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Wildlife Crossing Over Route 101 and the Benefits and Challenges it Presents

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Wildlife Crossing Over Route 101 and the Benefits and Challenges it Presents

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Civil and Environmental Engineering

by

Sheik Moinuddin

2021

ABSTRACT OF THE DISSERTATION

Wildlife Crossing Over Route 101
and the Benefits and Challenges it Presents

by

Sheik Moinuddin

Doctor of Philosophy in Civil and Environmental Engineering

University of California, Los Angeles, 2021

Professor Michael K. Stenstrom, Chair

Biodiversity across the world is in decline due to population increases as well as urban development. Subsequently, fragmentations of the landscape and habitat loss are occurring. Globally, only twenty-one biodiversity hotspots remain, and nowhere is the risk more severe than in Southern California. In countering these threats, it has become necessary to connect all available open lands in Southern California to create a network for wildlife movement. Such an interconnected set of reserves will allow natural ecological processes to continue and thrive, as they have for centuries. Thus, researchers in the field identified the Santa Monica – Sierra Madre Connection as the highest priority linkages to conserve, which would provide miles of roaming ground to a wide variety of animals, ranging from shrews to mountain lions. Mammals, especially mountain lions, require a large area for hunting and to thrive genetically.

However, this once-contiguous mountain range stretching from Santa Monica to

Sierra Madre was severed in the early 1970s by the construction of the US-101 Freeway, dividing the habitat range into isolated habitat fragments and severely restricting movement for many wildlife species, including mountain lions, bobcats, gray foxes, coyotes, and mule deer, between the two mountain ranges. For mountain lions in particular, this restriction has led to increased inbreeding, territorial fighting, and very low genetic diversity. Research conducted by the National Park Service since 2002 has demonstrated that because of a fragmented landscape, mountain lions could face extinction in the Santa Monica Mountains within fifty years, with a median of fifteen years.

Therefore, researchers analyzed several locations and investigated probable alternatives and recommended the development of a vegetated bridge over US-101, near Liberty Canyon Road, in the City of Agoura Hills, which would both provide the best location in the region for improving connectivity and serve the broadest range of species.

Once built, this bridge would be the largest wildlife crossing of its kind in the world and the first to attempt a large-scale intervention for wildlife in an urban area with over twenty million people—and over a roadway carrying over three hundred thousand vehicles per day. This project will set a model worldwide for urban wildlife conservation and help inform future efforts. It has renewed the urgency to keep our wildlife from going extinct because of urban development and demonstrates that animals and humans can coexist.

The dissertation of Sheik Moinuddin is approved.

Jennifer A. Jay

Sanjay K. Mohanty

I.H. Suffet

Michael K. Stenstrom, Chair

University of California, Los Angeles

2021

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Sheik Moinuddin

Summer 2021

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- Dynamic lane project was published in LA Times (front page) in July, 2009.
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CHAPTER 1

1. INTRODUCTION

There are only thirty-six different recognized biodiversity hotspots in the world, six of which are in the United States. Three out of the six biodiversity hotspots in the United States are in California: South Coast Ecoregion, San Francisco Bay Area, and Death Valley (along with Hawaii, Southern Appalachians, and the Florida Panhandle).

Among the threatened and endangered species in the continental United States, ranging from plants and invertebrates to birds, mammals, fish, amphibians, and reptiles, California has the largest number, with over 400 species considered at risk or endangered.

Figure 1-1: Biodiversity Hotspots in California

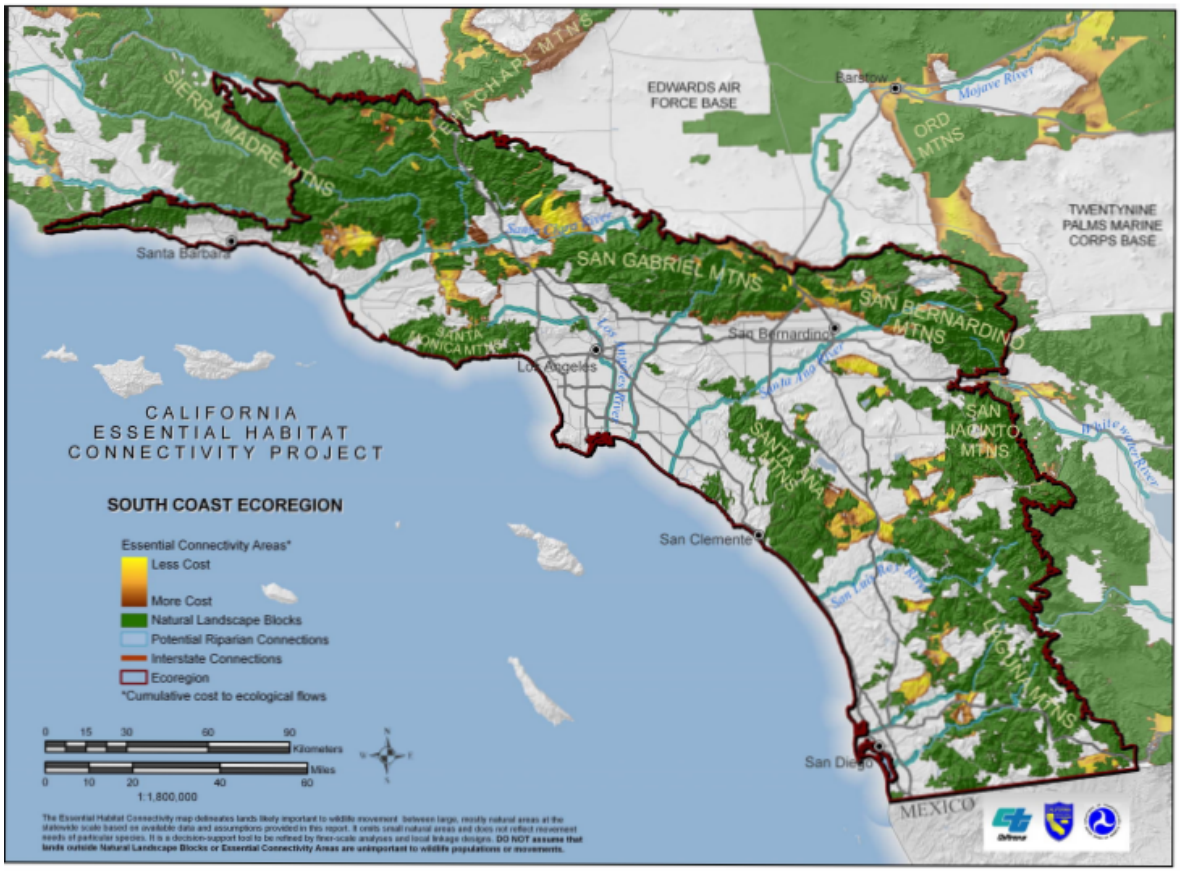


Figure 1-2: South Coast Ecoregion

Among the California hotspots, the South Coast Ecoregion is the most threatened hotspot of biodiversity in California—and in the United States (State of California, Natural Resources Agency, 2021).

In order to remedy this, the South Coast Wildlands initiated a study called the South Coast Missing Linkages project, which identified several unlinked conservation lands (national and state parks, national forests, and private lands) within the South Coast Ecoregion. If linked, these areas would create a vast, uninterrupted land of over 18 million acres for wildlife to roam (South Coast Wildlands, 2008)—its boundaries being the Sierra

Nevada to the north, Baja California to the south, Camp Pendleton to the west, and Anza-Borrego Desert State Park to the east (South Coast Wildlands, 2008). This project has been widely considered to be a critical wildlife conservation strategy for Southern California.

Figure 1-3: Missing Linkages (South Coast Missing Linkages: A Wildland Network for the South Coast Ecoregion, 2008)

The South Coast Missing Linkages project has identified the Santa Monica – Sierra Madre Connection as the most crucial linkage to conserve because of its varied wildlife presence, land use pressure, and climate change (South Coast Missing Linkages, 2008). Another study called The California Essential Habitat Connectivity Project, commissioned by Caltrans, the California Department of Fish and Wildlife, and the Federal Highways Administration (California Department of Transportation & California Department of Fish

and Game, 2010), has also recommended restoring this linkage. Once this occurs, the linkage would connect the Santa Monica Mountains at the coast to the south to the Santa Susana Mountains' jagged peaks and the Sierra Madre Ranges (Los Padres National Forest) to the north. The Santa Monica – Sierra Madre linkage is also regarded as one of the few coastal-to-inland connections remaining in the South Coast Ecoregion.

The Santa Monica Mountains, with their lush green valleys, rugged coastlines, and mountain peaks ranging from 1,000 to 3,000 feet, spans over 153,000 acres and extends approximately 40 miles from the west to the east. Point Mugu borders it to the northwest and Griffith Park to the east. Santa Monica Bay borders the southern end of this mountain range (National Park Service, 2002).

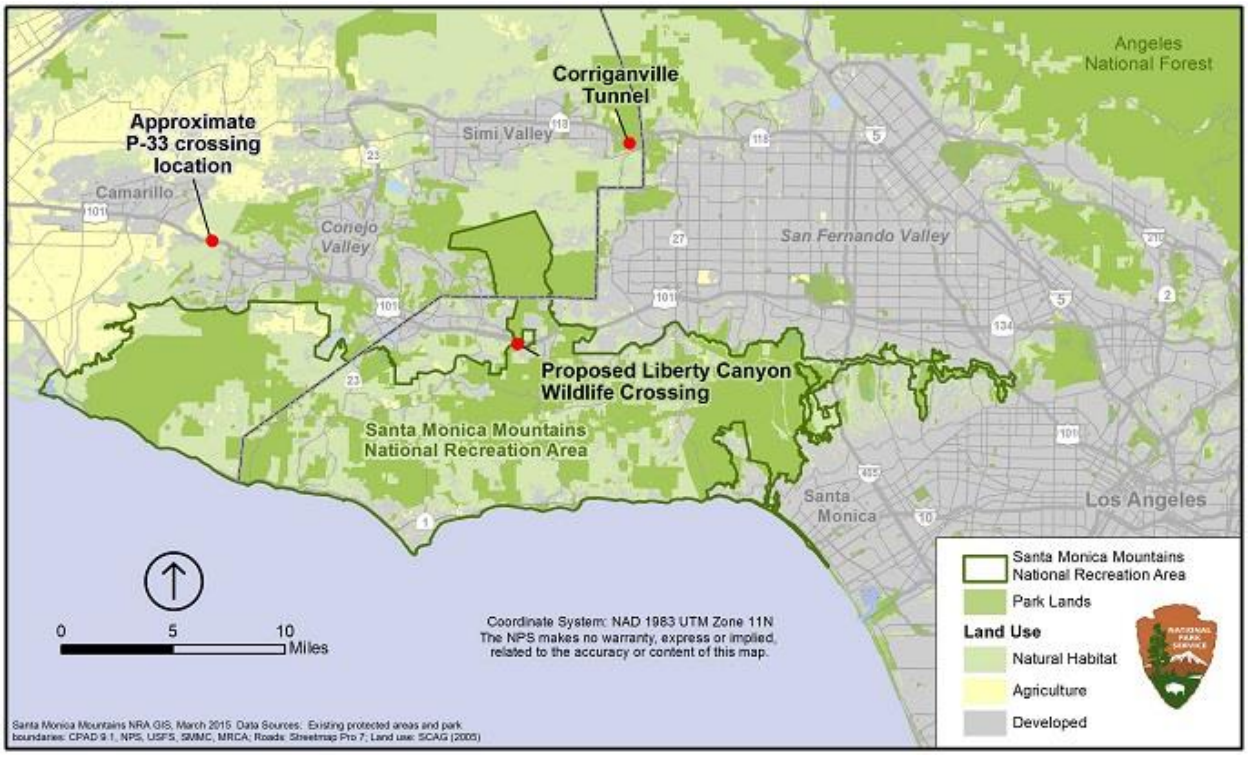


Figure 1-4: Santa Monica Mountains National Recreation Area (Courtesy: National Park Service)

The Santa Monica Mountains are among the most bio-diverse hotspots in California. It has over 45 different mammal species among other wildlife populations, and they range from shrews to mountain lions. The shrews typically weigh less than an ounce, while mountain lions weigh approximately 150 pounds (National Park Service, 2002). Other smaller mammal species include rats, rabbits, gophers, mice, squirrels, bats, and moles. These smaller mammals are an essential part of this ecosystem as they eat insects, disperse seeds, and till soils. They are also the food source for other mammalian carnivores, reptiles, and raptors.

Mammals usually define their home range as an area in which they look for food, hunt, and breed. They generally chase away same-sex species from their territories. However, as urban sprawl continues, their home ranges are shrinking and becoming fragmented, which poses a severe threat to the survival of these mammals, as they have less room to hunt and breed. This threat is especially formidable for large carnivores such as mountain lions, which are finding it more challenging to find suitable home ranges. Roadways, especially extensive highways, also contribute to this problem. They fragment the already decreasing habitats, and sometimes create an impenetrable barrier to wildlife movement.

As Seiler (2003) shows in Figure 1-5, highways that carry between 2,500 and 10,000 vehicles per day present a deadly obstacle to wildlife movement, and highways with over 10,000 vehicles per day present a total barrier for wildlife movement.

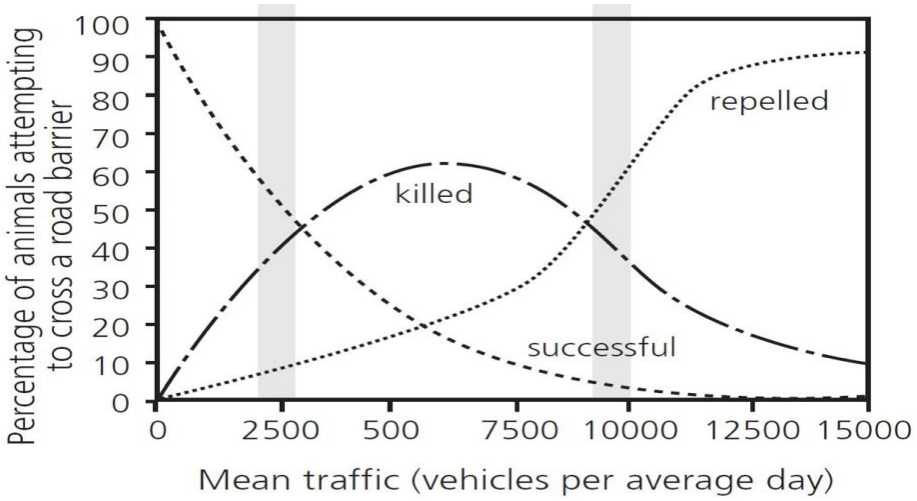


Figure 1-5: Effects of Roadways on Wildlife (Andreas Seiler, 2003)

Further, research conducted by UC Davis's Road Ecology Center shows an alarming number of accidents involving wildlife between 2015 and 2016 in California. Nationally, over 5% of all accidents involve wildlife, which costs US residents nearly $8.4 billion (Shilling, 2018).

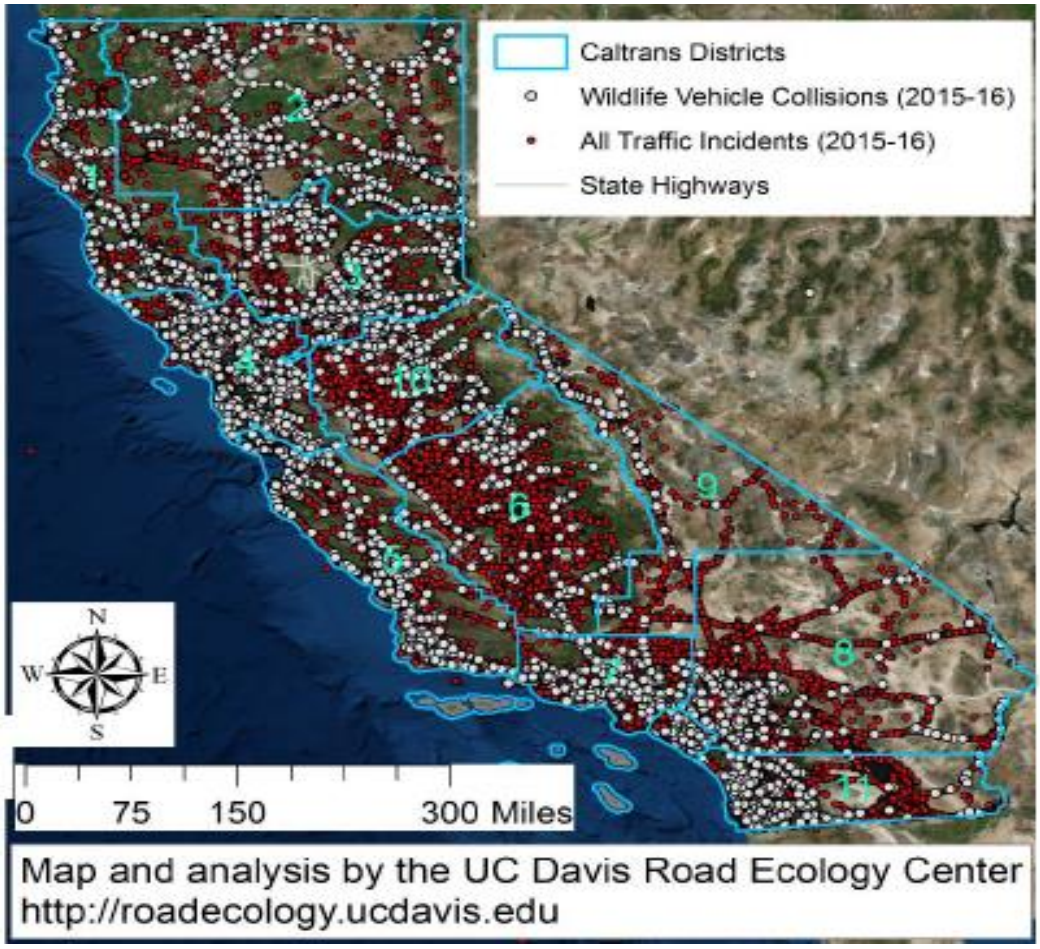


Figure 1-6: Wildlife-Vehicle Collisions (2015–2016)

The Santa Monica Mountains, once a contiguous mountain range and thriving ground for mammals such as mountain lions, bobcats, gray foxes, and mule deer, were fragmented when the US-101 highway was built in the 1970s. This freeway runs mostly north-south in California and became a heavily traveled commuter route between Los

Angeles and Ventura Counties. Near the City of Agoura Hills, US-101 is an eight-lane Freeway that runs east-west. US-101 traverses the City of Agoura Hills, thus separating the once-contiguous mountain ranges into the Santa Monica Mountains to the south from the Simi Hills and the Santa Susana Mountains to the north. At this location, US-101 is 210 feet wide, with four lanes in each direction and carrying over 300,000 vehicles per day (Caltrans, 2016). The freeway has become an impenetrable barrier between those two mountain ranges and severely restricts movement for larger mammal species, including mountain lions, gray foxes, coyotes, bobcats, and mule deer. These mammals, especially mountain lions, need an extensive home range to hunt and breed to survive and thrive. Smaller home ranges and restricted movement result in increased inbreeding, territorial fighting, and very low genetic diversity (Benson, 2016).

