Separate north- and south-bound bridges. Railroad adjacent, has bridge. Work with landowner.
I-25 MP 431.8 Fence End			Fence End	North fence end
I-25 MP 433.7 Fence End			Fence End	South fence end

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-8 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
I-25 MP 433.7 New Wildlife Underpass Culvert	Road is about 10′ above landscape	Two cell concrete box culvert, 7′ x 5′ x 200′ each	Culvert Underpass	New Arch culvert. Rest area nearby. Atrium recommended. Work with landowner.
I-25 MP 434.5 Retrofit bridge	Road is about 20′ above landscape	Bridge, 18′ x 30′ x 200′	Retrofit Bridge	Tie fence to culvert. Railroad crossing under highway. Large atrium present, will likely have to fence. Concrete slopes on each side. Work with landowner.
I-25 MP 435.3 Overpass	Road is about 70′ below landscape	No structure	Overpass	Cut present on both sides of the road. Located at the intersection of turnouts. Work with landowner.
I-25 MP 435.6 New Wildlife Underpass Bridge	Road is about 23′ above landscape	Three cell concrete box culvert, 7′ x 8′ x 150′ each	Bridge Underpass	Will need atrium. Work with landowner.
I-25 MP 437.5 Retrofit Bridge	Road is about 25′ above landscape	Bridge, 25′ x 100′ x 200′	Retrofit Bridge	Tie wildlife exclusion fence to the bridge. Separate northbound and southbound bridges. Railroad adjacent, has bridge.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-8 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
I-25 MP 438.7 Retrofit Culvert	Road is about 20′ above landscape	One cell concrete box culvert, 16′ x 15′ x 150′	Retrofit Culvert	Tie wildlife exclusion fence to the culvert. Vehicle interchange underpass, minor farm road. Railroad adjacent. Deer tracks present in the concrete box culvert.
I-25 MP 438.8 New Wildlife Underpass Bridge	Road is about 20′ above landscape	Five cell concrete box culvert, 4′ x 6′ x 200′ each	Bridge Underpass	Atrium recommended. Work with landowner
I-25 MP 438.9 New Wildlife Underpass Culvert	Road is about 20′ above landscape	One cell concrete box culvert, 8′ x 12′ x 200′	Culvert Underpass	Replace existing culvert. Concrete box culvert curves, better if straight when replaced. Atrium recommended.
I-25 MP 440.1 Retrofit Bridge	Road is about 25′ above landscape	Bridge, 25′ x 200′ x 150′	Retrofit Bridge	Tie wildlife exclusion fence to the base of the bridge in all directions. Canadian River. Separate northbound and southbound bridges (atrium).
I-25 MP 440.1 Fence End			Fence end	North Fence end
I-25 MP 441.9 Retrofit Culvert	Road is about 20′ above landscape	One cell concrete box culvert, 13′ x 12′ x 150′	Retrofit Culvert	Tie wildlife exclusion fence to existing culvert. 4′ atrium present. Fence blocking the culvert. Vehicle interchange underpass.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-8 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
I-25 MP 441.9 Fence End			Fence end	South Fence end, extends north to MP 443.4.
I-25 MP 442.3 New Wildlife Overpass	Road is about 35′ below landscape		Overpass	Northbound has material that could be used to build up southbound side for overpass.
I-25 MP 443.4 Fence End			Fence end	North fence end, fence extends from MP 441.9 in the south.
I-25 MP 443.4 Retrofit Culvert	Road is about 12′ above landscape	One cell concrete box culvert, 12′ x 10′ x 150′	Retrofit Culvert	Tie wildlife exclusion fence to culvert. 3′ atrium present. Some 8′ game fence present along southbound right-of-way.
I-25 MP 445.1 New Wildlife Underpass Culvert	Road is about 10′ above landscape	One cell concrete box culvert, 8′ x 10′ x 150′	Culvert Underpass	Replace with arch culvert. 3′ atrium present. Could serve as extension for second phase. Work with landowners.
I-25 MP 445.1 Fence End			Fence end	North fence end
I-25 MP 447.0 Fence End	Highway intersection		Potential fence end	Potential fence end for early phase if mitigation project. NMDOT yard.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-8 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
I-25 MP 447.6 New Wildlife Overpass	Road is about 50′ below landscape		Overpass	Cut much smaller on east side (~7′). Might be able to use material from west side to build up east side. Work with landowners.
I-25 MP 450.5 Fence End	Intersection		Fence end	Potential fence end. Tie into existing game fence from previous Raton mitigation project.
