





INTERSTATE 15 WILDLIFE CROSSINGS: DESIGN CONSIDERATIONS FOR FOCAL WILDLIFE SPECIES

Santa Ana-Palomar Mountains Linkage
Southern California

Prepared by:
The Nature Conservancy
California Department of Transportation
US Geological Survey
UC Davis Wildlife Health Center
San Diego State University
LSA Associates
Wildspring Ecology

September 2023

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Executive Summary

The Nature Conservancy (TNC) and the California Department of Transportation (Caltrans), along with landowners including San Diego State University, California Department of Fish and Wildlife, Western Riverside Regional Conservation Authority and Riverside County Flood Control District are developing wildlife crossing infrastructure projects along a 3-mile stretch of Interstate 15 (I-15) in the Santa Ana-Palomar Mountains Linkage (hereafter 'Linkage') in southern California. These crossings will provide a critical missing link that will help reconnect wildlife in the coastal Santa Ana Mountains west of I-15 with those in the interior Palomar and Eastern Peninsular ranges to the east of I-15. The Linkage supports intact and diverse habitats including coastal sage scrub, grasslands, chaparral, and oak and riparian woodlands, and has been a focus of regional conservation efforts for the last 30 years.

The three wildlife crossing infrastructure projects include enhancement of the existing Temecula Creek I-15 Bridge, construction of a new vegetated wildlife overcrossing, and construction of a new stand-alone wildlife culvert.

Given the challenges and level of financial investment required to secure wildlife crossings for I-15 in the Linkage, TNC and Caltrans proposed that planning efforts would benefit from input by taxonomic experts on design concepts that meet the needs of the broadest range of wildlife. While wildlife crossings are becoming more common, optimal designs that meet the needs of a variety of wildlife species are largely unknown and can be site specific. To address this challenge, we held a workshop in February 2022 that brought together over 50 wildlife experts to brainstorm and identify specific design considerations for various focal wildlife species groups (medium/large mammals, small animals, birds, bats, plants, and invertebrates) that might use the identified I-15 wildlife crossings (The Nature Conservancy 2022).

Lead experts for each focal species group worked together to identify specific wildlife crossing features or attributes for each of the three proposed wildlife crossings.

Specific attributes evaluated by experts for each crossing type and species group included, at a minimum:

- Crossing Structure Attributes:
  - Habitat features (cover, habitat structure, substrate, moisture, light and noise mitigation)
- Crossing Approach Area Features:
  - Habitat features (cover type/density, substrate, water, light and noise mitigation)
- Barrier design to reduce roadkill and/or to funnel wildlife to the crossing
- Additional research to resolve uncertainties related to crossing design

Based on the design considerations for each potential crossing type, the experts then weighed in on the suitability of the existing location and probability of use by their focal species or groups of species. With proposed design features, Temecula Creek Bridge has moderate or high probability of use by 27 of the 36 focal wildlife species assessed, while the vegetated overcrossing could meet the needs of 26 of the 36 species. When combined, Temecula Creek Bridge and the vegetated overcrossing have a moderate or high probability of use for 34 of the 36 species. The wildlife culvert has a moderate or high level of expected use by 10 of the 36 focal species and could serve connectivity needs for representative species from all but the bird and plant species groups.

1. Introduction

The Nature Conservancy (TNC) and the California Department of Transportation (Caltrans), along with landowners including San Diego State University, California Department of Fish and Wildlife, Western Riverside County Regional Conservation Authority and Riverside County Water Conservation and Flood Control District are planning two proposed wildlife crossing infrastructure projects along a 3-mile stretch of Interstate 15 (I-15) in the Santa Ana-Palomar Mountains Linkage (Linkage) in southern California (Luke et al. 2004). These crossings will provide a critical missing link that will help reconnect wildlife in the coastal Santa Ana Mountains west of I-15 with those in the interior Palomar and Eastern Peninsular ranges to the east of I-15 (Figure 1). The Linkage supports intact and diverse habitats including coastal sage scrub, grasslands, mixed chaparral, and oak and riparian woodlands, and has been a focus of regional conservation efforts for the last 30 years.

As stated in the Federal Highway Administration's Wildlife Crossing Structure Handbook (Clevenger and Huijser 2011): "There is currently an urgent need to provide transportation and other stakeholder agencies with technical guidance and best management practices on the planning and design of wildlife crossing mitigation measures. While wildlife crossings are becoming more common, the design of crossings to meet the needs of a variety of wildlife species is largely unknown and can be site specific".

Figure 1: Regional Location Map, I-15 Wildlife Crossing Project Locations

Given the challenges and financial investment required to secure wildlife crossings for I-15 in the Linkage, TNC and Caltrans proposed that planning efforts would benefit from input by taxonomic experts on design concepts that would meet the needs of the broadest range of wildlife. A workshop was held, bringing together over 50 wildlife experts to identify specific design considerations for various focal wildlife that might use the identified I-15 wildlife crossings.

This report presents the results of that effort, and includes background on the Linkage, focal wildlife species, wildlife crossing planning efforts to date, methods on how focal species experts evaluated wildlife crossing designs, and summary results for each focal species group and crossing type that was evaluated.

1.1 Workshop Objective

The objective of the workshop was to provide information to TNC and Caltrans for the development of new or improved wildlife crossings across I-15.

1.2 Background

The Santa Ana Mountains represent the largest block of coastal open space in the South Coast Ecoregion and support intact communities of coastal sage scrub, native grasslands, Engelmann oak woodlands, chaparral, and riparian woodland habitats as well as the Santa Margarita River, the longest free flowing river in Southern California (The Nature Conservancy 1992). This landscape supports many of southern California's rarest wildlife species, including southwestern arroyo toad (*Anaxyrus californicus*), least Bell's vireo (*Vireo bellii pusillus*), cactus wren (*Campylorhyncus brunneicapillus*), California gnatcatcher (*Polioptila californica*), and Tecate cypress (*Cupressus forbesii*). This landscape also sits at the intersection of three regional planning areas for the State of California's Natural Communities Conservation Plan in Orange, Western Riverside, and San Diego Counties (R.J. Meade Consulting, Inc. 1996, Riverside County 2003, Ogden Environmental and Energy Services 1996).

Although large, at roughly 500,000 acres, the Santa Ana Mountains and its biological diversity are at risk of degradation because it is not large enough to sustain populations of wildlife that inhabit the area nor ecosystem processes. Dr. Paul Beier, who conducted the first regional mountain lion (*Puma concolor*) study in the late 1980s, identified the need for landscape-scale connections to other southern California mountain ranges. Dr. Beier's research revealed that I-15 was a nearly impenetrable barrier for mountain lions, and that if connections across I-15 to the eastern Peninsular ranges were not restored, mountain lions of the Santa Ana Mountains would be extirpated within the next 100 years due to effects of small population size and associated inbreeding (Beier and Barrett 1993). This research has been validated by more recent studies (Benson et al. 2019) that identify an 11–21% risk of extirpation in the next 50 years due to demographic, stochastic, and environmental factors, and a probable extirpation within a median time of 12 years if inbreeding depression should occur.

The Linkage is one of 15 South Coast Missing Linkages identified by SC Wildlands that are widely considered the backbone of a regional conservation strategy for southern California, stitching together over 18 million acres of existing conservation lands. The missing linkages are critical for maintaining connected wildlife populations from Baja California Norte, Mexico to the southern Sierra Nevada and from the beaches of Marine Corps Base Camp Pendleton eastward to the deserts of Anza-Borrego Desert State Park. The 15 linkages were designed based on the habitat and movement needs of 109 focal species across the 15 priority linkages, including 26 plants, 25 insects, 4 fish, 5 amphibians, 12 reptiles, 20 birds and 17 mammals. These focal species cover a broad range of habitat and movement requirements such that planning linkages adequate for their needs is expected to cover connectivity needs for the ecosystems they represent (SC Wildlands 2008).

The Linkage is the only viable landscape connection that would link the Santa Ana Mountains and coast to the inland mountain chain that includes the Palomar, Laguna, Santa Rosa, and San Jacinto ranges. The Linkage sits at the San Diego-Riverside County line and supports a band of habitat roughly 16 miles long from west to east and 4 miles wide at its narrowest point where it intersects I-15. The Linkage extends from Marine Corps Base Camp Pendleton, Fallbrook Naval Weapons Station, and the Trabuco Ranger District of the Cleveland National Forest (CNF) in the west to the Palomar Ranger District of the CNF and Agua Tibia Wilderness in the east and encompasses riparian and upland habitats (Luke et al. 2004). The Linkage design was informed by a suite of focal species that represented the widest range of movement needs and ecosystem function. Focal species represent diverse taxonomic groups and include both common and rare species, with the goal of maintaining common species and enhancing the resilience of rare species (SC Wildlands 2008). Table 1 lists the focal species originally identified by the SC Wildlands linkage design in 2004 as well as those added by species experts in 2022. Appendix B provides a list of the focal plant and wildlife species with special federal or state regulatory status.