Since 1996, researchers from various organizations, including the National Park Services (NPS), have studied regional wildlife connectivity within the Santa Monica Mountain National Recreational Area (SMMRA) (National Park Service, 2002). From an evaluation of the linkage between the Santa Monica Mountains and the Sierra Madre Range, experts determined that the presence of a wildlife crossing is critical, as it represents one of the few remaining Southern Californian connections between the coastline and inland habitats (South Coast Wildlands, 2008). This evaluation also emphasized the need to sustain developmental and ecological processes in California's South Coast and Ecoregion by maintaining and enhancing this crucial linkage. Data collected and published by the NPS concerning carnivore movement over a decade only reinforce the significance of developing a linkage to preserve Santa Monica Mountain wildlife populations (National Park Service, 2002).

To preserve a viable mountain lion population, the NPS has concluded from analyzing genetics and tracking home range sizes that developing systems of wildlife connectivity in the Simi Hills, Santa Susana Mountains, and the larger ecosystem of the Sierra Madre Range is imperative. Analysis of the mountain lions in the Santa Monica Mountains has found that the lack of connections has led to the lowest level of genetic diversity in California and, indeed, in the Western United States (National Park Service, 2002). Mountain lions are also not particularly skilled at crossing highways, especially those with wide roads and heavy traffic, making roadkill another leading factor in the declining mountain lion population (Shilling, 2008).

According to National Park Service Data, providing connectivity is essential for local species other than mountain lions. Data have shown that, since the freeway was built, bobcats and coyotes have also exhibited significant genetic effects. Likewise, smaller species such as lizards and birds have been affected by habitat fragmentation primarily caused by roads and urban development (National Park Service, 2002). Movement between remaining areas of natural habitat in the Santa Monica Mountains has become severely restricted, and without a safe and sustainable wildlife crossing, many species are essentially trapped.

To assess the possibility of a linkage across US-101, multiple sites along a stretch of US-101 were evaluated. Eventually, experts working in the field of wildlife movement concluded that the Liberty Canyon area was the optimal location for such a project and a viable solution for a safe and sustainable wildlife crossing across US-101. Both sides of the freeway are already protected lands for the wildlife. If connected, the link would create a vast, contiguous swath of protected habitat from the Santa Monica Mountains to the south and the Sierra Madre Mountain Range to the north (Riley, 2018).

Several construction alternatives were analyzed, including tunnels as well as a bridge crossing US-101. Scientists argued that a narrow tunnel might not be effective, as animals are reluctant to pass through a narrow unvegetated tunnel. A wider tunnel may be more conducive to the animal movement (Spencer, 2010); however, it was not considered feasible due to constructability considerations and high traffic impact. A large tunnel would require using the cut-and-cover technique and the closure of US-101, one of the region's busiest freeways, for an extended period. Therefore, it was proposed to build a vegetated bridge across US-101, west of Liberty Canyon Road, and a tunnel over Agoura Road, south of US-101.

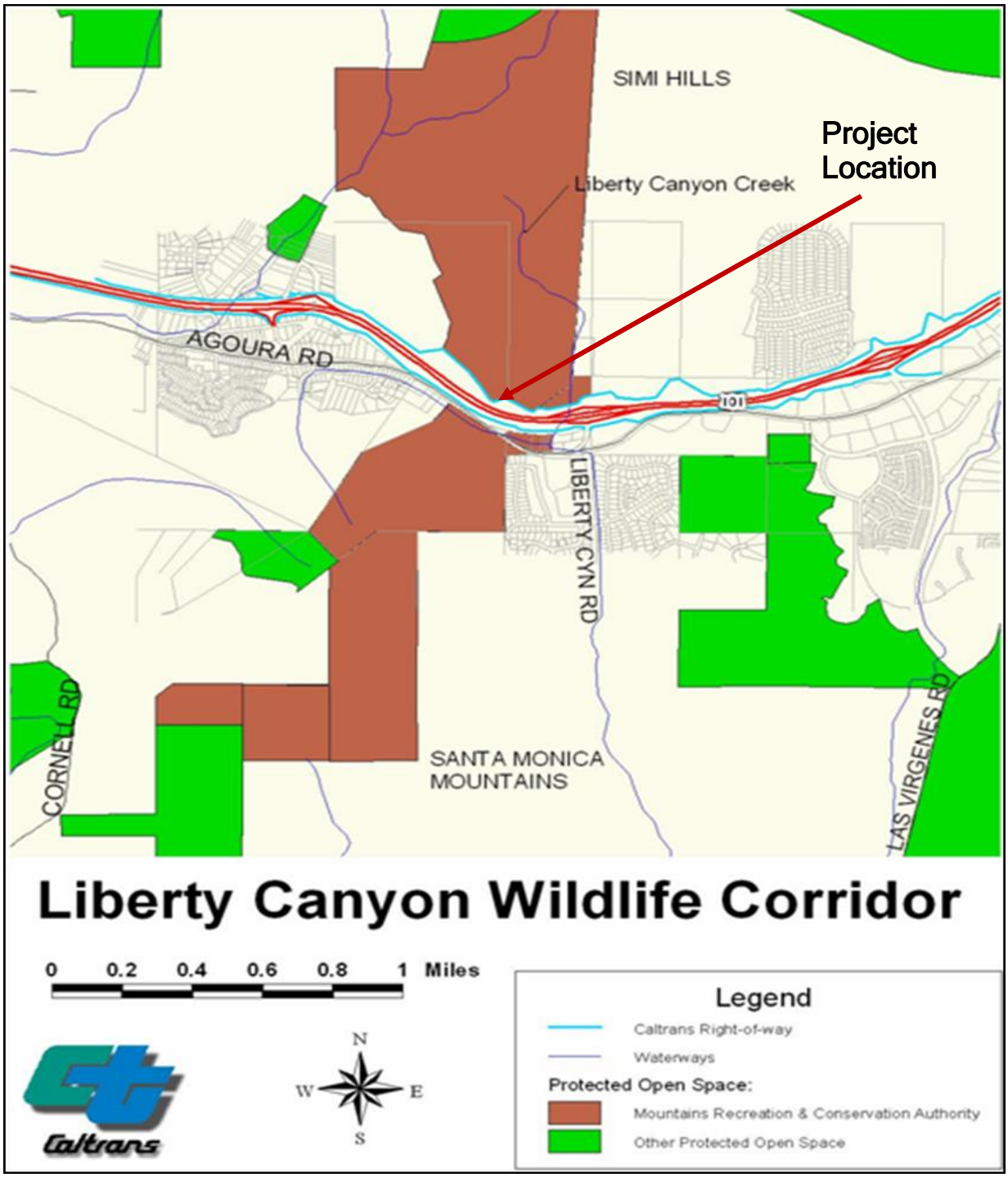


Figure 1-7: Project Location

The scope of the work includes:

• Construct a two-span, 165-foot-wide by 216-foot-long bridge with columns on spread footings in the US-101 Freeway median. Construct retaining and sound walls at both the north and south end of the bridge and sound walls along the outer edges of the bridge to mitigate traffic noise and light to make navigating more conducive to wildlife crossing. Plant native vegetation on the bridge to provide a passage that resembles the natural extension of the wildlife habitat.

• Construct a tunnel over Agoura Road. Fill and grade the area between the bridge (US-101) and the tunnel (Agoura Road) to provide a continuous grade, allowing the wildlife crossing to extend over Agoura Road before descending to join the existing ground near the creek.

Figure 1-8: Architectural Rendering of the Bridge and the Tunnel

Figure 1-9: Architectural Rendering of the Vegetation over the Bridge

The project is in the final design stage and anticipated to break ground in Winter 2022. Overall, the project would have a positive impact on wildlife corridors. The proposed project can facilitate safe and sustainable wildlife passage across US-101 for all target species and other wildlife species living within these mountain ranges. This project will reduce wildlife mortality as it will mitigate wildlife crossing the highway, facilitate animal movement across habitats, and allow for a greater exchange of genetic material of large mammals such as mountain lions and bobcats whose populations have been adversely affected due to urban development and habitat loss/fragmentation between the Sierra Madre Mountain Range and the Santa Monica Mountains. These mountains have been almost completely isolated from other natural areas due to urban sprawl and agricultural lands, resulting in even further habitat loss/fragmentation,

according to the SMMRA General Management Plan. Connectivity is vital to the survival of wildlife species affected by habitat fragmentation. This damage will only be aggravated as climate change further impacts species distribution patterns.

This dissertation aims to draw attention to the how housing development, freeways, and malls are rapidly diminishing the wildlands around us and how this transformation is impacting the wildlife population. It describes how other countries are tackling this issue and what solutions are being discussed for this location. Finally, the dissertation documents the decision to use a vegetated bridge over US-101 Freeway.

CHAPTER 2

2. REVIEW OF OTHER WILDLIFE CROSSINGS

Wildlife crossings have become a widespread practice in habitat conservation, as they allow for the conjunction or reconnection of habitats and ecosystems subjected to the ever-growing problem of habitat fragmentation. These crossings are also vital to preventing animal and vehicle collisions, which result in property damage and potential injury to wildlife and humans.

Wildlife crossings are usually structures that help animals safely cross human-made barriers. They include but are not limited to tunnels and culverts (for fish as well for small mammals such as otters, hedgehogs, and badgers), viaducts, overpasses, or green bridges (mainly for large or herd-type animals), fish ladders, canopy bridges (especially for monkeys and squirrels), and green roofs (for butterflies and birds).

The first known use of wildlife crossings dates back to seventeenth-century France, where locals used bundles of branches to create a rough fish ladder that helped fish freely navigate steep channels and bypass human-made obstructions. This concept was later transformed by Richard McFarlan of New Brunswick, Canada, in 1837. He designed a separate fishway to bypass a dam in his water-powered lumber mill (Mario, 2001). As the world became more industrially advanced, many other countries, including the United States, began to adopt these fish bypasses. They soon became common practice. In 1880, Rhode Island, United States, built the first fish ladder, on the Pawtuxet Falls Dam (Office of Technology Assessment, Washington DC, 1995).

During the 1950s, France and other European countries started building overland wildlife crossings to reduce conflicts between wildlife and roads. These overland crossings, which include a variety of different overpasses and underpasses, are an effort

to re-establish many threatened species such as small mammals, invertebrates, badgers, and amphibians (Chilson, 2003). Other countries, including the United States and Canada, have also started focusing on these overland crossings as effective measures for reducing vehicle-wildlife collisions and providing wildlife with significant and connected habitats for roaming, hunting, and breeding.

Ecoducts in the Netherlands:

The most successful case of wildlife crossings in Europe is in the Netherlands. The construction of over 600 tunnels in both major and minor roads has significantly increased the population of the endangered European badger (twistedsifter, 2012). The Netherlands has over 66 crossings (overpasses and viaducts), which target the conservation of the European badger and other native species such as the roe deer, red deer, and wild boar.

A leader in wildlife preservation, the Veluwe is the largest lowland nature area in North-Western Europe. As of 2012, the Veluwe contained nine viaducts (called “ecoducts,” due to the presence of turf and foliage) to help wildlife to cross highways. The first two ecoducts were introduced in 1988 when the A50 highway was first built. Five of the other ecoducts in Veluwe were built on existing highways. The ecoducts along the A50 have proven to be the most effective, with nearly 5,000 dear and wild boars using it during one year in 2012 (Bank et al. 2012). The Netherlands is also home to the world's longest ecoduct-wildlife overpass, the Natuurbrug Zanderij Crailoo (Danby, 2004).

Figure 2-1: Natuurburg Zanderij Crailoo Ecoduct in the Netherlands (atlasobscura.com)

At the cost of 14.7 million Euros, the ecoduct was completed in 2006. About 2,600 feet long and 165 feet wide, ecoduct is built across a railway line, business park, roadway, sports complex, and a river. This ecoduct has been closely monitored to determine the effectiveness of such a massive project regarding wildlife conservation and its impacts on urban development.

Slaty Creek Wildlife Underpass, Calder Freeway, Black Forest, Australia:

Another important wildlife crossing is located in the Black Forest in Victoria, Australia, an underpass that aims to mitigate the effects of the Calder Freeway on native wildlife. The Slaty Creek underpass is located at the Black Forest Section of the Calder Freeway and was built by the Victorian Government Roads Corporation at $3 million (AU)

in 1997 (Abson & Laurence 2003). This underpass is approximately 230 feet wide and crosses two bridges carrying traffic in both directions. It is about 330 feet long, connecting habitats separated by the Calder Freeway bridge piers (Abson & Laurence 2003). After construction ended, the underpass was closely monitored using 14 different techniques over 12 months (Abson & Laurence 2003). During this time, 79 out of 116 of the species in the Black Forest were detected in this underpass, including kangaroos, gliders, reptiles, birds, bats, koalas, wombats, reptiles, and many other species (Abson & Laurence 2003).

Figure 2-2: The Salty Creek Wildlife Underpass (Abson & Laurence 2003).

Crab Bridge at Christmas Island National Park, Australia

Animals like the kangaroo, elk, and koalas are not the only species that get safe passage in Australia. A bridge was built for the protected movement of red crabs on Christmas Island National Park as well. Each year, between October and January, between 40 and 50 million red crabs from all over the island head to the ocean to mate

and lay their eggs in the ocean. During this time, traffic and the roadways through the park become an impediment to their journey due to the presence of hundreds of people from around the world to see this spectacle. They have to cross several busy roadways before reaching the ocean and frequently get crushed by vehicles.

Figure 2-3: Crab Crossing at Christmas Island National Park in Australia (parksaustralia.gov.au)

In response, the park authority built a 16-foot-high bridge across the highway, scalable by the crabs, to make their journey over the highway safer. Miles of plastic barriers were also installed to funnel these tiny creatures to 31 underpasses as well as to this overpass (Debczak, 2020).

Wildlife Overpasses at Banff National Park in Alberta, Canada

Banff National Park is the home to a thriving ecosystem. It hosts about 3.5 million visitors a year, with an additional 4.5 million drivers who drive through the park using the Trans-Canada Highway (Park Canada, 2017); thus, vehicle collisions possess a significant threat to the wildlife in the area.

Figure 2-4: Banff National Park Wildlife Crossing (Canadiangeographic.ca)

To remedy this problem, Banff has installed extensive fencing to discourage animals from crossing the highway. Highway fencing has reduced wildlife-vehicle collisions by more than 80%. Collision involving elk and deer have been reduced by more than 96% (Parks

Canada, 2017). Since 1996, Banff has constructed six wildlife overpasses and 38 underpasses; 24 were built during a road improvement project in 1978 (Clevenger, 2007). Parks Canada have recorded, between 1996 and 2012, that eleven species of large mammals used wildlife crossings more than 150,000 times (Parks Canada, 2017).

In recent years, wildlife crossings have also started to gain traction in the United States, partly because of the increasing number of animal-vehicle collisions. Over 5% of all roadway accidents involve wildlife, which costs US residents nearly $8.4 billion per year (Shilling, 2018). On a yearly average, about 200 human fatalities and well over 26,000 injuries occur in the United States—and thousands of cases are unreported (Westerpriorities.org, 2020). Over the last 30 years, thousands of wildlife crossings, mostly culverts and under crossings, have been constructed across the United States to assist in the conservation of wildlife including Montana mountain goats, California desert tortoises, Colorado bighorn sheep, and endangered Florida panthers (Chilson 2003).

Wildlife Crossings at Collier and Lee Counties in Florida

Florida panthers are at-risk animals. Before 2000, four or fewer panthers would get killed on the roadways every year. However, since 2000, that number has increased to about 34 annually. To cope with the dwindling number of Florida panthers, the Florida Fish and Wildlife Conservation Commission (FWC), in 1972, decided to construct Florida's first wildlife crossing in Collier County, over I-75. Since then, by the early 1990s, twenty-four highway underpasses, ranging in size from 5-feet tall by 10-feet wide to 8-feet tall by 120-feet wide were constructed; and 12 bridges were modified, along a 40 mile stretch on I-75 in Collier and Lee counties (Florida Fish and Wildlife Conservation Commission, 2021). These crossings were explicitly built to target the conservation of

the endangered Florida panther.

Figure 2-5: Under crossings on I-75 (Florida Fish and Wildlife Conservation Commission)

This panther is particularly prone to vehicle collisions. National Wildlife Federation (2020) reported that an estimated 120 to130 panthers are left in the wild North American territories, putting them on the list of most endangered species in North America.

Along with the above underpasses and bridges, the FWC has used various other tactics, with crossings and fences being the most effective (Scott, 2007). Since 2007, no additional panthers have been killed in areas where wildlife crossings and fences have been implemented. The underpasses on I-75 targeted toward these panthers have also been proven to benefit raccoons and deer (Foster & Humphrey, 1995).