US 64 MP 321 - 345				
US 64 MP 321.4 Fence End			Fence end	South fence end
US 64 MP 321.4 New Wildlife Underpass Bridge	Road is about 25′ above landscape	Bridge, 25′ x 140′ x 150′	Bridge Underpass	Retrofit with wildlife exclusion fence, or replace with single span. Large enough for elk to use as-is. 3-span. Deer and elk sign present.
US 64 MP 321.7 Retrofit Bridge	Road is about 25′ above landscape	Bridge, 20′ x 30′ x 40′	Retrofit Bridge	Retrofit with wildlife exclusion fence. May be large enough for elk as-is. Water present, not much room for passage.
US 64 MP 323.3 Retrofit Culvert	Road is about 10′ above landscape	One cell concrete box culvert, 8′ x 6′ x 50′	Retrofit Culvert	Retrofit with wildlife exclusion fence. Remove fence blocking entrances. Likely target carnivores.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-8 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 64 MP 323.7 Retrofit Culvert	Road is about 12′ above landscape	One cell concrete box culvert, 6′ x 6′ x 50′	Retrofit Culvert	Retrofit with wildlife exclusion fence. Likely target carnivores.
US 64 MP 324.9 Retrofit Culvert	Road is about 15′ above landscape	One cell concrete box culvert, 8′ x 10′ x 60′	Retrofit Culvert	Retrofit with wildlife exclusion fence. First retrofit, then replace with arch culvert. Likely target carnivores.
US 64 MP 325.7 Retrofit Culvert	Road is about 12′ above landscape	One cell concrete box culvert, 8′ x 8′ x 50′	Retrofit Culvert	Retrofit with wildlife exclusion fence. Deer and pronghorn bones found. Too small for passage of ungulates. Likely target carnivores.
US 64 MP 327.3 Retrofit Culvert	Road is about 12′ above landscape	One cell concrete box culvert, 8′ x 10′ x 50′	Retrofit Culvert	Retrofit with wildlife exclusion fence. Likely target carnivores.
US 64 MP 329.4 New Wildlife Underpass Culvert	Road is about 12′ above landscape	One cell concrete box culvert, 8′ x 12′ x 75′ each	Culvert Underpass	

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-8 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 64 MP 330.3 New Wildlife Underpass Culvert	Road is about 8′ above landscape	One cell concrete box culvert, 4′ x 10′ x 70′	Culvert Underpass	Replace with larger box culvert. Very little height potential.
US 64 MP 330.7 Retrofit Culvert	Road is about 12′ above landscape	One cell concrete box culvert, 8′ x 8′ x 60′	Retrofit Culvert	Retrofit with wildlife exclusion fence. Likely target carnivores.
US 64 MP 331.7 Retrofit Bridge	Road is about 40′ above landscape	Bridge, 20′ x 60′ x 50′	Retrofit Bridge	Retrofit with wildlife exclusion fence. Great single span bridge for deer and maybe elk.
US 64 MP 333.1 Retrofit Culvert	Road is about 10′ above landscape	One cell concrete box culvert, 8′ x 8′ x 60′	Retrofit Culvert	Retrofit with wildlife exclusion fence. Likely target carnivores.
US 64 MP 333.7 New Wildlife Overpass	Road is about 10′ below landscape		Overpass	Fill likely needed on east side. Cut only to northwest side.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-8 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 64 MP 334.1 New Wildlife Underpass Culvert	Road is about 17′ above landscape	One cell concrete box culvert, 8′ x 7′ x 70′	Culvert Underpass	Replace with larger box culvert. Fence tied-in to both sides. Right-of-way fence blocking the west. Use arch culvert if possible.
US 64 MP 335.2 Retrofit Culvert	Road is about 8′ above landscape	Three cell concrete box culvert, 7′ x 7′ x 70′ each	Retrofit Culvert	Retrofit with wildlife exclusion fence. Blocked on its west side by a fence that should be removed. Some natural substrate.
US 64 MP 336.3 New Wildlife Underpass Culvert	Road is about 15′ above landscape	Four cell concrete box culvert, 6′ x 8′ x 90′ each	Culvert Underpass	Replace with arch culvert. Partially silted-in, more so to the east. Culverts encased in concrete.
US 64 MP 336.5 New Wildlife Underpass Culvert	Road is about 20′ above landscape	Four cell concrete box culvert, 10′ x 10′ x 80′ each	Culvert Underpass	Replace with arch culvert. Two elk carcasses found but likely dumped here. Partially silted-in.
US 64 MP 337.3 New Wildlife Overpass	Road is about 12′ below landscape		Overpass	Two live pronghorn in the right-of-way. Cut is present only on the west side.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-8 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 64 MP 338.9 Retrofit Culvert	Road is about 9′ above landscape	One cell concrete box culvert, 8′ x 5′ x 80′	Retrofit Culvert	Retrofit with wildlife exclusion fence. Partially obstructed, clear debris and fences.