Common Name	Scientific Name
Medium/Large Mammals	
American badger	*Taxidea taxus*
Bobcat	*Lynx rufus**
Coyote	*Canis latrans**
Gray fox	*Urocyon cinereoargenteus**
Mountain lion	*Puma concolor*
Ringtail	*Bassariscus astutus**
Southern mule deer	*Odocoileus hemionus fuliginatus**
Small Animals	
Arroyo toad	*Anaxyrus californicus**
Big-eared woodrat	*Neotoma macrotis*
Blainville’s horned lizard	*Phrynosoma blainvillii**
California tree frog	*Pseudacris cadaverina*
Red diamond rattlesnake	*Crotalus ruber*
Western gray squirrel	*Sciurus griseus**
Western pond turtle	*Actinemys pallida*
Western spadefoot toad	*Spea hammondii**
Western toad	*Anaxyrus boreas halophilus*
Bats	
Big brown bat	*Eptesicus fuscus**
Pallid bat	*Antrozous pallidus**
Birds	
California gnatcatcher	*Polioptila californica**
Cactus wren	*Campylorhyncus brunneicapillus**
California quail	*Callipepla californica*
California thrasher	*Toxostoma redivivum**
Greater roadrunner	*Geococcyx californianus**
Hawks/Owls	*Accipitridae/Strigidae**
Least Bell’s vireo	*Vireo bellii pusillus*
Oak titmouse	*Baeolophus inornatus**
Wrentit	*Chamaea fasciata**
Yellow warbler	*Setophaga petechia*
Plants and Invertebrates	
California sister	*Adelpha californica*
Chaparral yucca	*Hesperoyucca whipplei*
Comstock’s fritillary	*Speyeria callippe comstocki*
Engelmann oak	*Quercus engelmannii*
Jerusalem cricket	*Ammopelmatus* spp.*
Monarch butterfly	*Danaus plexippus**
Pale swallowtail	*Papilio eurymedon*
Rainbow manzanita	*Arctostaphylos rainbowensis*
Timema walking stick	*Timema podura**

Table 1: Santa Ana-Palomar Linkage Focal Species Assessed during February 2022 Workshop process. Focal species added by species experts are asterisked (*).

1.3 Wildlife Crossing Infrastructure Planning Efforts

Wildlife connectivity needs within the Linkage have been addressed by stakeholders through significant research and planning, including strategic land protection and the identification of locations and concepts for wildlife crossing structures for I-15.

Numerous studies have been conducted to evaluate the best location along I-15 for a wildlife crossing structure (Gibbons 2008, Tracey et al. 2011, Zeller et al. 2016, Riley et al. 2018). In addition, camera monitoring studies conducted at existing drainage culverts along I-15 (Stricker 2015, Regional Conservation Authority 2013, Vickers et al. 2020) have documented numerous wildlife species on both sides of I-15, including bobcat (*Lynx rufus*), coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), ringtail (*Bassariscus astutus*), spotted skunk (*Spilogale gracilus*), striped skunk (*Mephitis mephitis*) and mountain lion, with only a few instances of wildlife using existing culverts to get to the other side of the highway. Stricker (2015) identified ringtail moving through a 4-foot culvert, while Vickers (unpubl. data) documented at least three separate instances of a three-legged coyote moving through a 4-foot culvert approximately 1.5 miles south of the Temecula Creek Bridge. In October of 2021, and again in October 2022, camera traps set up along Temecula and Pechanga Creeks documented a mountain lion successfully moving eastward under the Temecula Creek Bridge, with the October 2021 lion documented further to the east in Pechanga Creek (Vickers 2022).

Thus, while mountain lions and other wildlife have been documented on both sides of the highway, existing crossing structures appear to be inadequate to allow regular safe passage. While regular accounting of wildlife mortalities is not conducted for I-15, four known fatalities of mountain lion by vehicle strikes were documented along a 6-mile stretch of I-15 between 2017 and 2020 (Vickers et al. 2020).

In response to wildlife mortality from vehicle strikes, Caltrans (District 8) installed wildlife exclusion fencing along both sides of I-15 from the Temecula Creek Bridge southward to the San Diego County border as part of a highway pavement repair project in 2020. The installation of wildlife exclusion fencing has increased the urgency to plan, secure funding for, and implement needed wildlife crossing structures.

Data from studies as well as expert opinion have prioritized three locations for enhanced or new wildlife crossing structures: one at the north end of the Linkage to enhance the function of the existing Temecula Creek Bridge, and two locations 1.3 miles to the south, for a new wildlife undercrossing and a new vegetated wildlife overcrossing (Riley et al. 2018).

In 2019, UC Davis received a planning grant from the California Department of Fish and Wildlife to work with student teams and faculty from Cal Poly Pomona School of Civil Engineering and Caltrans to develop concepts and feasibility studies for these three prioritized wildlife crossing locations along I-15 (Vickers et al. 2020).

Below are summaries of the design concepts developed by Cal Poly Pomona, depicted in Figures 2 and 3 (Cal Poly Pomona 2019). Riley et al. (2018) recommended that a minimum of two wildlife crossings, including Temecula Creek Bridge and either a new culvert or vegetated overcrossing, be pursued to meet the needs of the broadest range of wildlife species. To this end, TNC is developing design specifications for Temecula Creek Bridge, while Caltrans is developing design plans and assessing alternatives for either a new culvert or overcrossing. All crossing structures may include installation of barriers along the highway to shield noise and light from the highway, which are known issues at each location (Shilling et al. 2022).

<u>Temecula Creek Bridge</u>

Tributaries to the Santa Margarita River, Temecula Creek and Pechanga Creek, are currently the only viable connections between the Santa Ana and Palomar Mountains and are the only riparian connection in the Linkage that could serve the needs of both aquatic and terrestrial wildlife. Temecula Creek is in the upper watershed of the Santa Margarita River and supports a diverse riparian habitat composed of emergent wetland, willow (*Salix* spp.), cottonwood (*Populus fremontii*), and coast live oak (*Quercus agrifolia*) woodlands typical of the region (ICF 2023). To the east of I-15, Pechanga Creek, which flows out of the Palomar Mountains, connects to Temecula Creek. The I-15 Temecula Creek Bridge spans Temecula Creek downstream of its confluence with Pechanga Creek and before its confluence with Murrieta Creek, which creates the Santa Margarita River. The bridge system is composed of two separate bridges for north and south-bound traffic lanes. Each individual bridge has four travel lanes with right and left shoulders, spans approximately 65 feet wide, and has 50-foot open-median baton-bridge decks. The bridge length is approximately 310 feet, and the height is approximately 50 feet (ICF 2023). Land ownership at this crossing location consists of California Department of Fish and Wildlife, San Diego State University, Caltrans, Western Riverside County Regional Conservation Authority, and Riverside County Flood Control and Water Conservation District.

Because riparian areas are natural dispersal corridors that can span elevational gradients, Temecula Creek may facilitate wildlife movement in response to a warming climate (Jennings et al. 2020). Rojas et al. (2021) identified Temecula Creek as an important linkage between refugia from multiple climate and non-climate stressors. Despite its values, Temecula Creek currently functions poorly as a wildlife corridor due to several issues, the biggest of which is frequent human presence. Human activity can deter wildlife use of natural areas and crossing structures (Murphy-Mariscal et al. 2015, Larson et al. 2016, Longcore et al. 2018) while urban runoff from upstream development can degrade water quality by the addition of chemicals, pollutants (e.g., nitrogen and phosphates from fertilizers), trash, and other debris (Larry Walker and Associates 2018). In addition, Temecula and Pechanga Creeks are inhabited by invasive exotic plants such as pampas grass (*Cortaderia selloana*), which can be inhospitable to wildlife and choke water flows. Light and traffic noise associated with I-15 are also likely deterring wildlife use of this crossing (Shilling et al. 2022).

To address these challenges at Temecula Creek, Cal Poly Pomona student engineers developed concept plans to enhance the function of a 58-acre area of Temecula and Pechanga Creeks, including under Temecula Creek Bridge, as a wildlife corridor (Cal Poly Pomona 2019). Design concepts for the crossing included fencing and signage at the urban interface to deter trespass, exotic plant control for pampas grass and other weeds that have displaced native riparian habitat, restoration of riparian woodland, and recommendations for measures to reduce traffic noise associated with I-15.

TNC received a grant from the State of California Wildlife Conservation Board to conduct baseline vegetation, wildlife, and noise studies for Temecula and Pechanga Creeks, and to use the Cal Poly Pomona Engineering School design concepts to produce detailed plans and complete the permitting requirements for a shovel-ready project by the end of 2023.

<u>Wildlife Culvert</u>

The proposed location evaluated for a new wildlife culvert intersects small drainages on both sides of the highway. Camera data from these drainages indicate activity by a wide range of wildlife species (Vickers et al. 2020). The new structure would be located close to, but would not replace, an existing culvert structure and would be designed primarily for wildlife use. To the east of I-15, the proposed undercrossing location supports coastal sage scrub, chaparral and a riparian/oak woodland drainage that flows to the north. West of I-15, the proposed crossing location supports a small drainage with intact oak woodland, chaparral, and rock outcrops. The culvert designed by Cal Poly Pomona students included a 12-foot by 12-foot box culvert or an 8-foot high by 11-foot-wide arched corrugated pipe, both with soil on the bottom, which would reduce the overall height but would promote wildlife usage. The Cal Poly designs would include a concrete lined drain on the side of the structure to facilitate water flows. The structure would be slightly elevated on the west side to prevent inundation. Students also investigated the potential for a larger arched culvert with a natural bottom at this location, but this was determined to be infeasible due to traffic-related construction constraints. Caltrans is currently considering a 15 x 15-foot-wide wildlife culvert design. Land ownership at the proposed wildlife culvert location consists of San Diego State University, Western Riverside County Regional Conservation Authority, Caltrans, and The Nature Conservancy.