Snoqualmie Pass in the State of Washington

Washington State is one of the latest State to participate in the construction of wildlife crossings. Its first wildlife bridge started in 2015 at the cost of $6.2 million, east of the Snoqualmie Pass, over Interstate 90, which runs from Seattle to Boston. The bridge was only a basic set of arches then, with native plants to be planted later; however, several species, including deer and coyotes, were already using it (Vartan, S., 2019).

Figure 2-6: Wildlife Bridge over I-90, East of Snoqualmie Pass (Google)

Alongside six other underpasses built since 2013, these crossings are only the first few planned to be a set of 20 along a 15-mile stretch along I-90 (Vartan, S., 2019). Once a near-impenetrable barrier for the wildlife, these passes will allow black bears, mountain lions, elk, and even stoat to traverse.

These wildlife crossings are not just for individual species but rather for species survival. The I-90, an economically crucial east-west lifeline in the Washington State, when built, fragmented the once-contiguous wildlife habitat. Wildlife, especially on the south side of the highway, got trapped between the highway and the Columbia River to farther south, creating an array of biological complications, including inbreeding (Vartan, 2019).

Wildlife Underpasses in Southern California:

Wildlife crossings have also been vital in protecting and preserving the biodiversity of Southern California. For example, Childon (2003) explained that the construction and implementation of the underpasses in San Bernardino County may have decreased tortoise deaths caused by vehicle collisions by about 93% within the first four years after construction. As seen in San Bernardino County, even makeshift wildlife crossings such as storm drainage culverts have proved effective in protecting threatened species (Chilson, 2003). Additional studies by Haas (2000) and Lyren (2001) have shown that the construction of underpasses in the Riverside, Orange, and Los Angeles counties are all frequented by a variety of animals, including coyotes, bobcats, the gray fox, long-tailed weasels, and mule deer.

Figure 2-7: Harbor Boulevard Wildlife Underpass

(Puente Hills Habitat Preservation Authority)

Los Angeles County's first wildlife underpass was built in 1990 at Harbor Boulevard in partnership between Los Angeles County, California State Parks, and the Puente Hills Habitat Preservation Authority (Puente Hills Habitat Preservation Authority, 2013).

Wildlife crossings come in all different forms, ranging from tunnels and culverts to canopy bridges. The benefits of these crossings have been well documented in the literature. Table 2-1 shows some of the significant crossings from around the world and their usefulness to animal diversity.

Table 2-1

Various Wildlife Crossings and the Species They Serve

Wildlife Crossings	Description and Location	Targeted Species
Natuurbrug Zanderij Crailoo	Vegetated bridge in Netherland	European badger, roe deer, red deer, and wild boar
Slaty Creek wildlife underpass	Underpass in Victoria, Australia	Kangaroos, gliders, reptiles, birds, bats, koalas, wombats, and reptiles
Crab-bridge at Christmas Island National Park	Bridge scalable to crabs, Christmas Island, Australia	Red crabs
Wildlife overpass	Vegetated bridge, Banff National Park, Canada	the red fox, hoary marmot, boreal toads, wolverines, lynx, garter snakes, and beavers
Wildlife underpasses and overpasses	Collier and Lee counties, Florida	Florida panther, raccoons, and deer
Snoqualmie Pass	Overpass over I-90, State of Washington	Black bears, mountain lions, elk, and stoat
Underpasses	Riverside, San Bernardino, Orange and Los Angeles County, California	Tortoise, coyotes, bobcats, gray fox, long-tailed weasels, and mule deer

As discussed in the previous chapter, wildlife—especially large mammals such as mountain lions, bobcats, mule deer, and bears—needs a large swath of land, known as a home range, for hunting and breeding. As the human population increases, so too do industrial and urban developments. More and more wildlife habitats are being used for urban development and agricultural land. The roadways are fragmenting the remaining habitats.

Small patches of fragmented habitat pose several problems to the wildlife. Smaller habitats are susceptible to natural calamities such as fire and flood. Wildlife may also encounter shortages of food. Animals that venture out of their small habitats searching

for food and a mate find it difficult to safely cross roadways and other human developments. The North Carolina Wildlife Federation (2021) reported that, in the United States, more than a million animals get killed each day in vehicle-wildlife collisions. Genetic drift is another concern as genetic variations are reduced in smaller habitats, resulting in inbreeding, which gives rise to genetic deformities. Recently, a neurological disease called feline leukomyelopathy (FLM) has been found in several Florida panthers. FLM causes limb weakness and partial paralysis in severe cases. Affected animals often face trouble walking, leading to starvation and death (National Geographic, 2021). Researchers are looking into several causes including genetic disorder.

Figure 2-8: A FLM Afflicted Florida Panther (National Geographic, 2021)

It has become imperative to sustain ecological diversity and help wildlife populations to thrive. To realize this aim, more expansive landscape is needed. The only solution is to create wildlife corridors by connecting fragmented habitats. Corridors will allow animals like mountain lions and mule deer to roam from one habitat to another without any interference from humans, thus making it safer for both. Without a large landscape, these mammals will be the first to disappear. Significant or connected habitats can also diminish climate change and natural calamities.

CHAPTER 3

3. SITE DETERMINATION

California, as the twentieth century began, was a playground for abundant wildlife, great and small. Grizzly bears dominated the landscape while mountain lions roamed from mountains to sea. Over time, as the population increased, developments increased as well. Much of California's landscape has been lost to housing/commercial developments and the many roadways between them. These developments have had an enormous impact on the diverse plants and animal communities that flourished here. Despite this rapidly encroaching development, the remaining land—if properly planned and maintained—can have a positive impact on the native plants as well as on the wildlife population. Developments and wildlife habitats can still coexist.

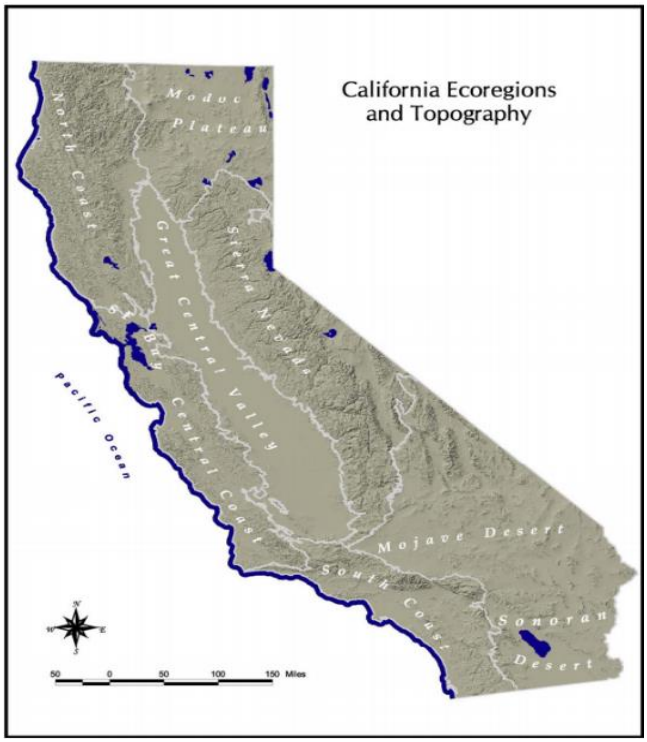


Figure 3-1: California Ecoregions (South Coast Wildlands, 2001).

These developments fragmented the landscape and decimated habitats, negatively impacting biodiversity. This impact is a worldwide phenomenon, but nowhere is the risk more severe than in South Coast Ecoregion in Southern California (South Coast Wildlands, 2008). To counter these threats, it has become essential to connect all available open lands and reserves in California to create a corridor for wildlife movement. An interconnected set of open lands and reserves would enable the continuation of natural ecological processes and allow them to thrive as they have for centuries.

Therefore, various agencies, academic institutions, land managers, planners, conservation organizations, and community groups became involved and, together, developed a comprehensive plan called the South Coast Missing Linkages Project (South Coast Wildlands, 2008). The plan was designed to connect existing reserves to maintain and restore critical habitats. This plan was a highly collaborative effort involving South Coast Wildlands, National Park Services, U.S. Forest Service, California State Parks, the Wildlands Conservancy, the Resources Agency, California State Parks Foundation, the Nature Conservancy, Santa Monica Mountains Conservancy, Resources Legacy Foundation, Conservation Biology Institute, San Diego State University Field Stations Program, Environment Now, Mountain Lion Foundation, and the Zoological Society of San Diego's Conservation and Research for Endangered Species. This project has also been supported by Pronatura Mexico, Universidad Autonoma de Baja California, Terra Peninsular, and Conabio for ecological connectivity from Baja (South Coast Wildlands, 2008).

The habitat linkages proposed by South Coast Missing Linkages have been widely recognized as the foundation of the Southern California wildlife conservation strategy. These linkages would connect over 18 million acres (South Coast Wildlands, 2008) of

existing conservation habitats (national forests, state and national parks, and some privately conserved lands) to form the South Coast Wildland Network. Spanning from the southern Sierra Nevada to Baja California and from the deserts of Anza-Borrego Desert State Park to the beaches of Camp Pendleton, these networks are composed of 19,435,105 acres (94% of which is already protected) and would connect fragmented wildlife habitats (South Coast Wildlands, 2008).

Figure 3-2: Missing Wildlife Linkages (South Coast Missing Linkages, 2008)

These linkages are vital to the eventual protection and restoration of a network in which wildlife and nature's biodiversity can flourish. The uninterrupted area of mountains and foothills created by this plan would give species like the mountain lion the freedom to roam from the Sierra Nevada to the Sierra Juarez in Baja California Norte.

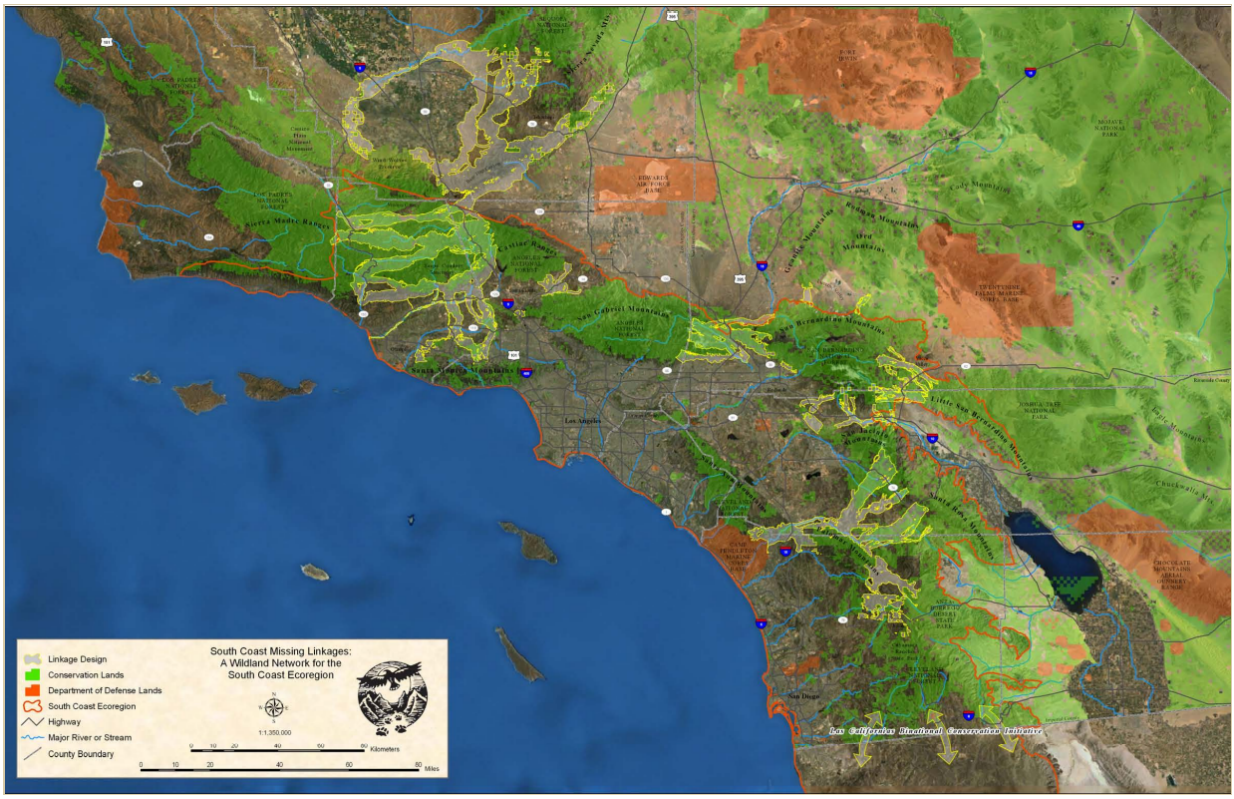


Figure 3-3: South Coast Missing Linkages (South Coast Missing Linkages, 2008)

One of the linkages identified in the South Coast Missing Linkages project is the Santa Monica – Sierra Madre Connection. In terms of existing land use pressures and the context of climate change, this linkage has been designated as one of the highest priorities by the South Coast Missing Linkage project to preserve the ecological and evolutionary processes of the California South Coast Ecoregion (South Coast Missing Linkages, 2008). This linkage was also identified as the essential linkage by the California Essential Habitat Connectivity Project, commissioned by Caltrans and the California Department of Fish and Wildlife, with support from the Federal Highways Administration (California Department of Transportation & California Department of Fish and Game, 2010). This linkage remains one of the few coastal-to-inland connections in the region. Once established, it will provide an uninterrupted landmass stretching from the Santa

Monica Mountains to the rugged landscape of the Santa Susana and the Sierra Madre mountains.

Figure 3-4: Santa Monica – Sierra Madre Connection (South Coast Missing Linkages, 2008)

Currently, approximately 34% (43,249 of 125,613) of the linkage provides some level of conservation protection, while the rest of the linkage design includes significant public ownership, which protects natural habitats from development (South Coast Missing Linkages, 2008). Further, this linkage accommodates various habitats and a variety of species and ecosystems, including woodlands, grasslands, savanna, chaparral, riparian

forests, and coastal sage scrub. The Santa Monica Mountains, a range in Southern California, spans over 153,000 acres and extends east-west for approximately 40 miles, from Point Mugu, north of Santa Monica to Griffith Park, east of Los Angeles, and parallels the north shore of Santa Monica Bay. The area includes rugged coastlines, lush valleys, and craggy mountain peaks ranging from 1,000 to 3,000 feet (National Park Service, 2002).

The Santa Monica Mountains are home to a wide range of mammal species, including shrews weighing less than one ounce and mountain lions weighing up to 150 pounds (National Park Service, 2002). Although most of the smaller mammals such as squirrels, gophers, mice, rats, rabbits, and insectivores such as bats, shrews, and moles are frequently overlooked, they still play an essential role in the natural ecosystem. They till the soil, disperse seeds, and eat insects. These smaller mammals are the food source for other mammalian carnivores, reptiles, and raptors (birds of prey).

Larger mammals, such as some carnivores, typically designate an area in the habitat and call it their home range. They would like to roam within their home range for food, shelter, and to locate mates. They will vigorously defend their home range and keep away animals of the same species and sex. For these species, movement is vital to their survival, including finding new homes, dispersing offspring, or migrating seasonally to find favorable conditions (National Park Service, 2002). This movement is also critical for species to adapt their geographic range in response to climate change, gene flow, and repopulating unoccupied habitats. Disrupting this natural movement can lead to potential loss of species and significant environmental services, as it severely inhibits essential ecosystem functions.

As urban development continues within and around the Santa Monica Mountains,

fragmentation of the natural habitat occurs due to roads and extensive highways, which significantly impact the survival and movement of wildlife, especially that of mammalian carnivores. Such interferences make finding suitable home ranges difficult and create barriers between populations and individuals.

Aside from the road itself, these thoroughfares trigger other deleterious consequences such as the spread of exotic species and increases in human pollution, light, noise, fire, roadkill, and the disruption of animal movement. These roads also affect smaller populations prone to local extinction as they fragment large habitat areas. (Riley, 2003).

Unlike roads, urban developments produce movement barriers that cannot be effectively mitigated, removed, or restored. This urbanization has many impacts, including the spread of non-native vegetation, artificial night lighting inhibiting night movement, removal of native vegetation, noise, pesticides/rodenticides, pollution, competition among other wild animals, and altered patterns of water sources.

The Santa Monica Mountains, once a contiguous mountain range and thriving terrain for mammals such as mountain lions, bobcats, gray foxes, was fragmented when the US-101 highway was built in the 1970s. This freeway runs north-south primarily in California and is a heavily traveled commuter route serving the Greater Los Angeles Area, connecting Los Angeles and Ventura Counties. The freeway facilitated the construction of sprawling developments in the Santa Monica Mountains region. US-101 is an eight-lane freeway that runs east-west while passing through the City of Agoura Hills, bisecting the Santa Monica Mountains to the south from the Simi Hills and Santa Susana Mountains to the north.

For many wildlife species, including mule deer, mountain lions, bobcats, gray foxes, and coyotes, the US-101 is an almost impenetrable barrier, prohibiting their movement between these two mountain ranges. Large mammals such as mountain lions and bobcats need large, contiguous habitats to breed, hunt, and thrive. Male mountain lions use about 200 square miles as their home range (National Park Services, 2016). US-101 divides this connected habitat into two separate fragments, significantly impeding the mountain lions' ability to move between the two mountain ranges. The results include increased inbreeding, territorial fighting, and very low genetic diversity for mountain lions. In March 2020, researchers found three mountain lions with tails kinked like the letter "L" and with only one descended testicle, a physical manifestation of extremely low genetic diversity. Known as cryptorchidism, these abnormalities refer to the failure of one or both testes to descend from the abdomen into the scrotum, causing infertilities among mountain lions (Los Angeles Times, 2020).

Figure 3-5: A Male with Reproductive and "L" Shaped Tail Defects (NBC Los Angeles, 2020)

Due to this fragmented landscape, mountain lions in the Santa Monica Mountains could face extinction within 50 years, with a median time to extinction of just 15 years, according to research conducted by the National Park Service since 2002 (Benson, 2016; Riley, 2014). A recent report by the U.C. Davis Road Ecology Center identified the 101 Freeway around the wildlife crossing as one of the Statewide Wildlife-Vehicle Conflict Hotspots (Shilling, 2018).