US 64 MP 339.1 New Wildlife Overpass	Road is about 12′ below landscape		Overpass	Additional fill needed. Lower on the east side.
US 64 MP 339.2 New Wildlife Underpass Culvert	Road is about 12′ above landscape	One cell concrete box culvert, 7′ x 5′ x 70′	Culvert Underpass	Replace with larger box culvert. Unidentified animal tracks in the culvert. Partially obstructed by a fence.
US 64 MP 339.3 New Wildlife Underpass Culvert	Road is about 10′ above landscape	One cell concrete box culvert, 7′ x 5′ x 80′	Culvert Underpass	Replace with larger box culvert. Adjacent to NRA Whittington Center.
US 64 MP 340.2 Retrofit Culvert	Road is about 10′ above landscape	Four cell concrete box culvert, 7′ x 7′ x 100′ each	Retrofit Culvert	Retrofit with wildlife exclusion fence. Possible pronghorn carcass found. Culverts filled with tumbleweeds. Dilapidated fence tied in.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-8 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 64 MP 340.9 New Wildlife Overpass	Road is about 15′ below landscape		Overpass	Possible pronghorn bones found in the right-of-way. Additional overpass location just to the south. Both locations better than the railroad bridge area. Cut closer to 10′ on the east side.
US 64 MP 341.5 Fence End	Railroad tracks		Fence end	Potential fence end at railroad tracks. Possibly extend along tracks over a short distance.
US 64 MP 341.6 New Wildlife Overpass	Road is about 30′ below landscape		Overpass	Close to the Canadian River. Railroad parallel, near the location where the railroad crosses US 64. An overpass would work on either side of the bridge.
US 64 MP 341.7 Retrofit Bridge	Road is about 70′ above landscape	Bridge, 70′ x 205′ x 60′	Retrofit Bridge	Retrofit with wildlife exclusion fence. Canadian River bridge. Three spans. Some water present but lots of open space.
US 64 MP 343.0 New Wildlife Underpass Culvert	Road is about 12′ above landscape	One cell concrete box culvert, 7′ x 5′ x 100′	Culvert Underpass	Replace with larger box culvert.
US 64 MP 343.5 New Wildlife Underpass Bridge	Road is about 20′ above landscape	Four cell corrugated metal pipe, 5′ x 5′ x 100′ each	Bridge Underpass	Replace with bridge. Right-of-way fence blocking. Lots of room for a larger structure.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-8 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 64 MP 343.7 New Wildlife Underpass Culvert	Road is about 20′ above landscape	One cell concrete box culvert, 4′ x 7′ x 100′	Culvert Underpass	Replace with a larger box culvert; potential fence end. The existing culvert is blocked by a fence.
US 64 MP 344.1 Fence End	Highway intersection		Fence end	Potential fence end Tie fence into I-25 fencing. May end fence here or possibly extend south later.
NM 505 MP 0 - 3				
NM 505 MP 2.9 Retrofit Bridge	Road is about 12′ above landscape	Bridge, 10′ x 30′ x 25′	Retrofit Bridge	Retrofit with wildlife exclusion fence two span. May need to open up banks for easier passage. Perhaps cut pathways in slopes.
NM 445 MP 0 - 11				
NM 445 MP 1.2 Fence end			Fence end	South fence end
NM 445 MP 1.2 Retrofit Culvert	Road is about 7′ above landscape	One cell concrete box culvert, 5′ x 3′ x 100′	Retrofit Culvert	Retrofit with wildlife exclusion fence. Canid and other, unknown animal tracks present. Likely only used by small mammals and carnivores as-is.
NM 445 MP 3.0 Retrofit Culvert	Road is about 6′ above landscape	Four cell concrete box culvert, 3′ x 6′ x 75′ each	Retrofit Culvert	Retrofit with wildlife exclusion fence. Very little overburden present. Likely only used by small mammals and carnivores as-is.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-8 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
NM 445 MP 3.5 New Wildlife Underpass Culvert	Road is about 6′ above landscape	One cell concrete box culvert, 3′ x 3′ x 60′	Culvert Underpass	Replace with a larger box culvert. May need to raise the road to make most use of a larger structure.
NM 445 MP 3.9 New Wildlife Overpass	Road is about 5′ below landscape		Overpass	At turnoff for Maxwell NWR. Would need considerable fill but cuts present to each side.
NM 445 MP 4.9 New Wildlife Underpass Culvert	Road is about 12′ above landscape	Three cell concrete box culvert, 5′ x 10′ x 70′ each	Culvert Underpass	Replace with an arch culvert. Three or four coyote carcasses found, likely dumped. Cow carcasses also. Some ungulate tracks but likely bovine. Banks steep to the east. Structure partially silted-in.