Figure 2: Wildlife Culvert Concept Design. Cal Poly Pomona. 2019.

Vegetated Wildlife Overcrossing

Just 0.1 mile south of the proposed wildlife culvert location is the proposed site for a vegetated overcrossing. Wildlife crossing experts suggested that this is the best location for an overcrossing because there are elevated benches on either side of the highway that could serve as anchor points for support (Gibbons 2008, Riley et al. 2018).

Figure 3: Vegetated Wildlife Overcrossing Design, Cal Poly Pomona. 2019.

Cal Poly Pomona produced engineering feasibility and preliminary design concepts for the vegetated overcrossing, which would span 10 lanes of highway (235 feet) and would be up to 165 feet wide, similar to the Wallis Annenberg Wildlife Crossing currently under construction, which will span Highway 101 in northern Los Angeles County. The overcrossing would include roughly 4 feet of engineered soil on top of the structure, which would require that plantings be shallow rooted. The student design also included berms on the edges of the crossing structure to buffer sound and light. Land ownership at the proposed vegetated wildlife overcrossing location consists of San Diego State University, Western Riverside County Regional Conservation Authority, Caltrans, and The Nature Conservancy.

Caltrans will prepare an alternatives analysis, technical studies, and environmental document for the wildlife culvert and vegetated overcrossing. Additional alternatives for the overcrossing and culvert have since been developed. Final engineering and construction documents for the preferred alternative (vegetated overcrossing or wildlife culvert) will follow and are expected to be completed by the end of 2026, pending funding availability.

2. Methods

For the workshop, focal species were broadly classified into 5 groupings for assessment by species experts: medium/large mammals, birds, bats, small animals (smaller bodied mammals, herpetofauna) and plants/invertebrates. Lead experts for each group were enlisted to develop the workshop format, solicit additional experts to participate in the workshop process for their focal species group, and facilitate, gather, and summarize expert input as part of the workshop process. Table 2 provides a listing of experts and facilitators for each species group. Appendix A provides a full listing of the species experts and their professional affiliations.

Workshop planners and lead experts gathered background data, maps, literature, reports, and drone footage of the crossing locations (Dudek 2021) and provided the information to workshop participants in advance of the workshop.

Lead experts worked together to identify specific attributes for evaluation by species groups for each of the three proposed wildlife crossings (Temecula Creek Bridge, vegetated overcrossing, wildlife culvert).

Attributes for each crossing type and species group included, at a minimum:

- Crossing Structure Attributes
  - Habitat features (cover type/density, habitat structure, substrate, moisture, light and noise mitigation, etc.)
- Crossing Approach Area Features
  - Habitat features (cover type/density, substrate, water, light and noise mitigation, etc.)
- Barrier design to reduce roadkill and/or to funnel wildlife to the crossing
- Other features critical to promote wildlife use
- Additional research to resolve uncertainties related to crossing design

Based on the input provided by the species experts for each potential crossing type, the groups then weighed in on the suitability of the existing location and probability of use by their focal species or group of species.

Medium/Large Mammals	Birds	Bats	Small Animals	Plants/Invertebrates
Megan Jennings (Co-Lead)	Barbara Kus (Lead)	Jill Carpenter (Lead)	Cheryl Brehme (Lead)	Spring Strahm (Lead)
Winston Vickers (Co-Lead)	John Taylor (Facilitator)	Trish Smith (Facilitator)	Sally Brown (Facilitator)	Kristeen Penrod (Facilitator)
Michelle Mariscal (Facilitator)	Melody Aimar	Alisha Curtis	Nancy Frost (Facilitator)	Allison Anderson
Eric Abelson	Peter Beck	Tim Dillingham	Adam Backlin	Greg Ballmer
Devin Adsit-Morris	Robb Hamilton	Stephanie Remington	Denise Clark	Pablo Bryant
Paul Beier	Gjon Hazard	Drew Stokes	Rulon Clark	Lauren Jonker
Kevin Crooks	Melanie Madden	Greg Tatarian	Katy Delaney	David Lipson
Justin Dellinger	Nicholas Peterson		Liz Fairbank	Dan Marschalek
Calvin Duncan	Kris Preston		Robert Fisher	Eric Porter
Julie King	Phil Unitt		Steve Montgomery	Gordon Pratt
Barry Martin			Will Miller	Zach Principe
JP Montagne			Debra Shier	Jessie Vinje
Brock Ortega			Scott Tremor	Susan Wynn
Dustin Pearce				
Seth Riley				
Carlton Rochester				
Fraser Shilling				
Jessica Sanchez				

Table 2: Lead Experts, Facilitators and Participating Species Experts for each Focal Wildlife Species Group

3. Results

3.1 Medium and Large Mammals

Importance of Wildlife Crossings for Medium and Large Mammals

Medium and large mammals are important to include when planning for connectivity because they tend to be wide-ranging, are sensitive to fragmentation by roads, and normal movements often result in encounters with infrastructure, particularly roads. Large and medium mammalian carnivores function as primary predators that affect prey populations ranging from small rodents to large herbivores and other carnivores, and the effects of roads interfering with carnivore movement behaviors can reverberate through the food web.

Focal Medium and Large Mammal Species

Medium and large mammals identified in the SC Wildlands report included mountain lion and American badger (*Taxidea taxus*). The mountain lion has guided much of the connectivity research in the Linkage since the early 1990s, as its population in the Santa Ana Mountains is known to be at risk of extirpation unless connectivity is restored to the eastern Peninsular Ranges (Beier and Barrett 1993). Based on known occurrences in the area and to ensure that crossing structures facilitate movement for a range of medium and large carnivores, experts added the following focal species: ringtail, coyote, gray fox, and bobcat. The southern mule deer (*Odocoileus hemionus fuliginatus*) was also added due to its importance as mountain lion prey and to increase its own regional connectivity (Mitelberg et al. 2019).

Probability of Use of Crossing Type by Focal Medium and Large Mammals

When considering wildlife crossing use by medium and large mammals, it is important to evaluate designs that support connectivity for daily movements, seasonal movements, dispersal, gene flow, and range shifts due to threats such as climate change or wildfire.

Experts evaluated the probability of use by focal medium/large mammals of all crossing types with the planned improvements based on occurrence information in the vicinity of the crossings (documented by available scat, track and camera trap data), the likelihood of a species encountering the structures based on habitat associations, and prior knowledge of species' responses to crossing structure designs elsewhere.

Based on the medium and large mammal expert group evaluation, the **Temecula Creek Bridge** plan has a high probability of use by mountain lion, mule deer, bobcat and coyote, and a moderate probability of use by gray fox, ringtail, and badger. Although mule deer have not been documented in Temecula Creek, they have been documented on lands farther to the east and west of I-15 and the large, open design of the bridge is well-suited for this species. Camera and radio collar data show that mountain lions approach Temecula Creek Bridge from the west fairly frequently, and recently a mountain lion used the I-15 underpass to reach Pechanga Creek. Coyotes are regularly documented at camera traps in Temecula Creek, as are bobcats and gray fox, although less frequently than coyotes (Vickers 2022).

Ringtail have not been documented on camera traps in Temecula Creek, though they have been documented to the south along I-15 between Temecula Creek and the proposed sites for a new wildlife crossing. The absence of ringtail in Temecula Creek itself is likely due to the lack of continuous tree canopy in the creek and the lack of boulders or crevices for hiding. Badgers have also not been confirmed in the vicinity of I-15 or Temecula Creek, although one workshop participant noted that they had seen badger sign just west of the I-15 Temecula Creek Bridge in 2007. Badgers have occasionally been documented using riparian corridors for long distance movements. In addition, the friable, loamy substrate in Temecula Creek and adjacent grasslands provides suitable habitat for burrowing.

The **wildlife culvert** design has a high probability of use for all species except mule deer and badger. Mountain lion, coyote, bobcat, and gray fox are all expected to use the wildlife culvert if there are natural travel routes leading to the entrances, such as along paths or drainages. Ringtails are also expected to use the wildlife culvert, as they have been documented using an existing 4-foot culvert along I-15 just north of the proposed wildlife culvert location (Stricker 2015). For ringtail, the presence of boulders and oaks in the vicinity of the crossing entrance may increase the probability of use. There is a question as to the suitability of habitat for deer in the area near the proposed culvert. Current use of the area by deer appears to be very low. Similarly, there are no records of badger in the vicinity of the proposed wildlife culvert location. Given the unsuitable soil conditions (compacted decomposed granite) in the approach areas, experts determined there was only a moderate probability of use of the culvert by badgers, although the structure itself may facilitate badger passage.