This connectivity is also vital for other species such as bobcats and coyotes, which, according to National Park Service data, have exhibited significant genetic effects with increased disease susceptibility since the freeway was built (Serieys, 2015). These data also show that smaller species such as lizards and birds are adversely affected. These species are practically trapped within the Santa Monica Mountains without access to a safe and sustainable wildlife crossing.

Therefore, researchers at the South Coast Missing Linkages recommended that a linkage be developed over US-101, near Liberty Canyon Road. A report published in March of 2018 summarized the recommendations of some of the world's foremost experts on crossing structures and wildlife connectivity, pairing them with data and characteristics of surrounding landscape and wildlife to prioritize locations for wildlife crossings. Their findings showed that the Liberty Canyon site would be the best location to improve connectivity in that region and would be the best solution for the broadest range of species (Riley, 2018). Importantly, this is the only site where the wildlife habitats extend to the edge of both sides of the US-101 Freeway (Los Angeles Times, 2020). Also, this plan is the lowest cost alternative as no land purchases are required to connect the habitats.

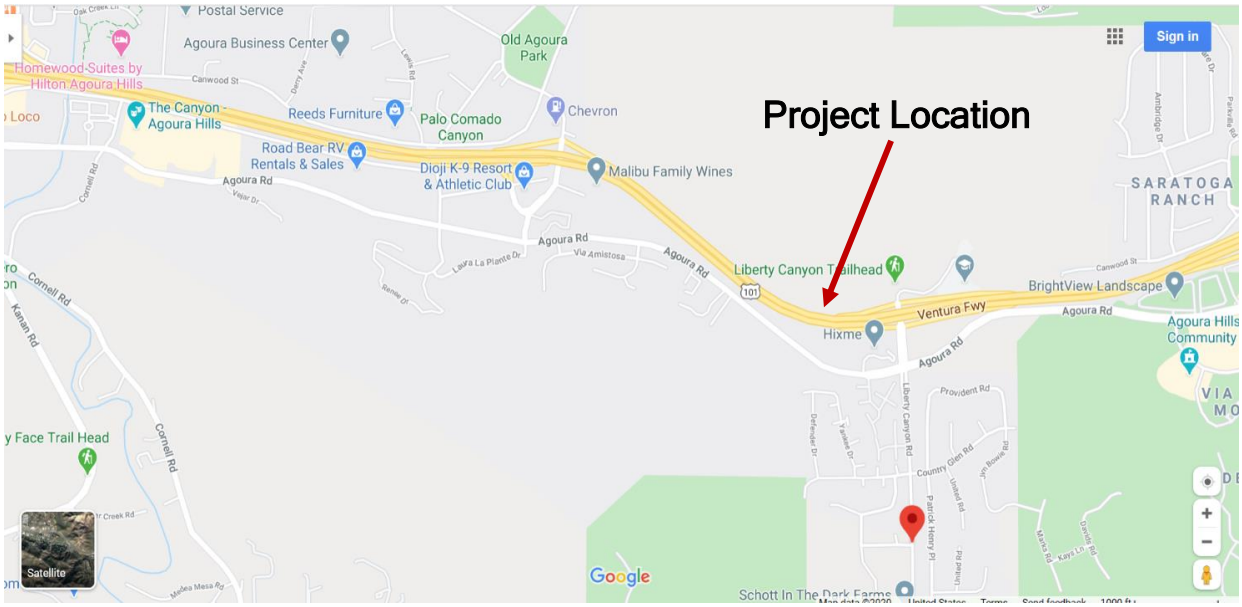


Figure 3-6: Project Location Map (Courtesy: Google)

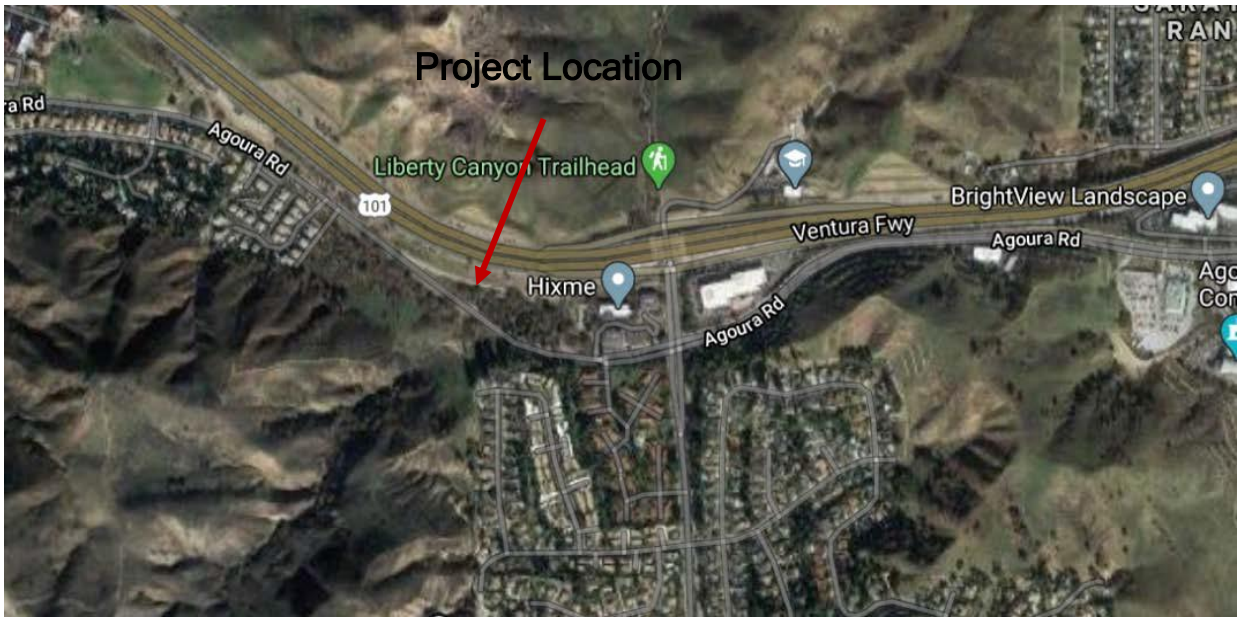


Figure 3-7: Project Location Map Enlarged (Courtesy: Google)

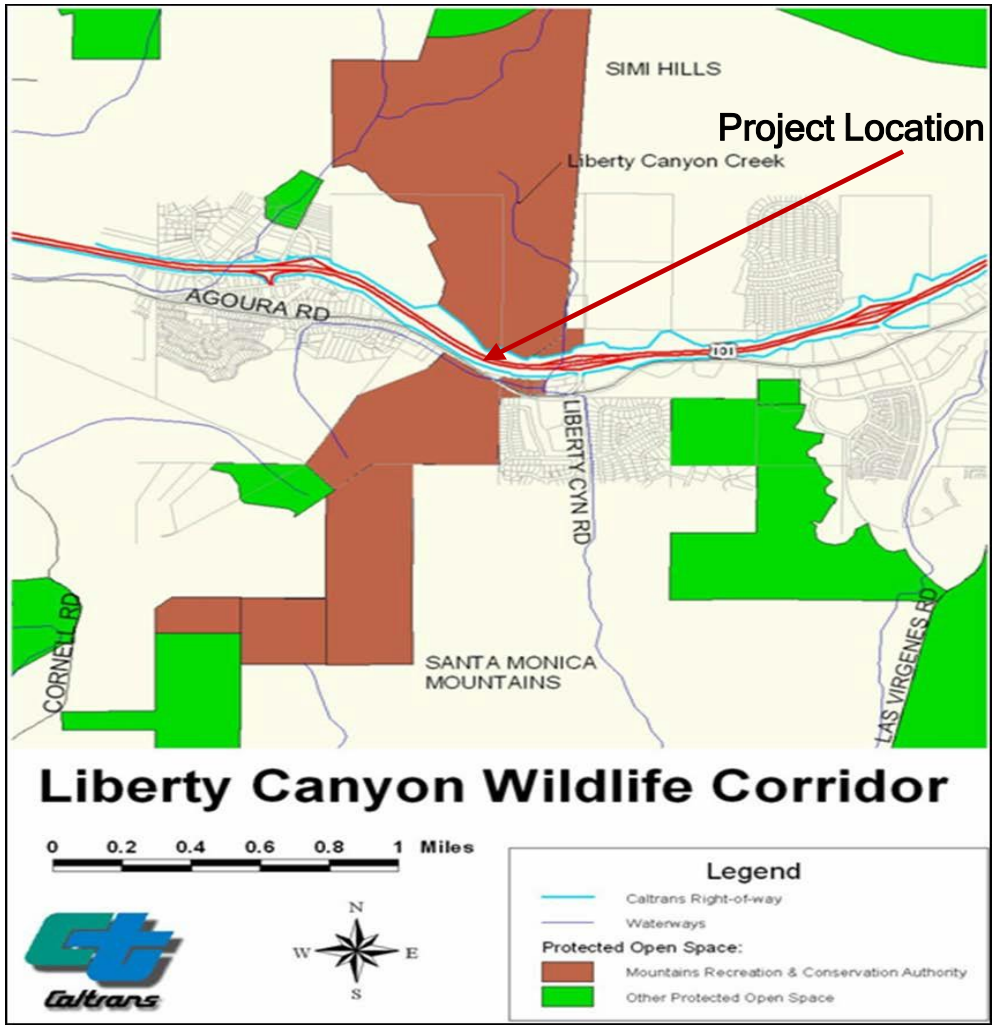


Figure 3-8: Project Location showing Protected Lands

The existing underpass at the Liberty Canyon Road facilitates various levels of animal movement across this freeway. It provides connectivity for mountain lions and badgers, and deer, coyotes, and raccoons to some degree (Ng et al., 2004).

However, both the South Coast Missing Linkages Project and the California Essential Habitat Connectivity Project recommended a bridge over US-101 to

1. safeguard against edge effects,
2. provide live-in habitat for specific species that require multiple generations to achieve gene flow through the linkage,
3. guarantee availability of vital resources,
4. allow for the continuation of natural processes,
5. allow species and natural communities to react to climate change appropriately, and
6. avoid potential collisions between vehicular traffic and animals.

Also, the Liberty Canyon area is the optimal location for a safe and sustainable wildlife bridge across US-101, as this location's prime habitat is connected to large areas of protected habitat to the north and south and has already been protected on both sides of the freeway, which makes it a feasible and low-cost solution for connectivity within the Santa Monica Mountains. Therefore, it was determined that this overpass would become a vegetated bridge to resemble the natural habitat on both sides of the freeway.

Figure 3-9: Architectural Rendering of the Bridge and the Tunnel

CHAPTER 4

4. PROJECT DESCRIPTION

All probable project alternatives were analyzed to determine their ability to facilitate movement of each target species (Clevenger, 2011). The results of this analysis were used to determine which alternative would be best suited for wildlife movement in this area. As the Agoura Road runs parallel to US-101 within the study area, the ability of each target species to cross Agoura Road was also taken into consideration.

Figure 4-1: Target Species for the Wildlife Crossing (courtesy: Living Habitat)

Alternative 1 is to build an overcrossing over US-101 and associated fencing along US-101, west of Liberty Canyon Road, in the City of Agoura Hills. The wildlife fencing and vegetation will be designed to guide wildlife to the overcrossing and prevent access

to the freeway. This alternative does not include any crossing over the Agoura Road, a parallel roadway to the south of US-101. It is believed that this alternative will facilitate the movement of five of the eight target species across US-101, allowing them to move between the Santa Monica Mountains and the Simi Hills. (See Table 4-1.)

Table 4-1: Modified Analysis of Target Species Ability and Willingness to Use Alternative 1 (Caltrans, 2016)

Common Name of Species	Scientific Name	Species Able to use Alternative 1	Rationale
Bobcat	*Lynx rufus*	Yes	Bobcats are expected to use the wildlife overcrossings over US-101. They have the physical capabilities and willingness necessary to cross Agoura Road at-grade.
Coyote	*Canis latrans*	Yes	Coyotes are expected to use US-101 wildlife overcrossings. They have the physical capabilities and willingness necessary to cross Agoura Road at-grade.
Desert Cottontail	*Sylvilagus audubonii*	Yes	The US-101 overcrossing structure is able to accommodate the cover needs of the desert cottontail to use. It is also anticipated that cottontail could successfully cross Agoura Road on a routine basis based on their physical capabilities and behavioral responses to roads.
Mountain Lion	*Puma concolor*	Yes	Mountain lions are expected to use wildlife overcrossings. They have the physical capabilities necessary to cross Agoura Road at-grade.
Mule Deer	*Odocoileus hemionus*	Yes	Mule deer are expected to use wildlife overcrossings. Mule deer have the physical capabilities necessary to cross Agoura Road at-grade.
Southern Alligator Lizard	*Elgaria multicarinata*	No	The overcrossing structure can accommodate the needs of the southern alligator lizard, but it is not anticipated that they could successfully cross Agoura Road on a routine basis based on their physical capabilities and behavioral responses to roads.

Common Name of Species	Scientific Name	Species Able to use Alternative 1	Rationale
Gopher Snake	*Pituophis catenifer*	No	Gopher snakes are expected to use wildlife overcrossings, with the inclusion of native vegetation and non-vegetated cover. However, it is not anticipated that they could cross the Agoura Road at-grade on a routine basis based on their physical capabilities and behavioral responses to the roads.
Western Toad	*Anaxyrus boreas*	No	Western toads are expected to use wildlife overcrossings, however, not anticipated to cross Agoura Road on a routine basis because of their physical capabilities and willingness necessary to cross Agoura Road at-grade.

Alternative 1 is anticipated to decrease habitat fragmentation as well as genetic differentiation by providing a connection between the wildlife habitat north and south of US-101. Since the proposed overcrossing would increase the connectivity of existing wildlife habitat and conserved lands, it would increase the ability of five of the eight target species to adapt to the effects of climate change (Caltrans, 2016). The ability to move and adapt to changing conditions and resource availability is critical to increasing wildlife species resiliency to climate change.

Although the wildlife overcrossing and associated wildlife fencing is anticipated to reduce the risk of wildlife mortality on US-101 for all target species, there is a potential for increased wildlife mortality on Agoura Road. Though the possibility for wildlife mortality on Agoura Road already exists, and wildlife have been observed attempting to cross Agoura Road, it is anticipated that the potential for wildlife mortality on Agoura Road may increase as more wildlife would attempt to access the proposed overcrossing over US-101 (Caltrans, 2016).

At the proposed project location, Agoura Road is classified as a Secondary Arterial Road in the City of Agoura Hills General Plan (Adopted March 2010). The road has one

travel and bicycle lane in each direction and has a posted speed limit of 45 miles per hour. Traffic volume data collected by the City of Agoura Hills in 2016 recorded a daily traffic volume of 5,039 cars per day on Agoura Road between Liberty Canyon Road and Chesebro Road. According to the Federal Highway Administrations Standard Traffic Volume Groups, Agoura Road falls into Group 4. This traffic volume is considered high and was found to be both a barrier to wildlife movement for some species and a source of mortality for all classifications of wildlife species (Jacobson, 2016).

Alternative 2 includes all the features described in Alternative 1 with the addition of a tunnel over Agoura Road as well as filling and grading the slope area between the US-101 overcrossing and the Agoura Road tunnel to provide a continuous grade, allowing wildlife crossing to extend over Agoura Road before descending to join the existing ground. It is anticipated that this alternative will facilitate the movement of all target species across US-101, as shown below.

Table 4-2: Analysis of Target Species Ability and Willingness to Use Alternative 2 (Caltrans, 2016)

Common Name of Species	Scientific Name	Species Able to use Alternative 2	Rationale
Bobcat	*Lynx rufus*	Yes	Bobcats are expected to use the wildlife overcrossings over US-101 as well as the tunnel over Agoura Road.
Coyote	*Canis latrans*	Yes	Coyotes are expected to use the wildlife overcrossings. They are expected to cross the Agoura Road tunnel.
Desert Cottontail	*Sylvilagus audubonii*	Yes	Cottontails are expected to cross the overcrossing and the tunnel if appropriate cover is provided throughout the length of the overcrossing.
Mountain Lion	*Puma concolor*	Yes	Mountain lions are expected to use wildlife overcrossings as well as the Agoura Road tunnel.
Mule Deer	*Odocoileus hemionus*	Yes	Mule deer are expected to use wildlife overcrossings and the Agoura Road tunnel.
Southern Alligator Lizard	*Elgaria multicarinata*	Yes	Southern alligator lizard is anticipated to use the UA-101 overcrossing and the Agoura Road tunnel.
Gopher Snake	*Pituophis catenifer*	Yes	Gopher snakes are expected to use wildlife overcrossings and the tunnel.
Western Toad	*Anaxyrus boreas*	Yes	Western toads are expected to use wildlife overcrossings and the tunnel.

Alternative 2 would facilitate movement across US-101 and Agoura Road for all target species, as opposed to Alternative 1. It is also anticipated that the extension of the US-101 overcrossing over the Agoura Road will increase the use of the overcrossing, as compared to Alternative 1, by eliminating the need to cross a road (Agoura Road) with active traffic. By providing an extension of the overcrossing over this adjacent secondary road, wildlife will be able to access the open space and habitat on both sides of US-101 without the danger or detriment of having to cross an additional road. This alternative

would also minimize the risk of wildlife mortality on Agoura Road, contrary to Alternative 1.

Two additional alternatives were also evaluated during the development of the proposed project. However, they were not included as alternatives based on initial evaluations and recommendations from the team comprised of Caltrans, National Park Services (NPS), Resource Conservation District of the Santa Monica Mountains (RCDSMM), Mountain Recreation and Conservation Authority (MRCA), National Wildlife Federation (NWF), and others. These tunnel alternatives were evaluated to determine their ability to meet the purpose and need of the project as well as their impact on the wildlife movement across US-101. The results of the evaluation are summarized below.