NM 445 MP 5.9 Underpass Culvert	Road is about 8′ above landscape	One cell concrete box culvert, 3′ x 4′ x 100′	Culvert Underpass	Replace with a larger box culvert. Partially silted-in. Possible ungulate tracks in the ditch.
NM 445 MP 6.3 New Wildlife Underpass Culvert	Road is about 13′ above landscape	Four cell concrete box culvert, 6′ x 10′ x 60′ each	Culvert Underpass	Replace with an arch culvert. Ungulate tracks found. Standing water and wetland habitat present. Fence tied in to both sides but blocking the west entrance.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-8 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
NM 445 MP 7.2 Retrofit Fence	Road is about 5′ above landscape	Five cell concrete box culvert, 3′ x 5′ x 60′ each	Retrofit Fence	Modify right-of-way fence. Live pronghorn present to each side. Ungulate tracks in right-of-way. Very little overburden to work with. Modify right-of-way fence to be wildlife-friendly likely represents the best option, but retrofitting is possible for medium-sized mammals.
NM 445 MP 8.2 New Wildlife Underpass Culvert	Road is about 7′ above landscape	Four cell concrete box culvert, 6′ x 8′ x 70′ each	Culvert Underpass	Replace with an arch culvert. Partially silted in. Spoil piles nearby (possibly from channel work). Fence blocking the west.
NM 445 MP 9.5 Retrofit Fence	Road is about 8′ above landscape	One cell concrete box culvert, 6′ x 5′ x 60′	Retrofit Fence	Modify right-of-way fence. Fence blocking the west entrance. Modification of the right-of-way fence to be wildlife-friendly is likely the best option but retrofitting for medium-sized mammals is possible.
NM 445 MP 11.0 New Wildlife Underpass Culvert	Road is about 8′ above landscape	Two cell concrete box culvert, 7′ x 7′ x 50′ each	Culvert Underpass	Replace with larger box culvert Natural substrate may increase use.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-9. Final project recommendations for the Peloncillo Mountains wildlife corridor.

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
I-10 MP 0.3 Fence End			Fence end	West fence end, in the flats.
I-10 MP 0.4 New Wildlife Underpass Culvert	About 18′ below road	One cell concrete box culvert 8′ x 6′ 130′	Span Bridge Underpass	New wildlife underpass, single span bridge or arch culvert for animals other than bighorn sheep. Clear brush/trees from the existing culvert.
I-10 MP 0.9 New Wildlife Underpass Bridge	About 10′ below road	One cell concrete box culvert 7′ x 6′ x 150′	Span Bridge Underpass	Place a single span bridge or arch culvert for carnivores, although no tracks were detected during the field reconnaissance. One bullsnake found.
I-10 MP 1.4 New Wildlife Overpass	Road about 15′ below cut		Overpass	Second best possible overpass location. Some human disturbance, rail line about 200′ to the north. Important location for desert bighorn movement.
I-10 MP 1.5 New Wildlife Underpass Culvert	Road is about 7′ above	One cell concrete box culvert 5′ x 8′ x 90′	Culvert Underpass	Place arch culvert for carnivores. The existing culvert has a lot of fill in it; it should be cleared out in the near-term. There is a culvert beneath the railroad nearby. These two culverts could provide passage for wildlife through the transportation corridors.
I-10 MP 1.9 Wildlife Overpass	Road is about 25′ below nearby cuts		Overpass	Third choice for an overpass site, tied with 2.9. South side needs fill. Rail road is farther away than at Steins Mountain. In middle of corridor.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-9 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
I-10 MP 2.0 New Wildlife Underpass Culvert	Road is about 6′ above	Concrete box culvert 5′ x 6′ x 100′	Culvert Underpass	New arch culvert would provide passage for carnivores.
I-10 MP 2.25 New Wildlife Overpass (Tied with 2.3)	Road is about 15′ below cut		Overpass	The other potential top overpass site if MP 2.3 is not appropriate. See MP 2.3 description. Could angle the overpass to sit between these two sites.
I-10 MP 2.3 Top New Wildlife Overpass site	Road is about 35′ below cut		Overpass	The most important overpass site. This could be situated between MP 2.3 and 2.25. It would be on state land. May need to go in at an angle to meet the rock cuts. Steep topography. It is near Steins Mountain where bighorn have been recorded. Cut bank is on the north side of I-10, cut bank also just beyond to the west on the south side. Drop into the drainage that parallels I-10 on the south side.
I-10 MP 2.6 New Wildlife Underpass Bridge	Road is about 15′ above	Concrete box culvert 17′ x 15′ x 140′	Bridge Underpass	Create a span bridge underpass. The existing culvert is at an angle.