The proposed **vegetated overcrossing** has a high probability of use by coyote, gray fox and bobcat, and a moderate probability of use by mountain lion, mule deer, and ringtail. Noise and light impacts on the approach slopes are the most limiting factors for mountain lions. If deer use in the vicinity of the proposed overcrossing increases, individuals would likely approach and use the structure due to its open character. More research is needed to understand crossing design features for ringtail. Cover on the overcrossing itself will also be a factor in balancing the crossing needs of mountain lion, gray fox, and coyote. Badgers are unlikely to use the crossing, due to a lack of occurrence records and poor soil conditions in the immediate area.

Species	Temecula Creek Bridge	Wildlife Culvert	Vegetated Overcrossing
American badger	M	M	L
Bobcat	H	H	H
Coyote	H	H	H
Gray fox	M	H	H
Mountain lion	H	H	M
Ringtail	M	H	M
Southern mule deer	H	L	M

Table 3: Probability of use of each crossing type by medium and large focal mammals: High (H), Moderate (M), Low (L). Scientific names are in Table 1.

Crossing Design Features to Encourage Use by Medium and Large Mammals

In assessing design elements of each crossing and approach area for medium and large animals, experts considered species' needs related to vegetation type and cover, movement behaviors, prey species, and the impacts of human activity and disturbance from the roadway.

Temecula Creek Bridge

To increase the likelihood of use of Temecula Creek by mountain lion, mule deer, bobcat, gray fox, and coyote, experts proposed measures to deter human use of the area by erecting security fencing at the perimeter of developed areas, controlling invasive plants, and managing understory vegetation to improve visibility and access to the crossing. Improving visibility through the crossing is particularly important for deer, which typically avoid high cover areas where they may be susceptible to predation. In addition, experts proposed measures to reduce lighting and noise associated with I-15 and adjacent residential uses. Some experts identified that the water treatment plant just west of the Temecula Creek

Bridge could be a potential deterrent due to lights and odors and may require management. Because the creek can have periods of water inundation, experts proposed incorporating dry ledges under the bridge to accommodate terrestrial wildlife movement. Maintaining smaller prey under and around the bridge will also be important for focal medium and large carnivores. To enhance the function of Temecula Creek for ringtail, suggestions included the removal of invasive plants, and adding oaks and other trees, boulders, logs or other structures. To accommodate the differing needs of species preferring more open or closed vegetation, different segments of the bridge span could be managed to achieve different levels of cover. For example, one section could be managed to be more open to enhance visibility for wildlife while the other section could be managed to retain more vegetation to achieve a closed canopy. In addition, the smooth wire on the cantilevered section of the I-15 exclusion fencing could be replaced with fine mesh to prevent ringtail and gray fox from climbing over into the highway. Also, it would be prudent to conduct regular inspections of the lower section of the I-15 exclusion fencing to ensure that wildlife are not able to burrow under it.

Wildlife Culvert

To encourage use of the wildlife culvert by mountain lion, coyote, gray fox, and bobcat, experts proposed that natural pathways leading to the crossing structure be maintained or created. In addition to the above design elements, a culvert of at least 15 x 15 feet would maximize natural light in the culvert and increase the likelihood of use by mule deer. For ringtail, it will be important to locate the culvert entrances in areas with adjacent boulders and trees and to replace any of these features if they are removed by construction. In addition, incorporating water features (proposed for other focal species) in the approach areas and within the culvert itself may attract ringtails. While lights have been recommended in other locations to increase visibility within the culvert for some species, ringtails prefer a dark environment. It was also proposed that the existing nearby drainage culvert be maintained to carry the bulk of existing water flows, allowing the wildlife culvert to function solely for wildlife passage. The wildlife culvert would be most effective if it is slightly elevated above the drainage inlet on the west side so that it does not become inundated during heavy rainfall events. It was suggested that the wildlife culvert incorporate a natural soil bottom with a small channel on one side to carry low flows. Finally, sound dampening treatments within the culvert as well as noise and light barriers along the highway at the crossing would increase probability of use.

Vegetated Overcrossing

Features to encourage use of the overcrossing by the widest range of focal medium and large mammal species include creating areas of varying cover where feasible, including small and large shrubs, occasional trees where the root systems can be accommodated, boulders (artificial boulders are fine if weight is an issue) and logs to provide shelter as well as habitat for prey species. It will be important to determine the right balance of cover that will shelter more cryptic species such as gray fox but will also attract other taxa that prefer more open habitat. As with the undercrossing, creating and maintaining pathways to the crossing are proposed to guide wildlife to the crossing. Barrier walls at least 10 feet in height are proposed for both along I-15 in the approach area and on the edges of the structure to prevent climbing, noise, and light.

<u>Areas For Additional Study</u>

- Evaluate the need for creating game trails to the crossings to attract large/medium animals. Would such paths only serve to attract human trespass? Is it possible to modify the habitat somewhat to facilitate access by medium and large mammals without creating trails? Could the creation of game trails be implemented as an adaptive management strategy after crossings are in place?

- Research potential movement pathways for badger by locating nearest suitable habitat east and west of I-15.
- Expand existing regional modelling for mule deer to better understand connectivity between the Santa Ana and Eastern Peninsular Ranges.
- Conduct research to better understand ideal crossing features for ringtail for all crossing types.
- Develop methodology to monitor human presence and its effect on wildlife crossing use by focal species.

3.2 Small Animals

Importance of Wildlife Crossings for Small Animals

Major highways are barriers to most terrestrial small animal species, because they often move shorter distances and are slower moving, making them susceptible to roadkill. These factors require that highway crossings for small animals incorporate both shelter and foraging habitat.

A connected and diverse small animal community assemblage is an important part of ecosystem function and resilience, and it is likely that if small animals use a crossing structure, their predators and larger fauna will use the crossing as well.

Focal Small Animal Species

A wide variety of small animal focal species was identified in the SC Wildlands report including reptiles, amphibians, and small mammals with varying conservation status and representing both terrestrial and semi aquatic species. Focal small animal species were categorized as either terrestrial or semi aquatic for wildlife crossing planning purposes (Table 4). Focal small animal species that were added by stakeholders or small animal experts to the list developed by SC Wildlands include arroyo toad, Blainville's horned lizard (*Phrynosoma blainvillii*), western spadefoot toad (*Spea hammondii*), and western gray squirrel (*Sciurus griseus*).

Experts identified that focal species could serve as umbrella species for a wider suite of small animals. For example, the red diamond rattlesnake (*Crotalus ruber*) could serve as an umbrella species for other snake species and/or for other small terrestrial animals that prefer open habitat.

All terrestrial and semi aquatic species have different habitat requirements that were considered when assessing their connectivity needs. For example, some terrestrial and semi aquatic species prefer open habitat, while others prefer more closed habitat.

Terrestrial species included specialists that require open habitat for thermoregulation and foraging (Blainville's horned lizard, red diamond rattlesnake) and those that require large shrubs and/or tree cover for their general habitat and dietary needs (big-eared woodrat [*Neotoma macrotus*], gray squirrel). Semi-aquatic species, which include the western spadefoot toad, arroyo toad, western toad, California tree frog (*Pseudacris cadaverina*), and western pond turtle (*Actinemys pallida*), use both aquatic and terrestrial habitats for their life history needs. For instance, western spadefoot toads require upland sage scrub and chaparral habitat and breed in upland pools, such as vernal pools (Stebbins 2003). Arroyo and western toads (*Anaxyrus boreas halophilus*) typically require low-flow shallow water (streams, creeks, rivers) for breeding as well as open sandy upland natural habitats for foraging and overwintering (Griffin et al. 1999). California tree frogs are specialists that require small pools and boulder habitats. Finally, western pond turtles can use streams for dispersal, but require deeper pools and basking habitat (logs, boulders) for breeding and other life history needs, as well as natural upland habitat for egg laying (Bury and Germano 2008, Rathbun et al. 1992).

Probability of Use of Crossing Type by Focal Small Animals

Not all focal small animal species were evaluated for each passage location due to differences in habitat composition and whether water is present. Terrestrial species were considered for all crossings, while semi aquatic species were only considered for the Temecula Creek Bridge where water is present year-round. In addition, the gray squirrel was only considered for locations where oaks are present on either side of the crossing, which is limited to the proposed wildlife culvert location and Temecula Creek Bridge.

In evaluating the use of each of the crossing types by focal small animals, experts assessed connectivity objectives and other factors. For example, is infrequent passage for genetic connectivity a sufficient goal for the species or is frequent use of the passage for living and breeding habitat more important for long term population viability?

All three crossing types would function for a subset of identified small animal focal species (Table 4). The **vegetated overcrossing** would function for all the terrestrial species, excluding the western gray squirrel, and would also function for the spadefoot toad, a semi aquatic species, if the designs included some sort of water feature in the approach area. The **wildlife culvert** would likely have a high probability of use for the red diamond rattlesnake and big-eared woodrat, with a lower probability of use for gray squirrel, spadefoot toad, and western toad. Finally, the **Temecula Creek Bridge** has some probability of use by all the small animal focal species, with the California tree frog and spadefoot toad having the lowest probability of use. Of all the focal small animals, both the red diamond rattlesnake and big-eared woodrat have high probability of use of all three crossing types, while California tree frog has only a low probability of use for one of the crossing types, the Temecula Creek Bridge.