Jacked Box Culvert (13' x 13')

One of the options considered, but not recommended as an alternative for this project, was a 13-foot-by-13-foot jacked box (example shown on Figure 4-2) culvert of over 300 feet in length that would serve as a wildlife crossing under US-101. Though a culvert of this size would physically provide a connection for wildlife to travel between the open spaces on either side of US-101, the number of species that this culvert has the potential to serve is limited. Guidance for wildlife crossing structures generally recommend that wildlife crossing structures minimize their length and maximize their width, as longer structures have shown to repel some species

Figure 4-2: Culvert on State Route 76 Corridor, San Diego

(Clevenger, 2011; Cramer, 2012). The lack of native vegetation and cover within a culvert eliminates the ability of the crossing to serve as an extension of the natural habitat and reduces the number of species that would utilize the crossing. Additionally, as with Alternative 1, this culvert could potentially increase wildlife mortality on Agoura Road as species attempt to utilize the wildlife undercrossing.

A 13-foot-by-13-foot jacked box culvert has the potential to reduce genetic differentiation and wildlife mortality on US-101 for some target species, including medium and large mammals (e.g., mountain lions, bobcats, and coyotes) and the amphibian target species (Western toads) but is unlikely to provide a functional crossing for ungulates, small mammals, reptiles, and avian species, such as desert cottontail, mule deer, and southern alligator lizards (Clevenger, 2011; Cramer, 2012). For these reasons, this alternative was removed from further consideration for the proposed project.

Cast-in-Place Rectangular Culvert (32' wide x 15' high)

Another option that was considered, but not recommended as an alternative for this project, was a 32-foot (wide) by 15-foot (high) cast-in-place rectangular culvert (See Figure 4-3) that would be over 300 feet in length. This culvert prohibits the planting of native vegetation within the structure. Therefore, although it has the potential to serve more target species, it is unlikely to provide a functional crossing for desert cottontail, southern alligator lizard, and gopher snake (Clevenger, 2011; Cramer, 2012). As with Alternative 1 and the smaller culvert, this alternative has the potential to increase wildlife mortality on Agoura Road for species that utilize the culvert to cross US-101.

Figure 4-3: Culvert on Highway 17, Santa Clara Co., CA

Additionally, constructing a cast-in-place culvert of this size would require using a cut-and-cover technique which would require extensive closures of US-101, one of the busiest freeways in the region, carrying over 300,000 vehicles daily. It also serves as one of the primary connections between Los Angeles and Ventura County. For these reasons, this alternative was removed from further consideration for the proposed project.

A recent camera study conducted at the underpass (1,100 feet in length, 15 feet in height, and 25 feet wide) under the I-5/405 interchange in Orange County (Kevin et al., 2016) shows that mammals such as bobcats and coyotes were reluctant to enter the

underpass. Their activities were highest at the far end of the underpass connected to the natural areas. The length of the underpass, lack of cover or elevated structures to hide from predators, human use of the underpass, and potential extreme darkness in the middle of the underpass may pose challenges for wildlife movement.

Based on the above analysis, Caltrans, in collaboration with partners (RCDSMM, MRCA, NPS, and NWF), decided to choose Alternative 2, which will accommodate all target species, increase the overall attractiveness of the crossing to wildlife, and minimize repellency rates. Repellency is defined as instances when wildlife approach crossing entrances and then turn around and walk away (Cramer, 2012).

The following factors were considered in determining the appropriate structures over US-101 and Agoura Road as well as the slope and landscaping between these two structures. The *Wildlife Crossing Structure Handbook: Design and Evaluation in North America* (Clevenger & Huijser, 2011), prepared for the Federal Highway Administration (FHWA), was used as a guide. Other existing wildlife crossings were evaluated to help determine the appropriate crossing.

Length and Width of the Structures

The length of the overcrossing over US-101 will be approximately 216 feet. The width of the overcrossing will be 165 feet, based on recommendations in the *Wildlife Crossing Structure Handbook* as well as on the physical constraints of the crossing site location. The handbook recommends a width of 165 to 230 feet for wildlife overcrossing to serve similar types of species. The height of the bridge was decided to be 16.5 feet, the minimum bridge vertical clearance on a freeway allowed by Caltrans.

The length of the Agoura Road tunnel was determined to be approximately 165 feet to match the width of the US-101 overcrossing, in order to have a continuous slope

between these two structures. The width (54 feet) and height (16.5 feet) of the tunnel interior was recommended by the City of Agoura Hills, as Agoura Road is under the jurisdiction of the city.

Slopes

The slope gradient of the approach slopes to the structures as well as between the structures were limited due to the surrounding topography and the height difference between the two structures. However, it is proposed to keep the slope at a rate of 3:1, or flatter, in order to maximize the structures usability. According to observations, some animals are reluctant to traverse a slope gradient steeper than 3:1 (Clevenger & Huijser, 2011).

Sightlines

The overcrossing is intended to be an extension of the surrounding natural habitat and, by minimizing the slope gradient of the approach slopes, animals would be able to see farther ahead. Therefore, the ability of wildlife to see clearly through or beyond a crossing structure increases the effectiveness of the structure for most wildlife species. In order to preserve sightlines to the greatest extent feasible, the overall height of the structure and the steepness of the approach slopes would be minimized. Density of vegetation was also taken into consideration in order to strike a balance between providing cover and maintaining visibility/sightlines across the structure. Below is the architectural rendering of the proposed project, when completed.

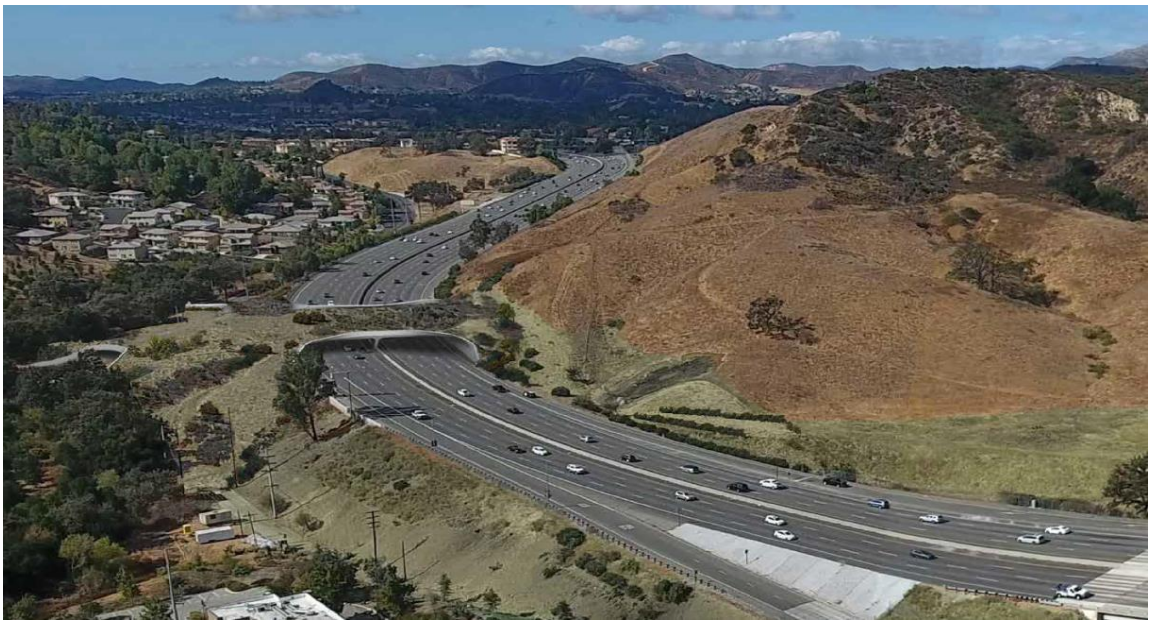


Figure 4-4: Architectural Vision of the proposed project

Light/Sound Barriers for the Overcrossing

Earth has a daily cycle of light and dark, and plants and animals depend on that cycle for their life-sustaining behavior such as nourishment, reproduction, sleep, and protection from predators (International Dark-Sky Association, March 2010). Research suggests that disrupting this cycle with artificial lights can have negative effects on natural ecosystems, including wildlife. Some nocturnal animals sleep during the day and hunt during the night under the cover of darkness. When this cycle is interfered, their life cycle gets disrupted, which can lead to malnourishment and affect reproduction. Because this proposed overcrossing is in an urban area and crossing over an 8-lane freeway, light pollution from streetlights and headlight glares from the passing vehicles would pose an issue.

Figure 4-5: Busy Freeway at Night (Courtesy: Google)

Just like light pollution, noise pollution can have a deleterious effect on the wildlife, interfering with their communication, hindering their foraging abilities, and impacting where they live. Research has shown that noise pollution—known as anthropogenic noise—caused by vehicles, sound from cities, and other sources can present significant problems for wildlife.

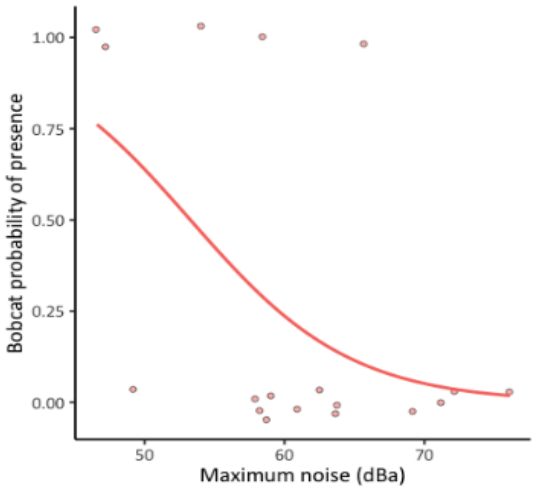


Figure 4-6: Bobcat Presence vs. Noise intensity (Courtesy: UC Davis)

Research conducted by the Road Ecology Center at the University of California at Davis (2021) shows that the presence of bobcats diminishes as the noise increases. The Road Ecology Center measured freeway traffic noise at various points around the project site and found that noise intensity was highest close to the proposed overcrossing, and then diminished away from the crossing.

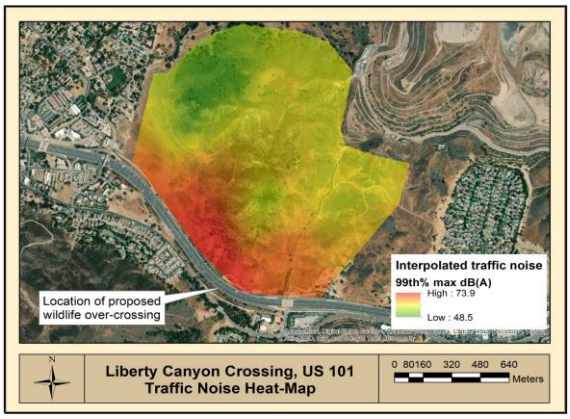


Figure 4-7: Sound Intensity at the Proposed Overcrossing (Courtesy: UC Davis)

Therefore, it is imperative to mitigate wildlife disturbances from both the light and sound

pollution around this overcrossing to make it more conducive to animal crossings.

Several measures have been recommended, including vegetated sound walls on the bridge and vegetated gabion walls and berms at the side of the freeway leading up to the overcrossing. Once sound waves meet these barriers, some deflect, some are absorbed, some transmit through, and the rest goes above the barrier and is refracted. Other conventional strategies were also proposed such as incorporating vegetated buffers to provide sound attenuation. Various sound treatments would be applied under the overcrossing, such as textured concrete panels, insulation, and textured metal panels to mitigate the sound impact. To reduce the impact of light sources on wildlife, several measures were also incorporated including a lighting shield to reduce light intensity, high-pressure sodium lamps for less-focused, wider-spread yellow light, and lower streetlight height and increased pole frequency to maintain the required level of roadway illumination.

Substrate:

The overcrossing would have a natural substrate covering the deck and deep enough to support native vegetations. Logs, stumps, and boulders would be scattered around to mimic similar topography from the surrounding habitats as well as to make the crossing more appealing for some wildlife species.

Native Vegetation Plan:

Because this overcrossing is intended to be an extension of the surrounding natural habitat and blend into the surrounding hillsides, the overcrossing and approach areas will be planted with vegetation native to the Santa Monica Mountain region (see Table 4-3, below). This landscaping will provide cover for obligate species and landing spots for aerial species as well as increase the effectiveness of the crossing to all species.

Table 4-3: Planting Palette Recommendations (Caltrans, 2016)

Common Name	Scientific Name
California Sagebrush	*Artemisia californica*
Coyote Bush	*Baccharis pilularis*
Mulefat	*Baccharis salicifolia*
Toyon	*Heteromeles arbutifolia*
California Black Walnut	*Juglans californica*
Western Sycamore	*Platanus racemosa*
Coast Live Oak	*Quercus agrifolia*
Valley Oak	*Quercus lobata*
Elderberry	*Sambucus mexicana*
Arroyo Willow	*Salix lasiolepis*
Narrow Leafed Willow	*Salix exigua*
California Blackberry	*Rubus ursinus*
Purple Sage	*Salvia leucophylla*
California Wild Rose	*Rosa californica*
Sugar bush	*Rhus ovata*

Non-Vegetated Cover:

As the overcrossing is expected to be used by cover obligate species and aerial species, the overcrossing structure will need to include elements that provide suitable cover and habitat for these animals. Woody debris and boulders should be mixed with native vegetation to serve as steppingstones that minimize exposure for cover obligate species and provide landing spots for aerial species. These steppingstones should extend onto the approach slopes and habitat surrounding the overcrossing as well as on the structure.

Wildlife Fencing:

Wildlife fencing along US-101–from Lost Hills Road to Palo Comado Canyon

Road—is needed to prevent wildlife from accessing the freeway and to direct wildlife toward the crossing. Some species can avoid fencing by climbing over or digging under; therefore, the fencing would have a minimum height of eight feet above ground with an additional two feet buried below ground or staked to the ground. Taller fencing may be needed on slopes. Vegetation in the area between the fencing and the freeway should be minimized to discourage wildlife from crossing over the fence.

CHAPTER 5

5. CHALLENGES AND BENEFITS

With population growth in California comes housing and industrial development. And, because of this continuous development, more and more land are being taken from already-diminished wildlife habitats. The remaining wildlife habitats have been fragmented further into smaller habitats. Decimation led to habitat loss and thus to a negative impact on biodiversity.

Mitigating this injurious pattern required connecting all available open lands in California to create a network for wildlife movement. Subsequently, the South Coast Missing Linkages (South Coast Wildlands, 2008) project was developed to establish a regional network to maintain and restore critical habitat linkages among existing reserves. The linkages would stitch together over 18 million acres of existing conservation to form the South Land Wildland Network. This network would connect wildlife populations from the southern Sierra Nevada to Baja California, and from the beaches of Camp Pendleton eastward to Anza-Borrego Desert State Park (South Coast Wildlands, 2008). The unbroken chain of mountains and foothills envisioned by the South Coast Wildland Network will allow wide-ranging species like the mountain lion and mule deer to roam from the Sierra Nevada to the Sierra Juarez in Baja California Norte.

Among the linkages, the South Coast Missing Linkages project identified the Santa Monica Mountains – Sierra Madre Mountains linkage as the most critical (South Coast Missing Linkages, 2008) because of its wide-ranging population of wild animals as well as its availability as one of very few coastal-to-inland connections. This linkage was severed in the early 1970s to build the US-101 Freeway, leaving large protected public land on both sides of the freeway; therefore, this location became the most logical and

economical way to re-establish the linkage. As discussed previously, expert opinions determined that an overcrossing over US-101 was the most effective way to connect two mountain ranges for the wildlife. This 165'-wide and over 210'-long vegetated bridge would blend seamlessly with the surrounding landscape, giving the appearance of an extension of those mountain ranges.

However, constructing an overcrossing of this magnitude poses multiple challenges. First and foremost is the funding. As this project has neither any direct traffic benefit rendered nor any environmental mitigation for freeway-related projects, it did not qualify for any state and federal funding for a hefty, estimated construction cost of approximately $88 million. Therefore, the only option was to find private donations. As a result, the task was taken up by the National Wildlife Federation (NWF), the largest private, non-profit conservation education and advocacy organization in the United States. The donations came in from large organizations and private parties, and Caltrans is on track to break ground to start construction by the end of the year 2021.

Wildlife crossing requires a high level of collaboration across agencies and jurisdictional boundaries. In this case, it would be between Caltrans, Mountain Recreation and Conservation Authority, Santa Monica Mountain Conservancy, and National Park Services. In addition, because this overcrossing would be built in a highly populated area, the full support of residents was needed. Although residents around the proposed overcrossing are accustomed to the mountain lions and other wildlife due to their proximity to the conserved land, they were still reluctant to see a wildlife bridge of this dimension close to their neighborhood. They were concerned about the bridge's visual impact and whether it would invite more wildlife into their neighborhood. The City of Agoura Hills and the residents were also skeptical about the sightliness of the bridge.

The biggest hurdle was finding the proper location—considering the cost savings, topography, road dimensions, vegetation, exposure, and climate condition of the site as well as the surrounding land use, disturbances, and development. Functionally speaking, the project spans one of the busiest freeways in the nation and is the major thoroughfare connecting two large counties: Los Angeles County and Ventura County. With over 300,000 vehicles passing the future bridge location in a given day, the technical challenges of such a large structure are made all the more challenging by the desire to reduce the impact to this busy thoroughfare during construction. At eight lanes of traffic, the span of the bridge structure across the roadway will be over 216 feet. To achieve this large over-roadway span without closing the freeway, we are using an innovative precast concrete solution that will enable us to build with a significantly reduced impact on the flow of the 101. Additionally, to increase the efficacy of this overcrossing, headlight glares and noises from the busy freeway will have to be mitigated.

The benefit of this significant undertaking is multifaceted. High-traffic roadways such as US-101 present an impenetrable barrier to wildlife movement between mountain ranges.