I-10 MP 2.9 New Wildlife Overpass	Road is about 40′ below cut		Overpass	Third choice overpass, tied with MP 1.9. The rail road is about 500′ from the shoulder of I-10.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-9 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
I-10 MP 3.0 New Wildlife Underpass Bridge	Road is about 25′ above	Concrete box culvert 6′ x 6′ x 130′	Bridge Underpass	Arch culvert or bridge pair for carnivores. Mexican wolves could use these. Small and mid-sized mammals such as coyote and javelina are already using the existing culvert.
I-10 MP 3.1 New Wildlife Overpass	Road is about 15′ below rock cut		Overpass	Need fill on the south side.
I-10 MP 3.5 New Wildlife Overpass	Road is about 30′ below rock cut		Overpass	
I-10 MP 3.6 East Fence End			Fence end	The flat topography to the east would preclude bighorn sheep from regularly moving across the highway east of here. A fence end would be appropriate, placing it to the existing culvert at the Steins interchange.
I-10 MP 3.6 New Wildlife Underpass Bridge at this interchange	Road about 25′ above	Two cell concrete box culvert	Bridge Underpass	Very little traffic on these ramps, although truck drivers might rest using the ramps. Possibly a single span bridge, with some natural substrate, for bighorn to go under. But private land at this location.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-9 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
I-10 MP 4.0 New Wildlife Underpass Culvert	Road is about 5′ above	One cell concrete box culvert 3′ x 8′ x 150′	Culvert Underpass	Arch culvert for small to medium sized carnivores. Javelina tracks found. The existing culvert is diagonal across I-10, with lots of sediment. Immediate actions include clearing the culvert of sediment and excavation. The rail line is not a factor here.
I-10 MP 4.3 New Wildlife Overpass	Road is about 40′ below rock cuts	None	Overpass	First overpass location found along the east side of the corridor, and top overpass location for the east side. Cut on the south side; the north side needs fill. The railroad is not a factor.
I-10 MP 4.5 New Wildlife Overpass	Road is about 20′ below cut	None	Overpass	Best location for an overpass based on topography and engineering – high cuts above the road on the north side. Fill would be needed on the south side. The railroad is farther north from I-10 at this location as compared to other overpass locations. There appears to be a train trestle north of this area where a dirt road goes beneath the rail line. Could be the best place for wildlife to cross beneath the tracks.
I-10 MP 4.8 Retrofit Culvert		Six cell concrete box culvert - each cell 3′ x 8′ x 150′		On East – potential fence end. Out on the flats, no bighorn sheep activity. Culverts are filled with sediment and tumbleweed. Excavate and keep open for wildlife.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-10. Final project recommendations for the Sandia-Jemez Mountains wildlife corridor.

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 550 - Northwest end of linkage working from the north southeastward toward Bernalillo				
US 550 MP 15.1 Fence End			Fence end	West end of fence, tie to new wildlife overpass.
US 550 MP 15.1 New Wildlife Overpass	Road is about 15′ above landscape		Overpass	Hill cut is about 15′ on the east, 20′ on the west. Note that a buried pipeline appears to run east-west and not parallel to road. Great overpass location next to good carnivore underpass (MP 14.9) and a good north fence end.
US 550 MP 14.9 Retrofit Culvert	Road about 12′ above landscape	Five cell concrete box culvert 7′ x 10′ x 100′	Retrofit Culvert	Retrofit exiting culverts, then replace with bridge. Fence on the east side only if MP 15.1 overpass is not chosen as a project. Concrete bottom covered in sand and gravel. Remove fence blocking entrances; tie into existing structure-culvert. In a large arroyo that could act to draw animals to the structure. In the future, replace with a bridge.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-10 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 550 MP 14 – Retrofit Culvert Then New Wildlife Crossing Bridge	Road is about 15′ above landscape	Four cell concrete box culvert, 6′ x 8′ x 120′	Retrofit Culvert	Retrofit culvert, and replace with single span bridge. The wash has silted in the culverts, need to clear sediment. Remove fence blocking on the west side. Then plan for a new wildlife crossing. Replace with a single span bridge. This is a major draw/arroyo, large and open. If west fence end for a short fence project, tie fence to the existing bridge.
US 550 MP 13.6 New Wildlife Overpass	Road is about 40′ below hillside cuts		Overpass	Cuts only on the west side. Drainage on the east side likely in the way of fill, and there is no east side cut. Poor overpass location due to the east side drainage, but possible if creative. On Pueblo of Santa Ana land.