Common Name	Terrestrial	Semi-Aquatic	Temecula Creek Bridge	Wildlife Culvert	Vegetated Overcrossing
Arroyo toad		X	M	-	-
Big-eared woodrat	X		H	H	H
Blainville's horned lizard	X		M	L	H
California tree frog		X	L	-	-
Red diamond rattlesnake	X		H	H	H
Western gray squirrel	X		M	L	-
Western pond turtle		X	M	-	-
Western spadefoot toad		X	L	L	H
Western toad		X	H	L	L

Table 4: Classifications for planning purposes and probability of use of each crossing type small animal species: High (H), Moderate (M), Low (L). Crossing type that is improbable for use is indicated using "-". Scientific names are in Table 1.

Crossing Design Features to Encourage Use by Small Animals

In assessing design elements of each crossing and approach area for small animals, experts considered species needs related to soils and vegetation structure, aquatic habitat, time of activity, prey availability, temperature, and cover.

Temecula Creek Bridge

Experts felt that after planned invasive plant control and native plant restoration are implemented for the Temecula Creek Bridge crossing, natural flood events will help create natural channels with a variety of depths and flows that would benefit semi-aquatic species. Experts did not suggest adding boulders or deep pools for the pond turtle or California tree frog, as they believe Temecula Creek in this location provides transitional habitat for these species to move through, using the habitat under the bridge during flood events.

To enhance connectivity for terrestrial species at this location, experts proposed the creation of ledges along the bridge abutments to facilitate small animal movement, particularly during winter months when seasonal inundation may occur. The installation of rope bridges between trees was also suggested to facilitate movement of the gray squirrel (a tree specialist) under the bridge where there are large gaps between trees (Timmermans 2018). Gray squirrels were documented in Pechanga Creek in 2022 (Martin 2022); however, the presence of gray squirrels west of I-15 warrants future investigation.

While Temecula Creek could potentially be suitable habitat for the arroyo toad and western toad, invasive predators, particularly bullfrogs (*Lithobates catesbeianus*) and large predatory fish, are a major threat to native herpetofauna in this location (Fisher et al. 2001). Collaboration with groups such as Cal Trout on invasive predator control could be important for connectivity and persistence of native aquatic species both at this location and within the larger scale planning area.

Experts proposed that any fencing designed to keep humans out of Temecula Creek extend as far upstream as possibe to reduce all known potential access points, as human presence and associated poaching, hunting, fishing, dogs, trampling, and waste, which are all a major concern for focal small animals. Fencing designs that incorporate fine or solid mesh fabric on the lower 4 feet of the fence would preclude small animals from inadvertently entering human development. In addition, the feasibility of constructing low barrier fencing along the border of the Temecula Creek Inn Golf Course could be explored to prevent turtles and toads from entering the golf course. Such low fencing would not preclude passage by larger wildlife species.

Wildlife Culvert

The proposed wildlife culvert poses design challenges for small animals, as such structures can be cold, dark, dry, and musty. Natural soils, grates and skylights, and designs that allow some passage of water can make underpasses more like their surrounding environment. Grates and skylights installed in the median and on road shoulders of the highway could provide light and air flow to the crossing (Langton and Clevenger 2020). These grate and skylight structures could be slightly elevated above grade so as not to create pitfall traps or drains into the culvert.

Cover, such as rocks, logs, or cinder blocks, placed throughout the interior of the culvert have been shown to provide hiding places for smaller species (Tracey et al. 2014). Cover structures are most effective if less than 2 feet in height. Incorporating ledges into the design of the culvert could provide elevated movement through the passage and a dry crossing for small animals when the culvert is inundated. Small wildlife ledges are typically 8 to 12 inches wide and approximately 4 feet in height and include ramps at the culvert entrances to facilitate access (Langton and Clevenger 2020, Clevenger and Huijser 2011).

The current culvert design includes a concrete channel for water flow. Experts proposed that the culvert be designed instead with a natural soil drainage channel that flows during rainfall events. High velocity flows could be directed to the existing adjacent culvert structure to reduce excessive flows in the wildlife culvert.

Sound absorbing materials could be added to the interior walls of the culvert to increase sound attenuation and reduce vibration, both of which could deter small animal use of the structure, particularly if a metal culvert is selected as the design.

Small animals can be funneled to the crossing with short barrier fencing that extends from the wing walls. The barrier fencing should be at least 2 feet high, and composed of solid or fine mesh material with overhangs, as necessary, to prevent climbing (Langton and Clevenger 2020).

Vegetated Overcrossing

For the vegetated overcrossing, tall walls or earthen berms over 6 feet in height are needed along the edge of the structure to provide a visual barrier and to shield small wildlife from light and noise from the highway. Tall barrier walls that incorporate the ledges discussed for the wildlife culvert could provide elevated passage for small animals.

Vegetation on the overpass and approach area would best include both dense and sparse shrub plantings to accommodate both open- and closed-habitat specialists as well as generalists. Dense habitat for closed-habitat specialists could consist of near continuous or overlapping shrub cover. Sparse habitat for open-habitat specialists could consist of small areas of bare ground, large patches of native forbs and grasses, and scattered shrubs. Other types of cover, such as logs or brush piles, could also be included in both the approach area and on the crossing.

In addition, small seasonal ponds could be created in the approach area on either side of the crossing for the spadefoot toad. USGS has had success in creating seasonal ponds for spadefoot toad, fed by rainwater, in Orange County, California (Baumberger et al. 2020). Experts felt that such seasonal pools would benefit many other species groups as well.

Any barrier fencing incorporated into the design for the approach area to funnel wildlife to the crossing would best include design considerations for small animals, as described above for the wildlife culvert.

<u>Areas for Additonal study</u>

- Conduct surveys to identify small animal species present or near crossing sites to validate or modify focal species.
- Test methods and feasibility for the establishment of ephemeral pools in the approach area for the proposed vegetated overcrossing.
- Deveop and incorporate design considerations for arroyo chub (*Gila orcuttii*) and southern steelhead (*Oncorhynchus mykiss*) to develop and incorporate into the planning for the Temecula Creek Bridge crossing.

3.3 Bats

<u>Importance of Wildlife Crossings for Bats</u>

It is a common misconception that because they are capable of flight, bats are not negatively affected by road development. However, the development and expansion of roads often results in the destruction of roosting habitat (e.g., mature trees, rock outcrops) and foraging habitat for bats. While transportation structures (e.g., bridges and culverts) in some cases can provide replacement roosting habitat, particularly when these structures span or are situated along natural flyways, these structures cannot provide suitable roosting habitat for all bat species that are affected by loss of roosting habitat related to road construction. In addition, there is increasing evidence that roads may alter bat movements related to both seasonal roost switching and nightly foraging behavior, and that bat populations may in fact be vulnerable to the barrier effects of roads. For instance, bats can be negatively affected by roadway noise (e.g., Schaub et al. 2018; Bennett and Zurcher 2013), lighting along roadways can disrupt commuting corridors for bats (e.g., Stone et al. 2009; Seewagen and Adams 2021), and bats can be killed when crossing roads, particularly when these roads are located at natural crossing points between areas of good habitat (e.g., Russell et al. 2009; Berthinussen and Altringham 2012; Medinas et al. 2013). Given the low reproductive turnover of bat species coupled with collision mortality estimates of up to 5 percent for local populations as calculated in some studies (e.g., Russell et al. 2009; Altringham and Kerth 2016), roadway mortality could present yet another conservation risk for bat species that are already declining from other factors. Therefore, when considering how roadways affect bats and how wildlife crossings can be created or modified to minimize those impacts, it is important to consider both the creation and/or enhancement of roosting habitat as well as methods of facilitating movement across roadways that will minimize the potential for barrier effects and collision mortality.

Focal Bat Species

No bat species were included in the list of focal species in the original SC Wildlands report, so experts added the following focal bat species for wildlife crossing consideration, based on their observed population declines in the region and their potential occurrence in the proposed crossing areas.

The pallid bat (*Antrozous pallidus*) is a large-bodied and broad-winged species that consumes ground-dwelling arthropods in addition to flying prey (e.g., moths). This species roosts in various types of crevices and cavities, and in southern California is associated with open scrub and grassland habitats, oak savannah, and relatively open sycamore riparian and oak riparian habitats. There is evidence that bat species that hunt by listening passively for prey-produced sounds, as pallid bats do, often avoid approaching or foraging near highways with high levels of noise (e.g., Bennett and Zurcher 2013), and it is hypothesized that roadway noise could mask the sounds that these bats rely on for hunting because some of these sounds are within the same range as roadway noise (California Department of Transportation 2016).

The big brown bat (*Eptesicus fuscus*) is a relatively large-bodied and broad-winged species that primarily consumes flying beetles, but also consumes a variety of other flying insects. Although it is considered a forest-dwelling species in other parts of its range, in southern California the big brown bat is often associated with a variety of habitats including scrub, chaparral, and riparian habitats, and this species can be found foraging over a variety of vegetation types, at ponds, and along riparian corridors. While their propensity to roost in human-made structures may suggest that this species can adapt to the anthropogenic environment, colonies have been disturbed or illegally exterminated and these structures may serve as habitat sinks. Recent studies in North America (Seewagen and Adams 2021) and in other *Eptesicus* species in Europe (e.g., Voigt et al. 2018) suggest that while big brown bats are known to opportunistically forage around streetlights, this species may be highly sensitive to lighting along commuting corridors. Consequently, roadway lighting may create additional barriers and fragment habitat for a species that is already sensitive to the effects of habitat fragmentation.