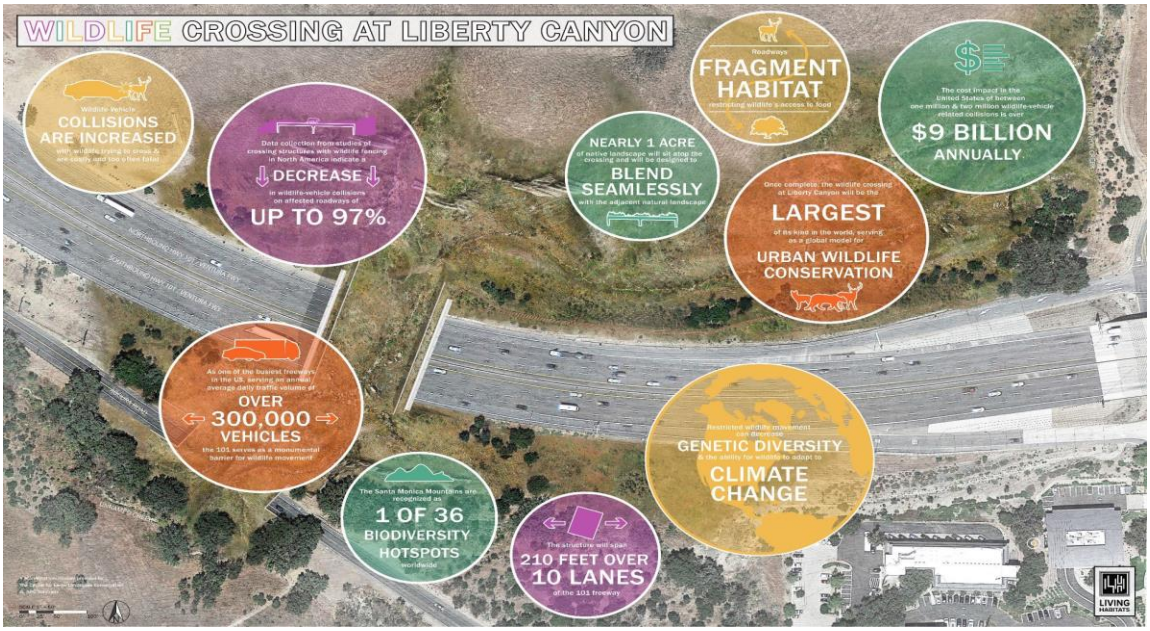


Figure 5-1: Benefits to the Wildlife

Further, US-101 increases wildlife-vehicle collisions—and thus animal mortality—poses a significant threat to motorists' safety. From 1990 to 2008, while the overall number of collisions on the roadway in the United States decreased, the number of wildlife-vehicle collisions doubled (ARC Solutions, 2017). Nationally, over 5% of all accidents involve wildlife, costing society nearly $8.4 billion (Shilling, 2018). Since 2002, motorists have struck and killed many big cats in the study area (ARC Solutions, 2017). These numbers might be even higher, as not all accidents are reported. Therefore, having a wildlife crossing here would reduce animal mortality as well as increase motorist safety. Wildlife-crossing structures designed to provide safe passage for wildlife, coupled with fencing, have shown to reduce wildlife-vehicle collision by 97% (ARC Solutions, 2017), thus lowering the many costs to the society. Safer highways can also foster motorists' sense of well-being and lessen their anxiety about driving.

Recognized as one of thirty-six biodiversity hotspots globally, and one of only six in the continental United States, the Santa Monica Mountains are home to more than 50 threatened or endangered plants and animals (South Coast Wildlands, 2008). As has been noted previously, it is quite well known that the project represents an opportunity to provide connectivity in support of the endangered California Mountain Lion population which are believed to be extinct in the next 50 years with a median time to extinction of just 15 years due to the lack of genetic diversity (Benson, J. F., 2016), and (Riley, S. P., 2014). Large mammals like mountain lions require a large swath of land for hunting and breeding. This bridge will establish that critical link between the Santa Monica Mountain range and the Santa Susana Mountain and Simi Hills, thus providing miles of open land for mountain lions to roam, hunt, and find mates for breeding. It will also safeguard against edge effects, guarantee the availability of vital resources, facilitate the continuation of natural processes, and allow species and natural communities to react to climate change appropriately.

CONCLUSION

Wildlife overpasses and underpasses are not new; they are, in fact, popular in Canada, Europe, and Africa– "wildlife overpasses in Banff National Park in Canada," Natuurbrug Zanderij Crailoo in the Netherlands, and elephant underpasses in Northern Kenya, to name a few. Wildlife crossings are usually structures that help animals safely cross human-made barriers, and include tunnels, culverts, viaducts, overpasses, fish ladders, canopy bridges, green roofs, and green bridges.

Wildlife crossings that have been built or are under construction across the world are thoughtfully located in rural areas along transportation corridors, where large amounts of open space or existing habitats sit adjacent to the roadway. In those circumstances, the emphasis is primarily on reducing vehicle-animal collisions, preserving wildlife mobility and migratory routes, and protecting both animal and human travelers. While these are indeed the goals with the Wildlife Crossing at Liberty Canyon, there is also a critical need to expand the genetic diversity of certain species and preserve one of the most important animals in the California ecosystem.

The crossing will also be in a particularly unique location on the edge of one of the most densely populated urban areas in the United States; from an ecological perspective, this site is one of the most important in the nation. The Santa Monica Mountains are recognized as one of 36 biodiversity hotspots globally, and one of only six in the continental United States, with more than 50 threatened or endangered plants and animals (South Coast Wildlands, 2008). This project represents an opportunity to provide connectivity supporting the endangered California Mountain Lion population, with the infamous P-22 as its mascot and champion. Further still, the project serves as a conduit for ecological health at all levels, enabling the reconnection of an entire ecosystem at a

critical location between Santa Monica and Simi Hills. The region is home to several endangered plants as well as animals; as such, the project offers a focused opportunity to support both, providing a comprehensive response to ecological health. To do this effectively, we have embraced an integrated design process, another unique element of the project, whereby decisions about the physical structure and its elements are considered in the context of landscape performance and habitat efficacy.

Another unique aspect of this project is that it will be funded primarily from private donations. Also notable is the incredible collaboration among partners. For nearly 20 years, the National Park Services (NPS) has studied the region's wildlife, bringing attention to this critical need. Through an alliance among NPS, Caltrans, the Santa Monica Mountain Conservancy, the Mountain Recreation and Conservation Authority, the Resource Conservation District of the Santa Monica Mountains, and the National Wildlife Federation, this project is, indeed, possible. It has also convened global experts on wildlife crossings.

The Liberty Canyon wildlife crossing is a once-in-a-lifetime project that will save a threatened population of mountain lions and opens the possibilities for wildlife conservation around the globe. This project is unprecedented in both scale and visibility—more than 300,000 vehicles a day will drive under its span. Covering eight lanes of traffic and an access road, the estimated 216-foot-long-by-165-foot-wide structure will rank as the largest such bridge in the world once built and the first freeway crossing in California. By building a wildlife crossing in the area that possesses protected land north and south of the US-101, this project will re-establish a critical connectivity path in the Santa Monica Mountains and link to vital open space to the north in Simi Hills, Santa Susana Mountains,

the over 2,700 square miles of Los Padres National Forest, and many more thousands of square miles of habitat beyond (South Coast Wildlands, 2008).

Creating a transportation system capable of harmonizing with nature is imperative to the survival of our ecosystem and has already been developed in our policies and direction. Current U.S. transportation law provides explicit authority for federal, state, municipal, and local authorities to reduce the number of motorist collisions with wildlife and to ensure connectivity among habitats disrupted by roads. It requires state and metropolitan long-range transportation plans to address potential environmental mitigation. It permits planners to develop programmatic mitigation plans at various scales encompassing multiple resources, such as wildlife habitat or aquatic resources.

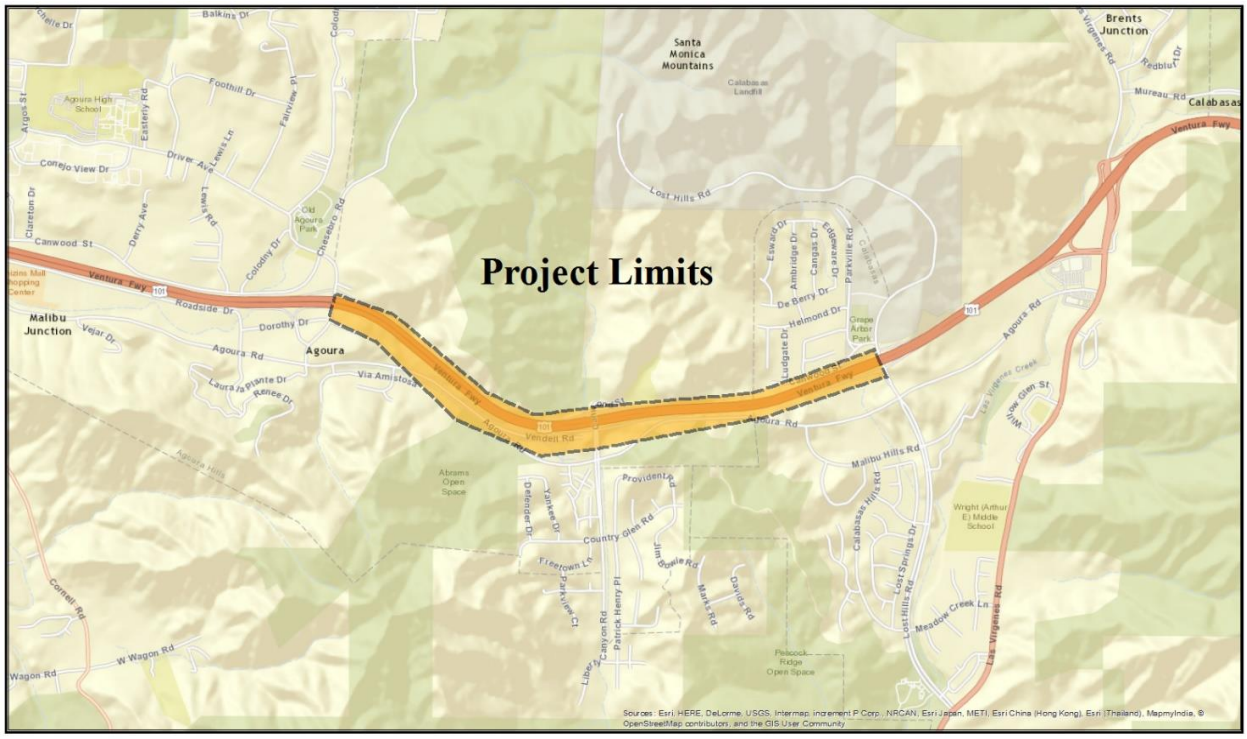
The world is already watching this wildlife crossing project—the first attempt at a large-scale intervention for wildlife in such an urban setting, the greater Los Angeles metropolitan area, the most densely populated in the United States and home to 20 million people. It has been featured on numerous news media, including *National Geographic Magazine*, *New York Times*, *Los Angeles Times*, and Associated Press, to name a few. This research on mountain lions and other wildlife, headed by the National Park Services, is already unprecedented. However, with the addition of the crossing, the study will provide landmark science that will set a model worldwide for urban wildlife conservation and inform future efforts. It has renewed the urgency to keep our wildlife from going extinct because of urban development and shows that animals and humans can coexist.

Appendix A – Project Partners and Stakeholders

Caltrans
Mountains Recreation and Conservation Authority
Resources Conservation District of the Santa Monica Mountains
National Park Service
National Wildlife Federation

Assembly member Richard Bloom
California State Coastal Conservancy
City of Agoura Hills
City of Calabasas
Congressmen Ted Lieu
Los Angeles County Supervisor Sheila Kuhl
State Senator Henry Stern