US 550 MP 12.3 New Wildlife Underpass Culvert	Road about 17′ above landscape	Three cell concrete box culvert 6′ x 5′ x 120′ each cell	Culvert Underpass	Elk, pronghorn, and mule deer have all been documented at the road edge and some have moved across US 550 here. Important for all three species, as well as black bear and cougar.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-10 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 550 MP 11.9 New Wildlife Overpass	Road is about 10′ below hillside cuts		Overpass	Hillside is 10′ above the road on the east side, 30′ above on the west side. Would need fill on east side. Decent overpass location. Another important location for the movement of mule deer, elk, pronghorn, black bear, and cougar.
US 550 MP 11.8 Retrofit Existing Bridge, Then replace with new Wildlife Underpass Bridge	Road about 7′ above landscape	Bridge with three cells, 10′ x 15′ x 100′, total width 80′	Retrofit Bridge	Retrofit existing structure, then replace with new bridge. Large wash-arroyo, open and broad. Bridge area needs clearance for large mammal passage. Heavy floods accumulate sediment. When the bridge is replaced, increase the height to accommodate the silt/sediment and wild ungulates. Suitable for smaller animals with clearing sediment and debris.
US 550 MP 9.9 New Wildlife Overpass	Road is about 30′ below cuts of landscape		Overpass	Good overpass location, not quite as good as MP 9.5 to the south, but still very good. There are many wildlife-vehicle crashes at and north and south of MP 10 as recorded by the Pueblo of Santa Ana. This is an important area for wildlife movement on Pueblo of Santa Ana land.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-10 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 550 MP 9.8 New Wildlife Underpass Bridge or Culvert	Road is about 15′ above landscape	Two cell concrete box culvert, 6′ x 8′ x 120′ each cell	Bridge Underpass	Bridge or arch culvert. Dry draw, water moves through in wetter times, fence is tied to the culvert on both sides. Replace culvert with larger culvert, arch culvert or single span bridge. There are many wildlife-vehicle crashes near MP 10, this is an important area for wildlife movement. If MP 9.9 does not receive an overpass, it would be important that this culvert is replaced with a bridge.
US 550 MP 9.5 New Wildlife Overpass	Road is about 40-50′ below landscape		Overpass	A future top-priority location for an overpass. Very high hillside cuts. Sandy soils (needs to be verified). On Pueblo of Santa Ana lands, but ultimately not prioritized, in spite of concentrations of crashes involving wildlife, as recorded by the Pueblo of Santa Ana.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-10 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 550 MP 9.2 Retrofit Existing Bridge	Road is about 100′ above landscape	Bridge 90′ x 150′ x 60′	Retrofit Bridge	Top Choice for Action Retrofit - fence to existing bridge. The most important retrofit to existing culvert and top priority for immediate action. Place wildlife exclusion fence to this bridge for about 1 mile in both directions. The bridge is very high above the surrounding landscape, plenty of room for all wildlife. Major natural draw/wash on the landscape that wildlife could follow under this bridge. It is in a high wildlife-vehicle crash area.
US 550 MP 8.9 New Wildlife Underpass Bridge	Road is about 30′ from landscape	Single cell metal culvert 4′ x 4′ x 150′	Bridge Underpass	To accommodate black bear and cougar, see polygon map above.
US 550 MP 8.6 New Wildlife Overpass	Road is about 30′ below hillside cut		Overpass	On Pueblo of Santa Ana land. Can prioritize if MP 8.3 structure does not work.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-10 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 550 MP 8.5 Retrofit Culvert	Road is about 8' from landscape	One cell concrete box culvert 5' x 5' x 120'	Retrofit Culvert	Retrofit – place wildlife exclusion fence to the culvert, trim vegetation, remove fence. Culvert could work well for carnivores, medium mammals, and possibly mule deer. Place the fence to culvert, and trim some of the vegetation so wildlife can find the culvert, and deer do not fear a high risk of predation by cougars. Pull back or remove the landowner barbed wire fence at the west entrance.
US 550 MP 8.3 New Wildlife Overpass	Road is about 15-20' below landscape		Overpass	Overpass location, good cuts on both sides, Good location for an overpass, might need some fill. On Pueblo of Santa Ana land, and the tribe supports this overpass as learned through G. Harper. Still in a high wildlife-vehicle crash zone.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-10 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
US 550 MP 8.2 New Wildlife Crossing Culvert	Road is about 17′ above landscape	Existing three cell box culvert 6′ x 8′ x 150′, total width 25′	Culvert Underpass	Retrofit - place fence, Replace with arch culvert. As a first step retrofit this culvert by bringing wildlife exclusion fence to the culvert, remove existing fence on the west side. When it is replaced with a new structure, make it an arch culvert, potentially this can be the fence end on the south side of US 550. There are a few elk collisions south of here. This is in an area where GPS data documented elk, pronghorn, mule deer, black bear, and cougar movements to the road from the north.
US 550 MP 8.2 Fence End			Fence end	East end of fence from the west.