Both species are well adapted to roosting in human-made structures, which can put them at risk for vandalism or illegal extermination. However, this behavior also creates opportunities for creation or enhancement of roosting habitat for these species at bridges or culverts, where they can be better protected from these threats. Bat movement on the landscape can be broadly categorized as nightly movements (e.g., commuting between roost sites and foraging areas) and seasonal movements (e.g., autumn/spring dispersal or summer aggregation at maternity sites for colonial species). Although research on the effects of roadways on bats has predominantly been conducted in Europe and limited data are available specific to the focal bat species, the experts were able to hypothesize how the focal bat species might cross roadways based upon their foraging ecology and flight behavior to evaluate whether wildlife crossings could be beneficial to improve movement across Interstate 15. Available data on the barrier effect of roads indicate that this effect is likely species-specific and is primarily influenced by factors including wing shape and foraging ecology (Altringham and Kerth 2016; Møller et al. 2016). While the specific flight and foraging behavior of pallid bats compared to big brown bats is distinct, both focal bat species have broad wings and relatively slow flight, and studies indicate species with these attributes are more likely to be affected by the barrier effects of roads (Norberg and Rayner 1987). Encouragingly, in addition to using culverts and bridges beneath roadways for day and night roosting, both species have also been observed using large culverts to cross beneath freeways (J. Carpenter, unpublished data, D. Stokes pers. comm., S. Remington pers. comm.).

Summary of Probability of Use of Crossings by Focal Bat Species

When assessing the probability of use of the three crossing types being analyzed, the **Temecula Creek Bridge** has the highest probability of use for both roosting and movement/connectivity, while the **wildlife culvert** has a moderate-to-high probability of use for roosting and a low-to-moderate probability of use for movement depending on the species. The use of wildlife overpasses by bats has not been well studied; however, some recent data from Europe suggest that vegetated wildlife crossings have a lot of potential to facilitate bat movement (e.g., Claireau et al. 2021; Martinez-Medina et al. 2022); therefore, if the best available knowledge to encourage use of this type of structure for bats is implemented, the **vegetated overcrossing** has a moderate to high potential for use as a flyway for bats to safely cross the highway. With regard to use of the vegetated overcrossing for roosting, because known successful roost designs are placed on the undersides of bridges, it would be generally incompatible with a vegetated overcrossing structure spanning a busy freeway. Thus, specific strategies for the creation of roosting habitat for the overcrossing were not pursued by the experts at this time.

It should be noted that efforts to make the wildlife crossings suitable for use by the focal bat species will likely also benefit other bat species, but the experts focused on identifying specific elements that will optimize the characteristics of each type of crossing structure for the focal bat species.

Species	**Temecula Creek Bridge**	**Wildlife Culvert**	**Vegetated Overcrossing**
Usage Type: Connectivity/Movement			
Pallid bat	H	L	M
Big brown bat	H	M	M
Usage Type: Roosting			
Pallid bat	M	M	-
Big brown bat	H	H	-

Table 5: Probability of use of each crossing type by focal bat species and usage type: High (H), Moderate (M), Low (L). Crossing type that is currently not being pursued for use is indicated using "-"; however, it should be noted that this categorization is specific to this crossing location and to current data limitations for the successful creation of freestanding roosting habitat. Current research is underway, and it is expected that these issues will be resolved so that this option can be pursued at other overcrossing locations. Scientific names are in Table 1.

Crossing Design Features to Encourage Use by Bats

In assessing design elements for each crossing and approach area to promote roosting by bats, experts considered species needs related to the design, potential placement locations, and access for roosting habitat. Both day- and night-roosting habitat features were evaluated. With regards to movement, experts considered design elements for each crossing and approach based upon knowledge of the focal species' foraging ecology and flight behavior.

Temecula Creek Bridge

Crevice features suitable for use by day-roosting bats can be added to the Temecula Creek Bridge by bolting on structures made from concrete or a material with similar thermal properties. Placement of these structures in different areas of the bridge to provide bats with more thermal options was proposed by the experts and is consistent with studies showing that varied placement locations increase the probability of use by bats across seasons (e.g., Carpenter 2017). While these crevices could also be used by night-roosting bats, including other types of roost structures that create cavity spaces to encourage night roosting was proposed. The pallid bat in particular favors cavity spaces for night roosting. The experts agreed that it is possible to create structures that incorporate both types of habitats in one modular design, and that the roosting surfaces of all roost structures would be most effective if they have a roughened texture. The design and placement of these roost structures would best be overseen by a bat biologist with documented experience and success designing and implementing bat roosts on bridge and culvert structures.

The experts discussed various attributes that would encourage the movement of bats beneath the Temecula Creek Bridge as bats move along the drainage course, rather than over the bridge where there is risk for collision mortality. The experts expressed concerns that the existing area beneath the bridge might be too cluttered and lack clear flyways to promote bat movement beneath the bridge. The experts considered thinning of some of the shrubs and trees along the approach to the bridge and beneath the bridge itself to create flyways that allow movement of bats below the height of the bridge; however, the trimming and removal of vegetation could conflict with needs of other species that require more vegetative cover and may require maintenance. Ultimately, this strategy was not proposed due to those factors and the likelihood that the removal of invasive vegetation will create some flyways. In addition, at least two species of bats, one of which is the focal species big brown bat, were documented crossing beneath the bridge during recent mist netting surveys (Carpenter pers. comm.), suggesting that the vegetation is not currently inhibiting movement beneath the bridge. It is possible that sound walls or flight elevating structures installed to force birds to fly across the bridge at a higher level and not at vehicle height could also be used by bats depending upon the design of those structures. Fencing and other measures that are effective in keeping humans out of Temecula Creek are proposed by the experts because the presence of humans is expected to cause disturbance that would reduce the potential for bats to both move through and roost at the bridge. Traffic noise could also be a deterrent, particularly for pallid bat, so measures to reduce vehicle noise in the vicinity of this crossing could benefit bats and aid in their use of the crossing. Finally, native plant restoration at the Temecula Creek Bridge crossing is expected to increase the quality of this area for foraging for the focal bat species by attracting a wider diversity and abundance of native insect prey.

Wildlife Culvert

To encourage use of the wildlife culvert by roosting bats, the experts agreed that using a design that creates higher structural complexity within the culvert structure would provide more thermal variation and options for roosting. This complexity could include adding one or more short side tunnels along the length of the culvert and/or the creation of domed recesses in the ceiling to trap heat and create areas sheltered from wind and ambient light. These recessed areas are particularly important if other taxa require more airflow or ambient light in the culvert because features installed to provide those conditions, such as grates or skylights, could be expected to lower the probability of use by bats unless the proposed enhancements described here are implemented. For example, siting grates or skylights far away from bat roosting habitat would minimize their deterrence on bat use. Providing roosting habitat in recessed areas in the ceiling, which are effective in creating areas of darkness and trapping heat, is proposed if skylights or grates are used to increase light and airflow. The experts agreed that the creation of multiple size options for the ceiling recesses would be beneficial and suggested 2 feet by 2 feet wide (or 4 feet square) and at least 2 feet deep would likely be suitable. Although bats often night-roost along the walls of concrete culverts, ceiling recesses would provide even higher quality night-roosting habitat. The experts noted that all roosting surfaces would be most effective if they have a roughened texture. Crevices that provide day-roosting habitat can be built into the culvert structure or bolted on as proposed for the Temecula Creek Bridge. These roost structures can be incorporated into recessed areas, along the tops of the culvert walls, or on the culvert headwalls.

The proposed 15 x 15-foot culvert is expected to be sufficient for use by the focal bat species, particularly given that most of the experts have observed one or both focal bat species roosting and/or passing through concrete culverts of this size. Maintenance of the culvert entrances to keep them open and free of obstruction from vegetation would allow bats to readily access the culvert interior for roosting and/or movement.

If a metal culvert design is selected, roosting habitat can still be provided for bats by installing vertical pipes or other recessed areas in the ceiling to trap heat. Given that some research indicates that corrugated metal culverts produce patterns of echoes to which some bats are averse (Simmons et al. 2020), if a metal culvert design is chosen, sound-absorbing materials could be added to the interior walls of the culvert to reduce these echoes and increase the probability of use by bats. Spraying the culvert interior with gunite or a similar material is likely to provide both sound-dampening effects and a textured surface that will also increase the probability that bats will roost within the metal culvert.

Vegetated Overcrossing

The experts agreed that the most important attribute to encourage bat use of the overcrossing was to place trees and/or large shrubs along the edges of the bridge to create an “edge” habitat for the bats to follow, thereby creating a flyway that will direct the movement of bats across the overcrossing. The placement of trees and large shrubs along the edges of the structure would also serve to shield bats and other wildlife on top of the overcrossing from noise and light along the roadway below.