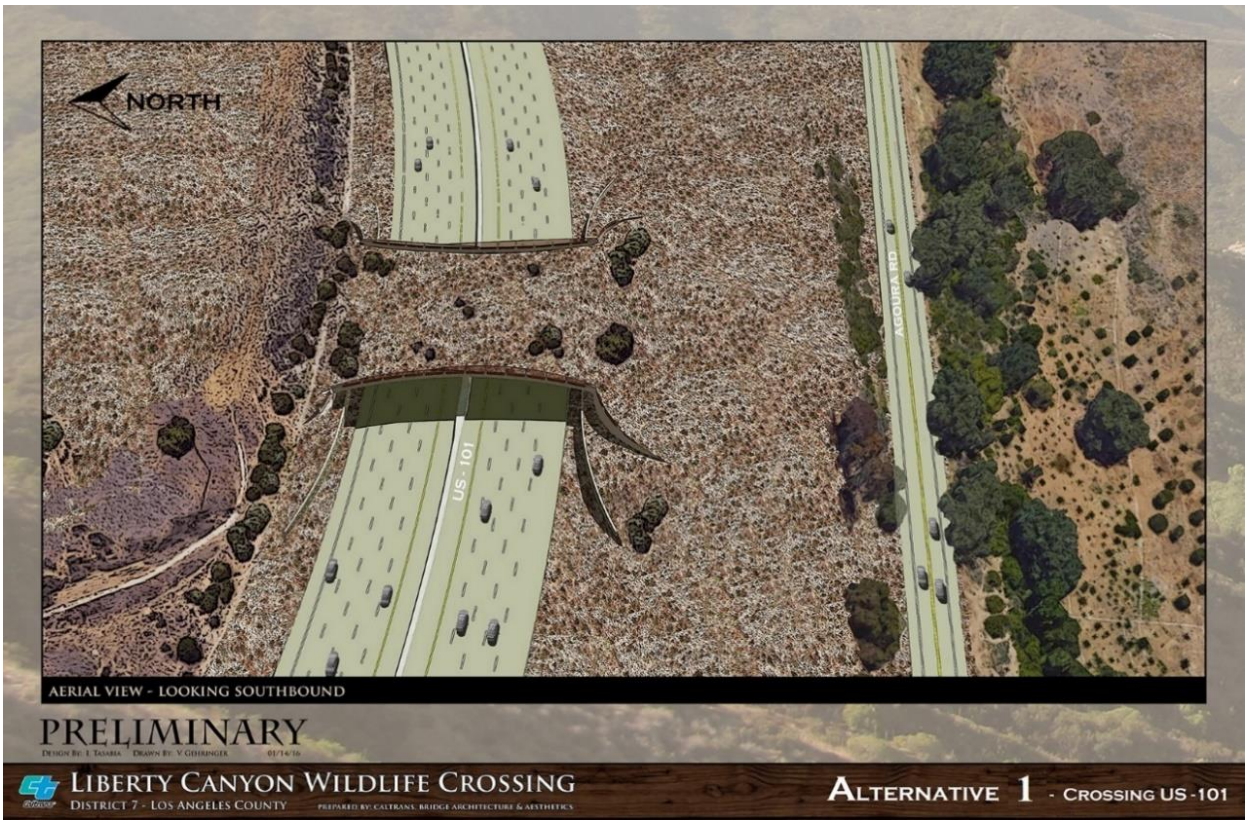
Site of the Wildlife Crossing



California Department of Transportation
District 7, Los Angeles

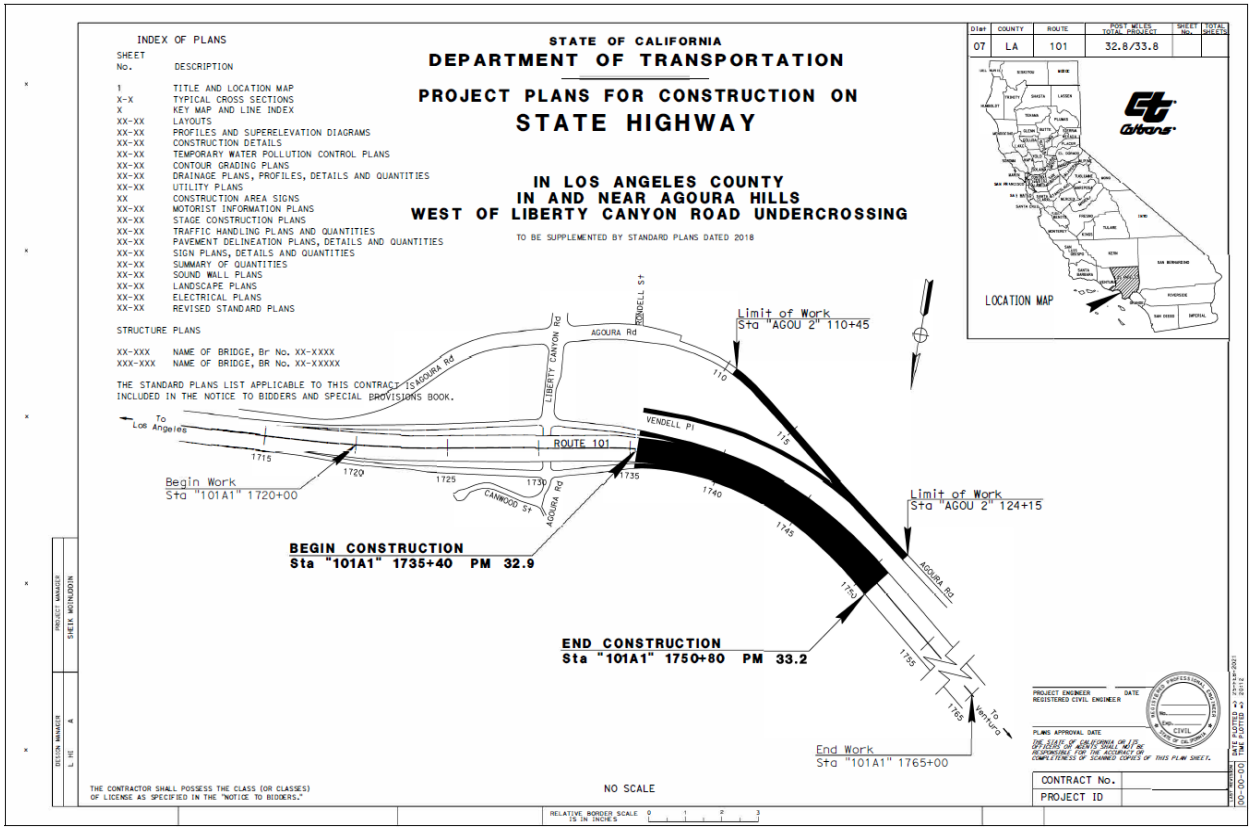
Project Limits

Biological Study Area (BSA) Map

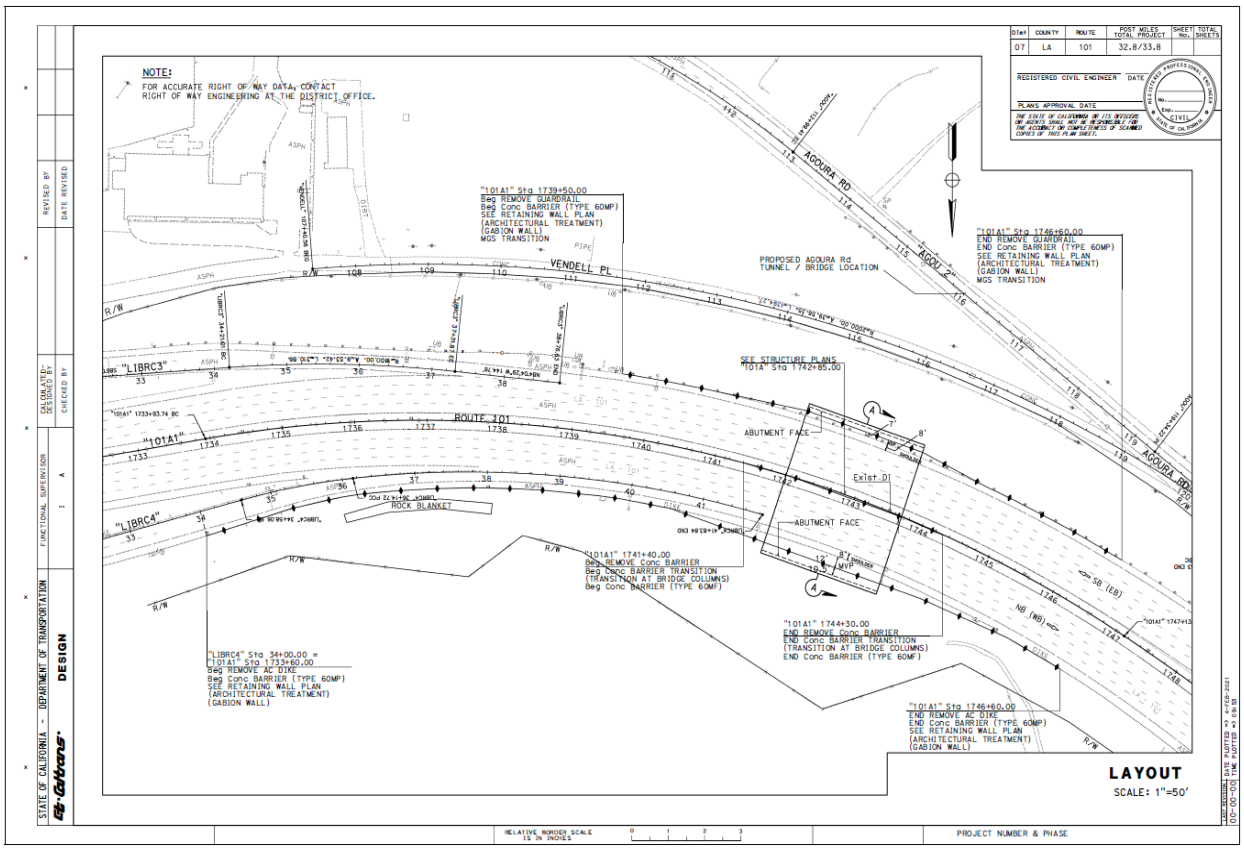


Alternative 1: Proposes to construct a 165’ x 216’ bridge across US-101, immediately west of Liberty Canyon Road.

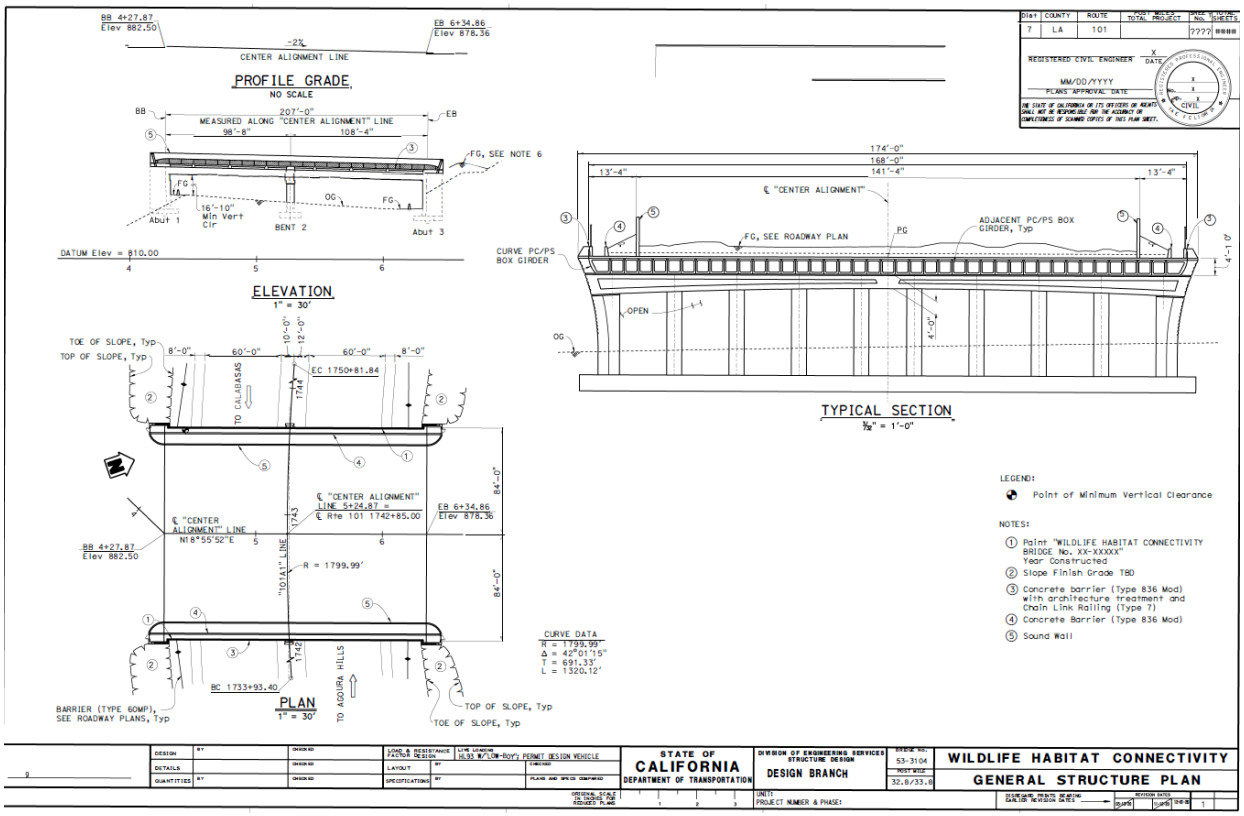
Alternative 2: Proposes to construct a 165’ x 216’ bridge across US-101, immediately west of Liberty Canyon Road, and a 200’ x 54’ x 16.5’ tunnel over Agoura Road.

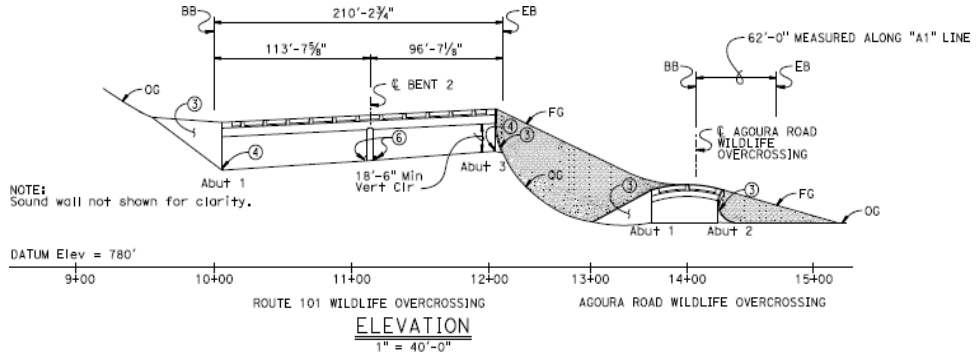


General Plan

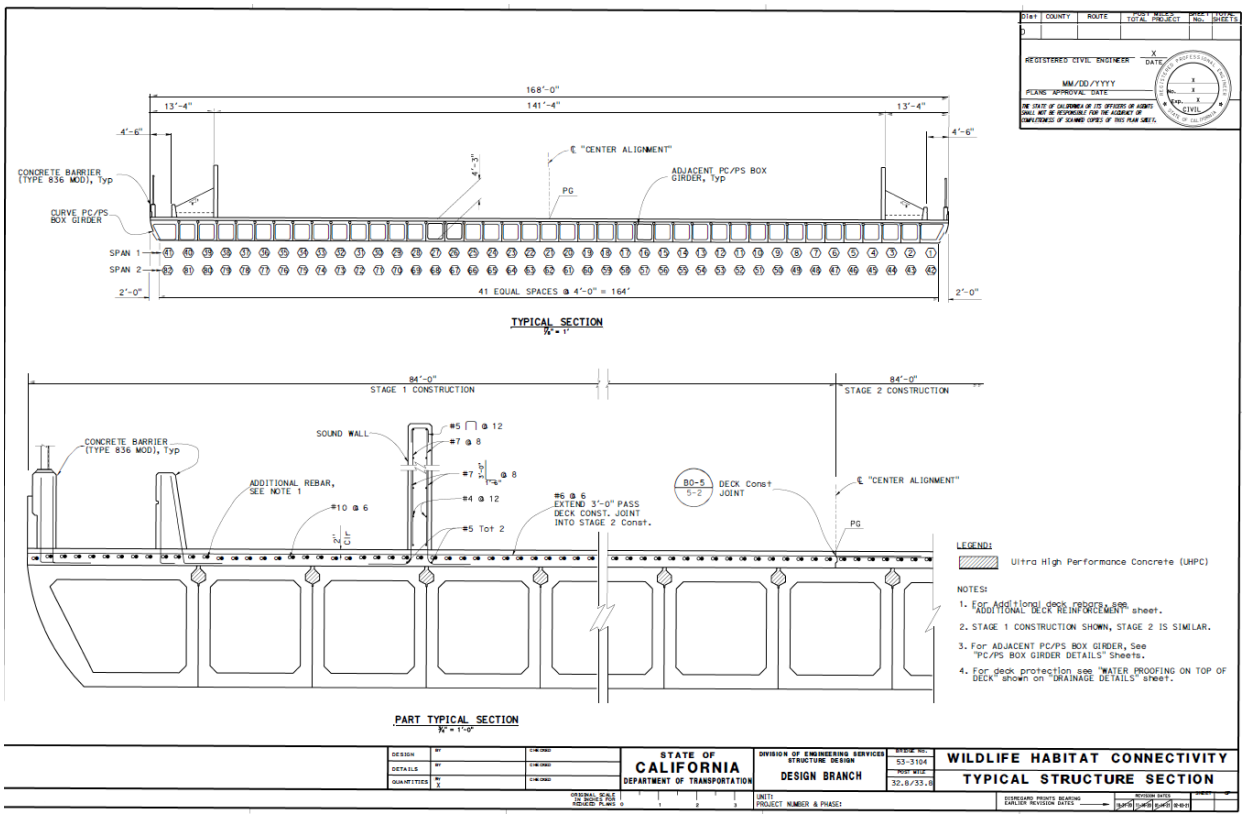

NOTE:
FOR ACCURATE RIGHT OF WAY DATA, CONTACT
RIGHT OF WAY ENGINEERING AT THE DISTRICT OFFICE.
"101A1" Sta 1739+50.00
Beg REMOVE GUARDRAIL
Beg Conc BARRIER (TYPE 60MP)
SEE RETAINING WALL PLAN
(ARCHITECTURAL TREATMENT)
(GABION WALL)
MGS TRANSITION
VENDELL PL
PROPOSED AGOURA Rd.
TUNNEL / BRIDGE LOCATION
"101A1" Sta 1746+60.00
END REMOVE GUARDRAIL
END Conc BARRIER (TYPE 60MP)
SEE RETAINING WALL PLAN
(ARCHITECTURAL TREATMENT)
(GABION WALL)
MGS TRANSITION
AGOURA RD
SEE STRUCTURE PLANS
"101A" Sta 1742+85.00
ABUTMENT FACE
Exist 01
ROUTE 101
"101A1"
"LIBRC3"
"LIBRC4"
ROCK BLANKET
"101A1" 1741+40.00
Beg REMOVE Conc BARRIER
Beg Conc BARRIER TRANSITION
(TRANSITION AT BRIDGE COLUMNS)
Beg Conc BARRIER (TYPE 60MF)
"101A1" 1744+30.00
END REMOVE Conc BARRIER
END Conc BARRIER TRANSITION
(TRANSITION AT BRIDGE COLUMNS)
END Conc BARRIER (TYPE 60MF)
"LIBRC4" Sta 34+00.00 =
"101A1" Sta 1734+60.00
Beg REMOVE AC DIKE
Beg Conc BARRIER (TYPE 60MP)
SEE RETAINING WALL PLAN
(ARCHITECTURAL TREATMENT)
(GABION WALL)
"101A1" Sta 1746+60.00
END REMOVE AC DIKE
END Conc BARRIER (TYPE 60MP)
SEE RETAINING WALL PLAN
(ARCHITECTURAL TREATMENT)
(GABION WALL)
SB (EB)
NB (WB)
LAYOUT
SCALE: 1"=50'
STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION
DESIGN
FUNCTIONAL SUPERVISOR
CALCULATED/ DESIGNED BY
CHECKED BY
REVISED BY
DATE REVISED
DIST
COUNTY
ROUTE
POST MILES TOTAL PROJECT
SHEET NO.
TOTAL SHEETS
07
LA
101
32.8/33.8
REGISTERED CIVIL ENGINEER
DATE
PLANS APPROVAL DATE
PROJECT NUMBER & PHASE