US 550 MP 1.6 Rio Grande Bridge	Road is about 25′ above landscape	Existing large, high bridge 12′ x 1,000′ x 200′	Retrofit Bridge	Retrofit- fence off both ends. Rio Grande major narrow corridor for wildlife. Cougar tracks found and GPS data indicate cougars are using the area. In a highly developed residential and commercial area with utilities. Retrofit- clear debris out of corridor and maintain clearance. Place - ¼ mile of fence in each direction of each bridge corner. Design fence in a manner that keeps wildlife off the roadway.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-10 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
I-25 - From Bernalillo in the South to the North				
I-25 MP 244 South Fence End			Fence end	South fence end, to extend all the way to MP 263. Not the best location, just recorded as a possibility, future field reconnaissance will be needed to set best location.
I-25 MP 245 New Wildlife Overpass	Road is about 25′ below cuts	None	Overpass	Overpass could be placed using cuts on both sides. West side has less to work with and is more steeply sloped on the back side. Cougar and black bear have been recorded killed by vehicles here. However, there is another road right behind the cut.
I-25 MP 245.1 New Wildlife Underpass Culvert	Road is about 20′ above landscape	Single cell corrugated metal culvert 8′ x 6′ 200′	Culvert Underpass	Underpass – Arch culvert or bridge. Box culvert has an atrium, with two corrugated metal pipes like chimneys going up to the surface, so there is minimal light coming in. Not a high priority, but when culvert is replaced, there is enough overhead fill to place a larger arch culvert.

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White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-10 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
I-25 MP 246.5 New Wildlife Underpass Bridge	Road is about 30’ above landscape	Three cell box culvert 12’ x 15’ x 200’	Bridge Underpass	Replace box culverts with single span bridge(s), Flash flood area. First retrofit with fence, and add an atrium in the median of the highway to let in light. 200’ is too long for most mule deer to use, but this could provide some very limited connectivity for a few individual animals. Coyote tracks and historical mule deer and elk use. Black bear and cougar recorded killed near MP 245, and NMDOT crash data indicate mule deer killed here. In one of the top priority smaller corridors for movement. Replace culvert with bridge as soon as possible. On Tribal land, Las Huertas Creek.
I-25 MP 252.5 Retrofit Bridges	Road is about 20’ above landscape	Four Existing bridges (two for I-25, two for service roads). Each with about 4 cells between support columns. Each cell about 150’ wide. Height = 12’. Total Combined width of bridge = 300’	Retrofit Bridge	Retrofit with wildlife fence, major arroyo. Multiple bridges for I-25 and service roads. Horse and cattle use this area under bridges. Coyote tracks. Place wildlife exclusion fence at both ends of this bridge to guide wildlife to it, if there is not a long fence project along I-25 already.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends,
White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-10 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
I-25 MP 254.5 Retrofit Bridges	Road is about 20′ above landscape	Existing two bridges, 12′ x 40′ per cell, two cells between columns in each bridge, 40′ length under bridge, 150′ to pass beneath both	Retrofit Bridge	Retrofit with wildlife fence. Tie in wildlife fence. Some elk may occur or occurred historically in the area. Area used by horses. Good sized arroyo that would draw animals to the bridge.
I-25 MP 258 Wildlife Overpass	Road is about 20′ below landscape		Overpass	Good cut banks, Cut is about 20′ above on the west, 40′ above on the east side. Some residential development. Private land, presents limitations.
I-25 MP 258.5 Wildlife Overpass	Road is about 12′ below landscape		Overpass	**The number one pronghorn overpass over I-25**. Pronghorn documented on north side of I-25. The road has heavy traffic but little human development. Could build an overpass using existing cut banks, would likely have to build up sides to meet interstate clearance requirements. Tribal land.

Blue rows = new overpasses, Pink rows = new bridges, Orange rows = new culverts, Yellow rows = retrofit existing structure and fence ends, White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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Table E-10 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
I-25 MP 259.5 Wildlife Overpass at NM 22 Interchange	Road is about 17′ below cut		Overpass	Overpass along either side of the intersection with SR 22. It would need to get animals to either cross NM 22, then over I-25 or get them around existing gas station and across I-25. If it is to the west side of NM 22, then would have to use fencing to direct animals away from the gas station. If on the east of NM 22, then it would have to get animals across NM 22 (animal detection system plus cattle guards are possible) and then to overpass. Not a top choice but just recorded as a possibility. See notes for MP 258.5.
I-25 MP 263.1 Retrofit Existing Galisteo Creek Bridge	Road is about 100′ above landscape	Existing bridge 90′x 200′ per cell x 400′. Total width of bridge across bosque is 600′.	Retrofit Bridge	Retrofit - tie in wildlife fence. Canid and possibly deer tracks present. Elk droppings also found. Arroyo. If not a long fence project present, add at least wing fences to this bridge.