Roosting habitat for bats is often created successfully on the undersides of bridge structures, where it is possible to take advantage of shelter from the elements as well as the structure’s thermal capacity to maintain stable roost temperatures. However, in the case of an overcrossing, the experts were concerned about potential for increased risk of collision mortality for bats emerging from roosts on the underside of the overcrossing at or near active traffic lanes. Some possibilities that were discussed to minimize or eliminate this risk included the creation of a pier wall between the roadway and the abutment where bats could roost away from the active lanes; this physical barrier would discourage exit toward the roadway while also serving as a barrier for disturbance (e.g., noise and light) from the roadway. The experts also discussed potential placement options for roosting habitat away from the roadway (e.g., on top of the overcrossing or near its approaches) to avoid this risk; however, these structures would need to be free-standing, and this type of roost structure is not typically successful in southern California due to the difficulty of providing adequate thermal stability required for occupancy by bats. Given that any roosting habitat included in the design of the overcrossing would be experimental, coupled with the fact that large rock outcrops with suitable day-roosting habitat are present in close proximity to the proposed overcrossing location, the experts ultimately decided that it would be best to focus funding and resources on adding elements to the overcrossing that are effective in creating a pathway across the road until more data are collected with regard to attributes of successful free-standing roosts in California. It is important to note that the suggestion not to include roosting habitat on the overcrossing is very specific to this Linkage site, and that at other wildlife crossings, it may be possible or even necessary to include roosting habitat for bats on the overcrossing structure.

Crossing Approach Features to Encourage Use by Bats

For all the crossing structures, experts agreed that creating or enhancing flyways to guide bats toward the structure was very important for both roosting and for movement across or through that structure. At the Temecula Creek Bridge and the wildlife culvert, the experts propose creating or enhancing approach flyways by trimming vegetation or otherwise decreasing cover enough to create pathways for bats to fly toward and beneath the bridge or into the culvert. On the other hand, at the vegetated overcrossing, the experts proposed planting large shrubs or trees along the edges of the overcrossing to provide a natural flight path for bats that also provides cover. The experts also proposed creating continuity between the rows of trees and large shrubs along the edges of the overcrossing and rows of trees and shrubs on each side of the crossing to form a flyway that will funnel bats across the overcrossing. Consistent with suggestions for other taxa, the experts strongly suggest implementing measures to reduce or eliminate light and trespass from adjacent highway and residential uses to increase the probability that bats will approach and use the crossings.

Areas for Additional Study

- Perform acoustic and mist-netting studies to gather data on existing use of the proposed crossing sites by focal bat species.
- Perform acoustic studies to identify where, if anywhere, bats are crossing I-15 as was done for European crossing studies.
- Monitor roadkills of bats in the area now and in future to evaluate success of crossings in reducing collision mortality.
- Monitor added roost features to evaluate effectiveness/use by bats for roosting.
- Monitor added crossing attributes to evaluate effectiveness/use by bats for movement/connectivity.

3.4 Birds

Importance of Wildlife Crossings for Birds

While it is known that birds can fly over highways, reports to the California Roadkill Observation System (2022) identify that, between 2009 and 2014, approximately 7,800 bird mortalities were reported, representing 234 species. While this is not a report of all bird mortalities, these reported bird mortalities made up 12% of all reports across all taxa. In addition, research conducted for the wrentit (*Chamaea fasciata*) in the Santa Monica Mountains in southern California has shown that highways have altered genetic connectivity for this species (Delaney et al. 2010).

When considering how barriers might affect movement of birds in the landscape, it is important to consider both movement type and migration status. Movement can either be a one-time dispersal event when a bird leaves its natal area or can be associated with movement within a territory or home range. Movement within a territory/home range may require repeated crossings if the territory spans the roadway. In terms of migratory status, migratory species are typically less impacted by highways than resident species. Migratory species can travel long distances and at higher altitudes as they seek suitable habitat, making them much less susceptible to roadway impacts. This is in contrast to resident birds, which tend to stay close to the ground and typically don't make long flight journeys.

Focal Bird Species

In addition to the focal species outlined in the original SC Wildlands report, experts added the following additional focal bird species for wildlife crossing consideration: California gnatcatcher, cactus wren, wrentit, California thrasher (*Toxostoma redivivum*), and greater roadrunner (*Geococcyx californianus*). In addition to golden eagle (*Aquila chrysaetos*), raptors (hawks and owls) were added as a group of species that need focus in the Linkage, not related to connectivity across the highway but related to reducing collision mortality associated with hunting for prey in the roadway.

Focal bird species were arranged into the following groupings for purposes of planning: 1) migratory and woodland species, 2) resident species, 3) ground-dwelling species, and 4) raptors (Table 6). Least Bell's vireo and yellow warbler (*Setophaga petechia*) are two migratory species that require connected riparian habitat, whereas the oak titmouse (*Baeolophus inornatus*) requires oak and riparian woodland. Resident species include California gnatcatcher and cactus wren, which are both coastal sage scrub-dependent species whose habitat is highly fragmented across the region, as well as wrentit and California thrasher which are both chaparral dependent species. Ground dwelling focal birds include California quail (*Callipepla californica*) and greater roadrunner, which are both sensitive to habitat fragmentation. The raptor group includes the golden eagle, which requires large contiguous blocks of intact habitat as well as barn owl (*Tyto alba*), great horned owl (*Bubo virginianus*), red-tailed hawk (*Buteo jamaicensis*), red-shouldered hawk (*B. lineatus*), western screech-owl (*Megascops kennicottii*), and other raptors that are highly susceptible to collision mortality.

Common Name	**Migratory/ Woodland**	**Resident**	**Ground Dwellers**	**Raptors**
California gnatcatcher		X		
California quail				
California thrasher			X	
Cactus wren		X		
Golden eagle				X
Greater roadrunner			X	
Hawks/Owls				X
Least Bell's vireo	X			
Oak titmouse	X			
Wrentit		X		
Yellow warbler	X			

Table 6: Focal Bird Species and Categories. Scientific names are in Table 1.

Experts identified that resident and ground dwelling birds likely require wildlife crossings to ensure connectivity across the highway. As for the California gnatcatcher, it has been documented that they are highly genetically connected across the region (Vandergast et al. 2019); however, we do not know how freeways affect gnatcatcher movement and distribution. To the extent that they do move across a highway, some sort of crossing would likely benefit California gnatcatchers.

In terms of reducing mortality due to roadkill, all species except raptors would benefit from a crossing. Wildlife crossings are not going to solve the issue of mortality of raptors on highways.

Summary of Probability of Use of Crossings by Focal Birds

Least Bell's vireo, oak titmouse, and yellow warbler are expected to have a high likelihood of use of the **Temecula Creek Bridge** crossing, as they are found on both sides of I-15. Quail and greater roadrunner are also likely to use the Temecula Creek Bridge to cross the highway. Experts felt that that there would only be moderate use of the Temecula Creek bridge by California thrasher, California gnatcatcher, and wrentit, as these species require more continuous low shrub cover than currently exists or can be supported in this location. Additionally, California thrasher is more associated with chaparral than the riparian habitat that is found under the bridge, although that does not entirely rule out that thrashers might move under the bridge. As for the cactus wren, experts were concerned about the lack of cactus elements in the surrounding environment for both Temecula Creek Bridge and the vegetated overcrossing location. While cactus wrens do not require cactus in their movement corridors, it is expected that there is only a moderate likelihood that cactus wrens would use Temecula Creek Bridge crossing.

When assessing probability of use of the three crossing types analyzed, the proposed **wildlife culvert** has the lowest probability of use, for reasons relating to lack of light and visibility through the crossing, as well as a lack of habitat needed to promote movement through the culvert structure.

Regarding the **vegetated overcrossing**, the migratory and woodland species would be unlikely to use the crossing due to lack of suitable continuous woodland habitat on or in the vicinity of the proposed crossing. Raptors would also be unlikely to use the crossing for passage across the highway but might use the overcrossing for hunting. There is a high likelihood of use of the vegetated overcrossing by resident and ground-dwelling bird species.

Species	Temecula Creek Bridge	Wildlife Culvert	Vegetated Overcrossing
California gnatcatcher	H	-	H
Cactus wren	M	-	H
California quail	H	-	H
California thrasher	M	-	H
Golden eagle	-	-	-
Greater roadrunner	H	-	H
Hawks/Owls	-	-	-
Least Bell's vireo	H	-	-
Oak titmouse	H	-	-
Wrentit	M	-	H
Yellow warbler	H	-	-

Table 7: Probability of Use of Crossing Type by Focal Birds: High (H), Moderate (M), Low (L). Crossing type that is improbable for use is indicated using "-".

Crossing Design Features to Encourage Use by Birds

The Temecula Creek Bridge and vegetated overcrossing structure were evaluated by experts in terms of specific design features such as substrate and vegetation composition and height that would be needed to encourage use by the focal species.

Temecula Creek Bridge

For the Temecula Creek bridge, attributes considered important for migratory and woodland bird species include natural substrate, tree and shrub cover, and light to support tree and shrub cover under the bridge. Maintaining natural substrate provides the soil, nutrient, and hydrologic conditions required by riparian vegetation. Native tree and shrub cover including various willow species, mulefat, cottonwoods, and coast live oaks are important to encourage focal birds to move towards and under the bridge structure. Maintaining the opening between bridge spans will be critical to ensuring the persistence of tree canopy under the bridge structure.