Layout

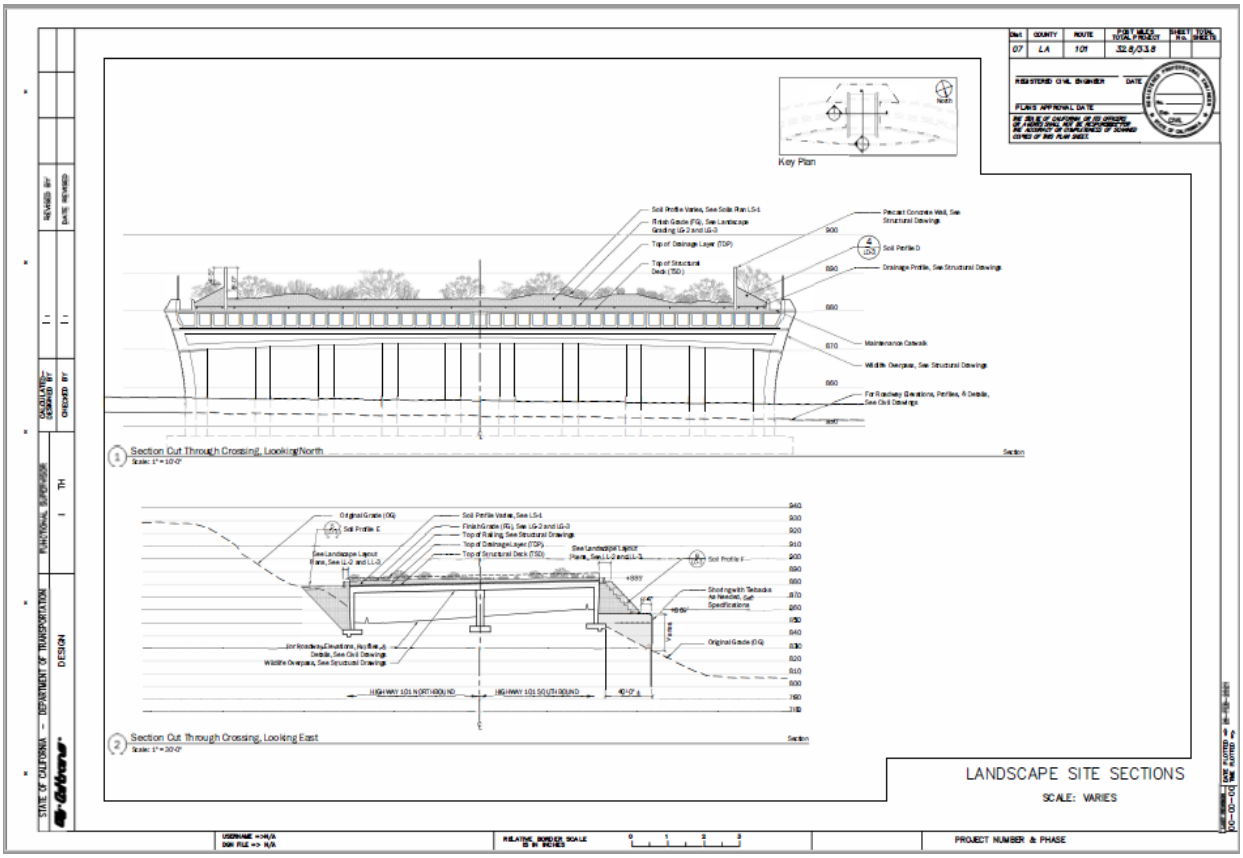




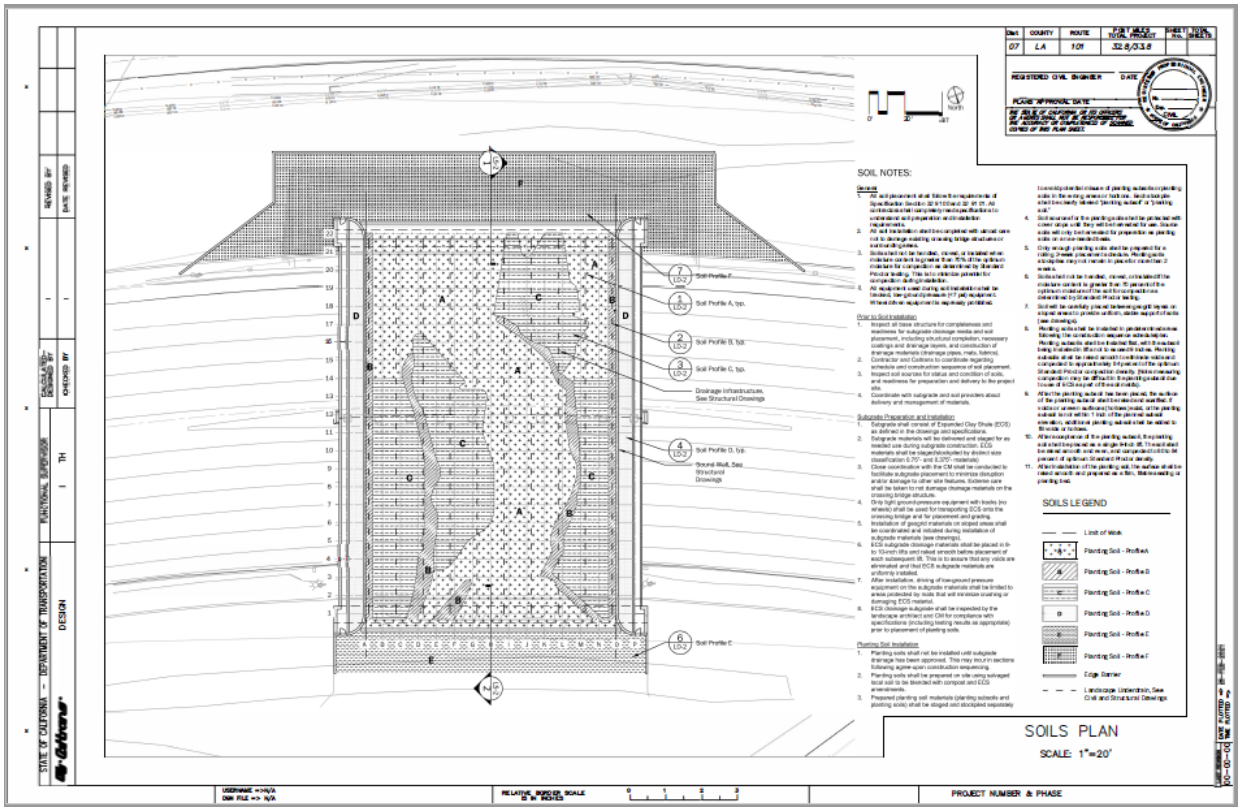
General Structure Plans



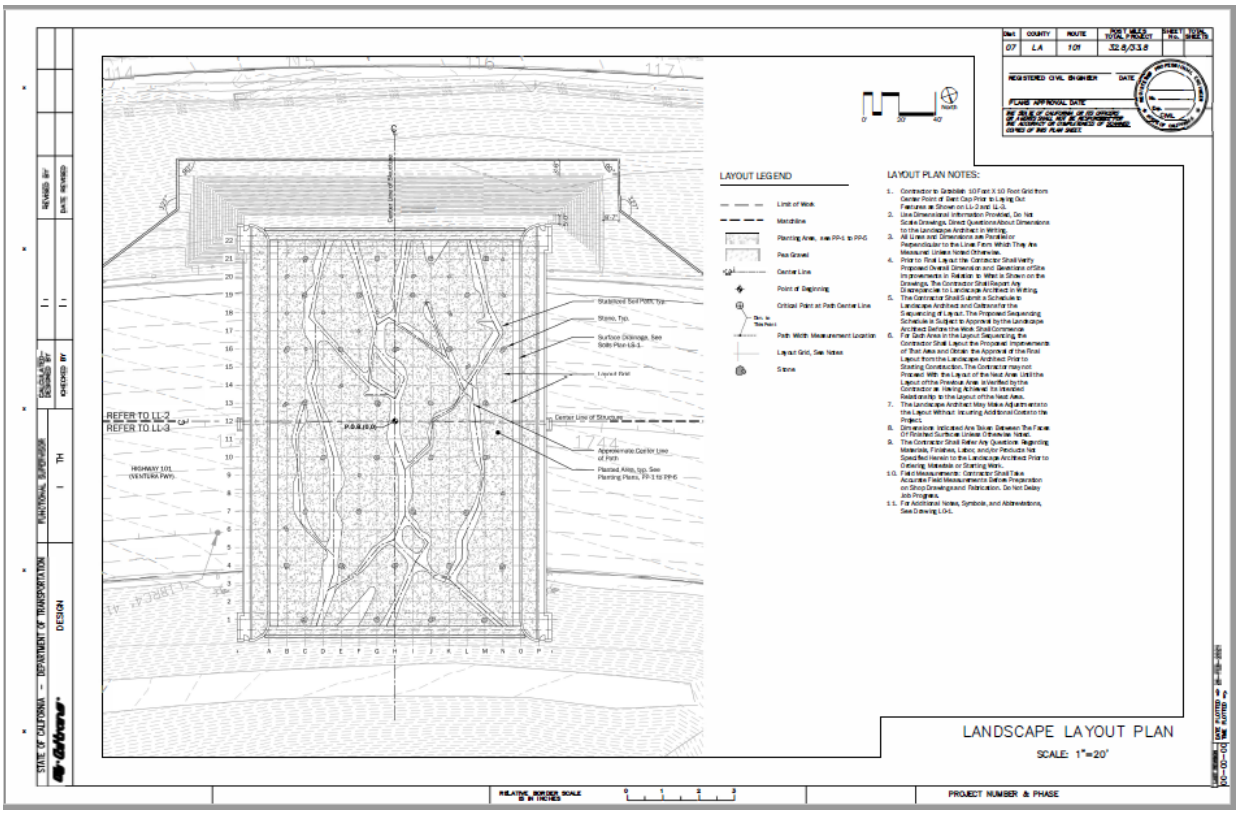
Typical Structure Section



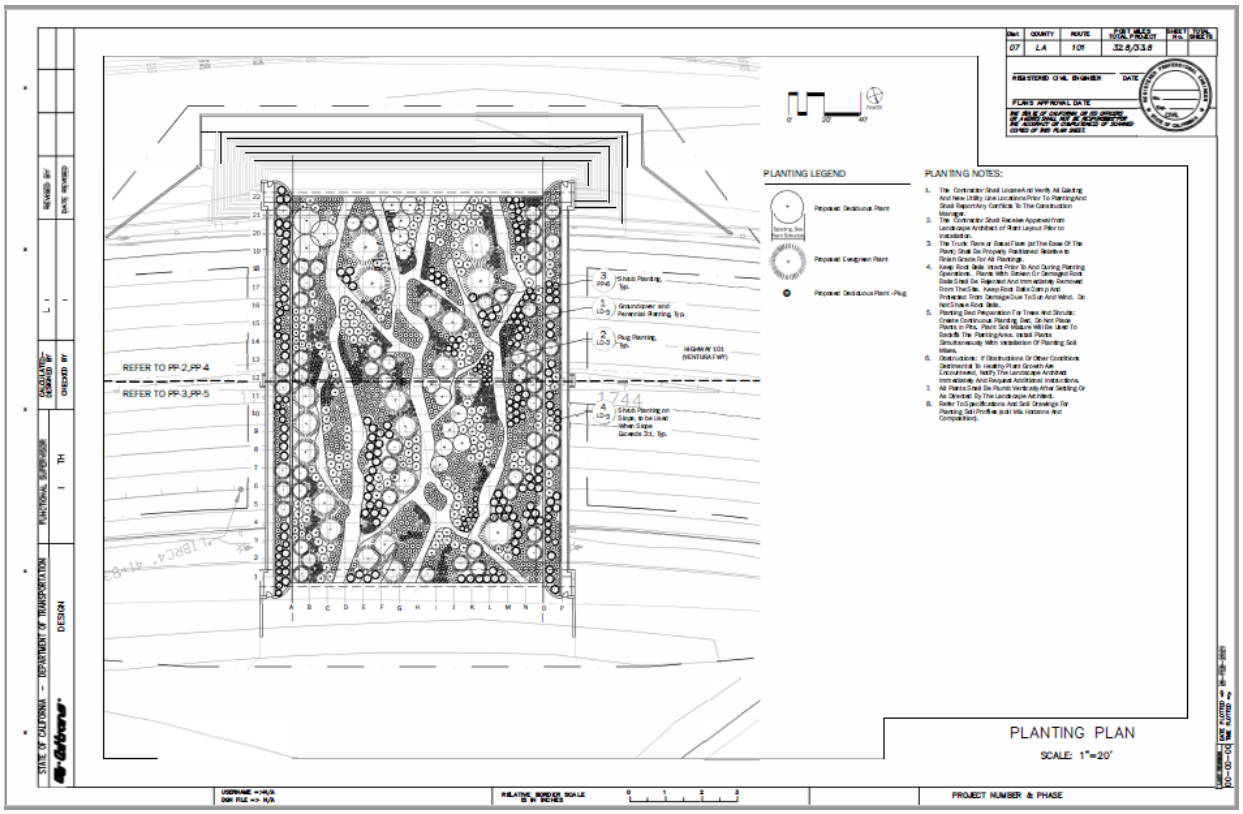
Landscape Site Sections



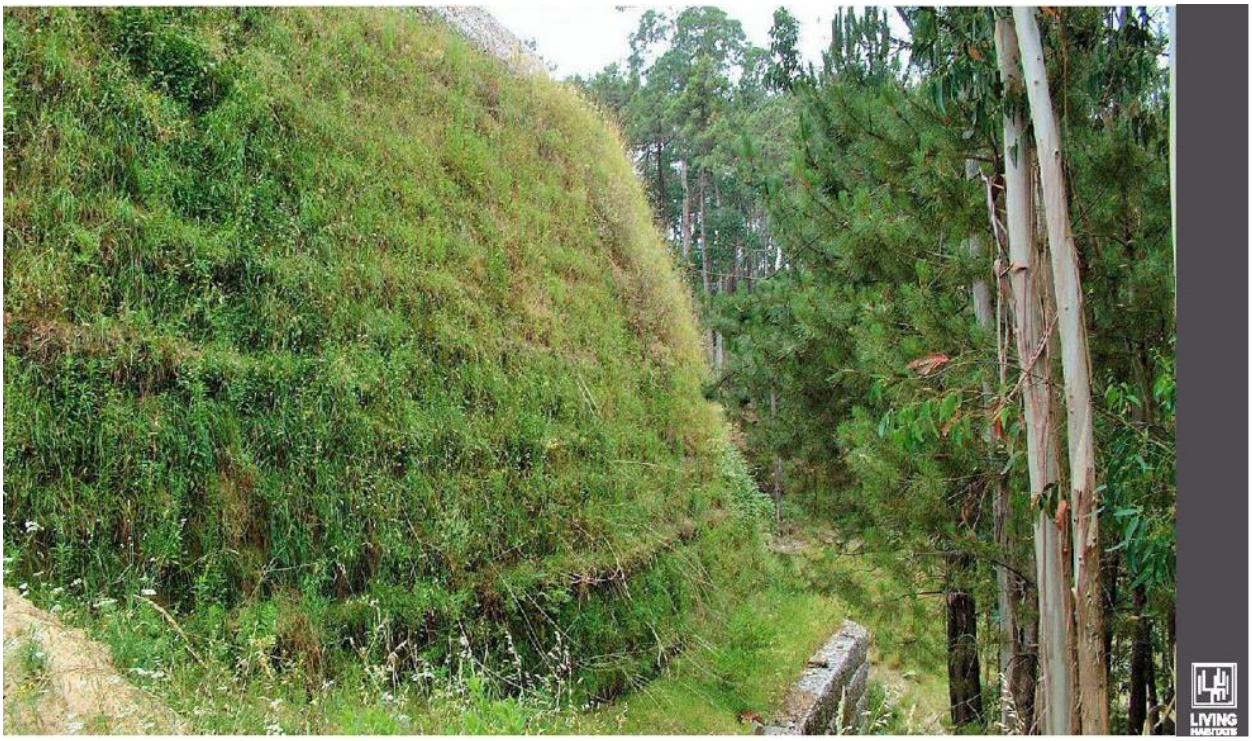
Soils Plan



Landscape Layout Plan



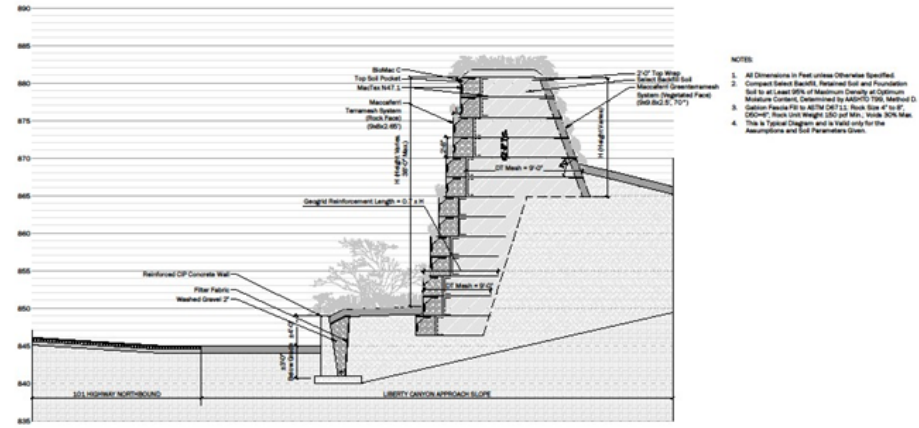
Planting Plan



Green Terramesh Gabion Wall (Vegetated Face)

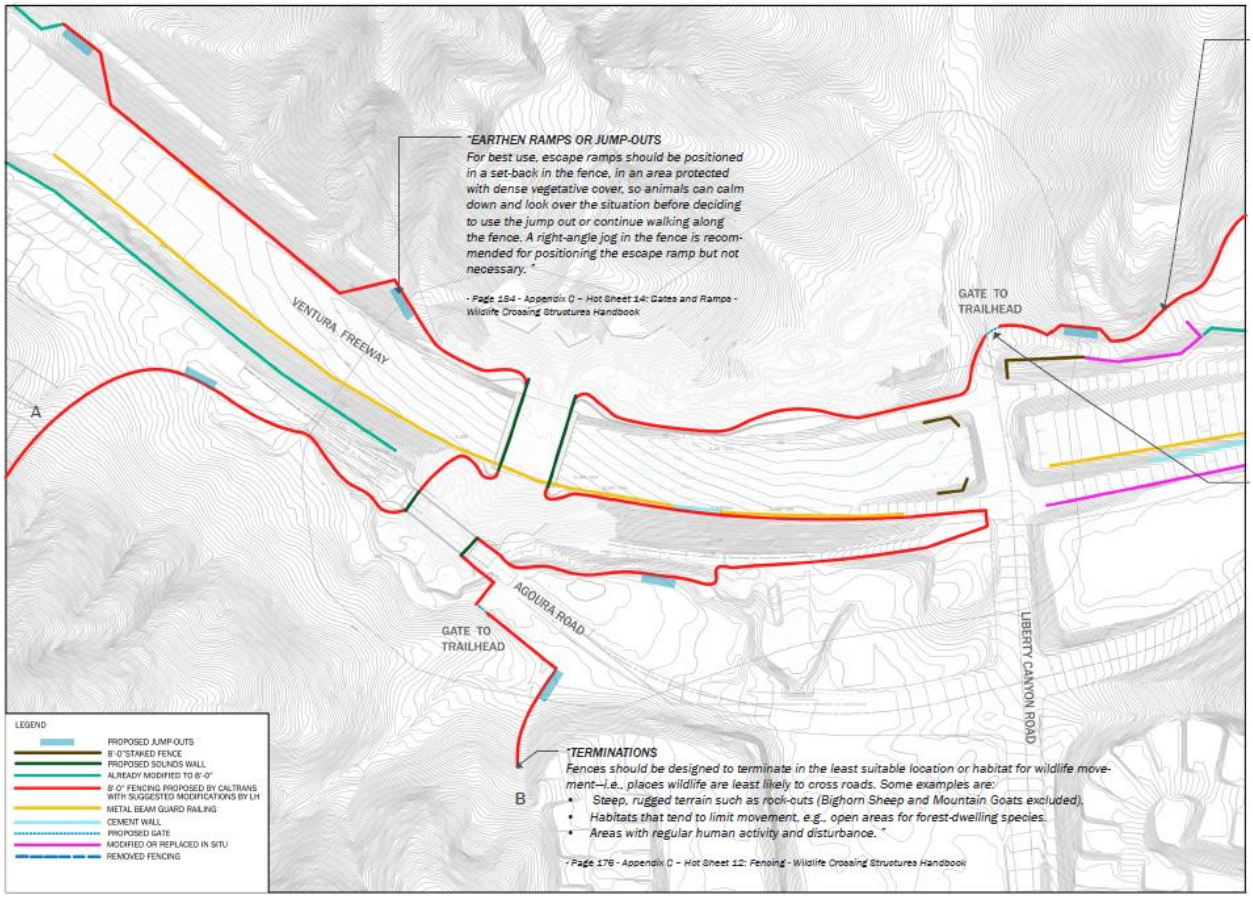
Terramesh Gabion Wall (Rock Face)

LIBERTY CANYON RETAINING WALL CROSS SECTION (ROCK FACE & VEGETATED FACE)



1 Wire Retaining Wall Cross Section

Retaining Wall Cross Section (Rock Face & Vegetated Face)



Proposed Fencing and Wall Modifications

Architectural Rendering of the Bridge with the Gabion Walls (Sound Walls)

Architectural Rendering of the Bridge

Architectural Rendering of the Bridge

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