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Table E-10 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
I-25 Fence End MP 263.1			Fence end	North Fence end, extends down to MP 244. Place either wing fence or tie in fence from the south to this existing bridge, which can be utilized by wildlife as is. This is a good fence end location but far from other observed structures. Field team did not inspect anything east of here. Further research could be conducted in surrounding area, if warranted.

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Table E-11. Final project recommendations for the Questa wildlife corridor.

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
NM 38 MP 1.3 Animal Detection Driver Warning System			Animal Activated Detection Driver Warning System	Place a fence end at MP 1.3. Aim the detectors down the fenced area, and flash signs several hundred feet before MP 1.3. Include electric pavement at the fence end to keep wildlife from moving around the fence and into the fenced right-of-way.
NM 38 MP 1.3 Fence End			Fence end	Potential fence end. May be an attractant for wildlife to cross the road and access water at this lake and park area. Could end the fence at the western edge of Eagle Rock Lake.
NM 38 MP 2.7 New Wildlife Overpass	Road is about 30′ below landscape		Overpass	Decent cut slope on one side. Possible disturbance: trail parking lot. Number one choice for an overpass in this corridor. Bighorn sheep have been killed in crashes to the west near MP 2. This would be an important alternative route for them to cross the highway.
NM 38 MP 4.6 New Wildlife Overpass	Road is about 15′ below landscape		Overpass	Only a few options for overpasses where there is enough space on either side of the road. Some form of cut slope would have to be built up here. This area has the Questa Mine to the north side. Mule deer and elk have been killed nearby.

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Table E-11 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
NM 38 MP 4.8 Retrofit Culvert	Road is about 6′ above landscape	Two cell concrete box culvert, 6′ x 20′ x 40′ each	Retrofit Culvert	Water underneath, making passage at this location probably not feasible for most wildlife. Retrofit would be to place wildlife exclusion fence to this culvert from both ends. Initially only wing fence.
NM 38 MP 5.2 New Wildlife Overpass	Road is about 30′ below landscape		Overpass	Good bighorn sheep habitat to the north, rocky. Mouth of Columbine Canyon, a wildlife corridor. Good escape terrain to the north, cut slope on the south. Lots of utilities including slurry pipeline.
NM 38 MP 5.3 Retrofit Culvert	Road is about 10′ above landscape	Two cell concrete box culvert, 5′ x 12′ x 40′ each	Retrofit Culvert	Slurry pipeline in the culvert, and water is present across the full width. Culvert too low and narrow for bighorn sheep or other ungulates. Any fence would only lead smaller animals under pipelines in the culvert. Retrofitting would involve the placement of wildlife exclusion fence to this culvert from both ends. Initially only wing fence.
NM 38 MP 6.8 New Wildlife Overpass	Road is about 40′ below landscape		Overpass	Mine tailing piles immediately to the north, potentially unstable. River ~100′ to the south. In the zone where bighorn sheep are found.

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Table E-11 (cont.)

Site/Milepost/ Recommendation	Type of Area	Approximate Dimensions of Existing Infrastructure (Height x Width x Length)	Type of Mitigation Recommended	Comments
NM 38 MP 7.8 New Wildlife Overpass	Road is about 50′ below landscape		Overpass	Overpass location but would need to also span the river. The most eastern bighorn sheep crash occurred near MP 6.8, west of here. This would be the most eastern overpass location for bighorn sheep based on crash data.
NM 38 MP 8.8 New Wildlife Underpass Bridge	Road is about 50′ above landscape	One cell concrete box culvert, 8′ x 8′ x 40′	Bridge Underpass	Replace with bridge. Should be a bridge to meet drainage needs, current culvert is undersized for flow. A new bridge would restore aquatic and terrestrial connectivity and hydrologic processes in the stream. It would not be for bighorn, but for other mammals, large and smaller. If the fence extends this far east, then this is an important structure for all wildlife.
NM 38 MP 9.0 Fence End	Drainage	One cell corrugated metal pipe, unknown size	Fence end	Fence to the existing small culvert. No easy retrofit or replacement potential.
NM 38 MP 9.0 Animal Activated Detection Driver Warning System			Animal Activated Detection Driver Warning System	Place the animal detection system on the east side of the fence end at MP 9. Aim the detectors down the fenced area, and flash signs several hundred feet before MP 9. Include electric pavement at the fence end to keep wildlife from moving around the fence and into the fenced right of way. The technology may not be ready for this in 2021, so a later stage priority.

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White rows = suggested changes that were not prioritized or potential causes of wildlife crashes

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