For ground dwelling bird species, shrub cover in the approach and crossing area would best be arranged such that there are openings/pathways between shrubs to allow movement. Pathways for ground dwelling birds, like the small animal group, would best avoid inundated areas. Elevated passages under the structure that include native substrate could function for ground dwelling birds during inundation events.

To avoid roadkill of birds flying above Temecula Creek Bridge, experts proposed the placement of "flight elevators" (fences or other tall structures) on the edges of the bridge to force birds to fly under or up and over the highway bridge and traffic. Flight elevators could also serve as noise and light barriers, although avoiding walls of clear glass would reduce the risk of bird collision. Adding flight elevators on the bridge structure and maintaining adjacent existing tall trees should help encourage birds to fly above traffic or under the bridge (Kociolek et al. 2015). Additionally, flight elevators could be designed to artfully represent the focal species. Experts suggested that bridge signage identify the waterway and its role as a wildlife corridor (e.g., Temecula Creek Bridge Wildlife Crossing).

Measures focused on preventing human trespass, controlling invasive plants, and abating noise and light from adjacent highway and residential uses will improve focal bird species use of the crossing. Any future reduction of the opening between bridge spans (e.g., highway widening) would cut down on light that currently allows the growth of trees and shrubs under the bridge structure and would negatively impact focal bird species use of the crossing. The vegetation cover currently under the bridge and between the spans is very important for birds in this crossing.

Vegetated Overcrossing

The vegetated overcrossing structure is anticipated to be used primarily by terrestrial species. Important attributes for the overcrossing include a natural substrate and vegetation cover composed primarily of coastal sage scrub and chaparral plant species. Taller shrubs or trees are proposed for placement in the middle of the structure to attract birds to cross. Taller shrubs and trees might also be considered along the edges to shield noise and light. For ground dwelling bird species, experts thought it important to arrange vegetation such that it creates paths or tunnels that provide cover but also accommodate movement.

The substrate of the overcrossing is a concern to experts, as they were unsure if the identified 4 feet of soil proposed is deep enough to support the level of shrub cover needed to promote wildlife use over the long term. Perhaps in locations where taller vegetation is required, such as along the edges of bridge where light/noise shield is desired, raised planters or deeper soil pockets can be installed to support trees and taller shrubs.

Given the limited substrate on the overcrossing, long term maintenance of the vegetation on the overcrossing was also a concern raised by the experts. Periodic plant replacement or supplemental irrigation may be required to maintain the desired habitat conditions required to promote wildlife use of the overcrossing structure. Maintaining sufficient vegetative cover on the overcrossing for prey species could deter use of the overpass as a hunting area for raptors.

Crossing Approach Features to Encourage Use by Birds

For both the Temecula Creek Bridge and vegetated overcrossing, experts proposed that the habitat in the crossing match as closely as possible with the habitat in the approach areas, with some modifications to attract habitat specialists. For example, experts proposed that cactus be added in the approach area for both the vegetated overcrossing and Temecula Creek Bridge to attract the cactus wren to use the crossing structure. For the Temecula Creek Bridge crossing, planners would best look for opportunities to add cactus in upland areas adjacent to the crossing, as cactus likely cannot be supported within the riparian area.

For the vegetated overcrossing, experts proposed planting taller vegetation on both ends of the overcrossing and in the middle of the crossing to both attract and elevate birds as they fly across the structure.

Water features were proposed for placement in the approach area for the vegetated overcrossing to both attract and create regular travel routes to the crossing for quail and roadrunner. Otherwise, trails could be created for ground dwelling birds to lead them to the crossing.

In terms of identifying measures to reduce raptor mortality on the highway, efforts would best focus on reducing raptor prey in the highway. Existing exclusion fencing may already be reducing raptor prey in the highway, but possible upgrades to the existing fencing, such as fine mesh barrier fencing on the lower 2-4 feet of the fence, may further reduce small animal roadkill and associated raptor hunting in the highway. Additionally, opportunities to reduce roadside raptor perches could also be evaluated, particularly perches that are at road level. Raptor hunting on the vegetated overpass could be discouraged by providing and maintaining adequate cover for prey species.

Areas for Additional Study

- Examine the level of genetic fragmentation of focal birds on either side of highway and monitor over time.
- Monitor roadkill of birds now and in future to evaluate effectiveness of crossings.

3.5 Plants and Invertebrates

Importance of Wildlife Crossings for Plants and Invertebrates

Plants and invertebrates are foundational elements of terrestrial ecosystems and a crucial consideration for the design of wildlife crossings for I-15. Plants and invertebrates are food resources for other taxa, and many are species of concern themselves. Plants and insects coevolved as pollinators and hosts, so much so that considering these taxa independently is nearly impossible.

Plants provide habitat structure. The density and stature of plants in the vegetated overcrossing and Temecula Creek will determine in large part which animal taxa will be most inclined to use them. Different planting and management schemes will determine if the habitat in the crossing is open or closed, how much cover is present to obstruct anthropogenic features and provide hiding spots for animals, and which food resources are available in what quantity.

Plants and invertebrates are key food resources for and gain benefits from animals. For example, synzoochory is the “intentional” dispersal of seeds by seed-caching animals such as scatter-hoarding mammals and birds that create caches. In this mutualism, the plant provides food and the animal acts as both seed predator and seed disperser. The same is true for endozoochory, except seeds are transported in the animal's gut unintentionally after being consumed as food. Coyotes and bobcats which consume fruit and acorns are prime examples of endozoochory (Luke et al. 2004).

Finally, plants and arthropods represent some of the most and least mobile species that the proposed crossings could accommodate, and addressing their connectivity needs involves additional considerations to the crossing design, ultimately serving a broader suite of species.

Focal Plant and Invertebrate Species

The focal plant and invertebrate species can be thought of in three general categories based on their dispersal mechanisms: plants (passive dispersal via wind, gravity, and animals), walking insects, and flying insects/butterflies (Table 8). Focal species share the need to disperse for various reasons, including genetic mixing, mating, migration and shifting ranges due to climate change.

Focal plant species utilize several modes of passive dispersal, including abiotic forces like gravity, wind, and water as well as transport via animals. Genetic mixing is (in general) achieved via pollination by insect pollinators, wind, and other means. Pollination keeps the species genetically viable but does not allow for range shifts. Walking insects (Jerusalem cricket [*Ammopelmatus* spp.] and Timema walking stick [*Timema podura*]) are likely the most dispersal-limited focal species under consideration (taking endozoochory and synzoochory into account). Some authors report that walking sticks may only move a few feet within their lifetime (Sandoval 2000) while informal observations by local experts suggest walking sticks may have somewhat greater dispersal ability and may move dozens of feet at a time in some scenarios (Strahm et al. 2022).

Jerusalem crickets are ground dwelling insects that disperse via walking (Vandergast et al. 2009). Local experts estimate movement distances of approximately 50 feet a day (Strahm et al. 2022). Jerusalem crickets require connectivity to find mates and forage (Strahm et al. 2022). Only the Mahogany Jerusalem cricket is known to exist on both sides of the I-15, but there are likely others (Strahm et al. 2022). Jerusalem crickets are a favored prey item for bats (Strahm et al. 2022).

Butterflies are prone to collisions with vehicles (Skórka et al. 2013). For some this is a function of their flight height and behavior. Host and nectar plants on the edge of roads may gain a benefit from water sheeting off the asphalt and collecting in brow ditches (Strahm et al. 2022), which draws butterflies to the edges of roads, increasing the chances of collision. Even species that fly relatively high (e.g., migrating monarch [*Danaus plexippus*] and painted ladies [*Vanessa cardui*]) are subject to collisions, and can benefit from a crossing. The degree of benefit to any one species of butterfly may vary by species and the location of the crossing.

Common name	Dispersal
Chaparral yucca	Gravity
	Pollination
	Synzoochory
Engelmann oak	Gravity
	Wind
	Synzoochory
	Endozoochory
Rainbow manzanita	Gravity
	Pollination
	Endozoochory
	Synzoochory
California sister	Flying (high)
Comstock's fritillary	Flying (low)
Jerusalem cricket	Walking
Monarch butterfly	Flying (high)
Pale swallowtail	Flying (high)
Timema walking stick	Walking

Table 8: Focal plant and invertebrate species and dispersal mechanisms. Scientific names are in Table 1.

Summary of Probability of Use of Crossings by Focal Plants and Invertebrates

Experts agreed that most plant and invertebrate focal species will do best with a **vegetated overcrossing** (Table 9). The **wildlife culvert**, if it incorporates a natural substrate, is only appropriate for the Jerusalem cricket because it does not require host plants and is primarily nocturnal. The riparian woodland at the **Temecula Creek Bridge** is inappropriate for most of our focal species, although the upland habitats nearby may be suitable. Upland plants reliant on endozoochory and synzoochory may benefit from out-plantings near but not within the Temecula Creek crossing.

Species	Temecula Creek Bridge	Wildlife Culvert	Vegetated Overcrossing
California sister	-	-	H
Chaparral yucca	-	-	H
Comstock's fritillary	-	-	H
Engelmann oak	M	-	H
Jerusalem cricket	L	H	H
Monarch butterfly	-	-	H
Pale swallowtail	-	-	H
Rainbow manzanita	M	-	H
Timema walking stick	-	-	H

Table 9: Probability of use of each crossing type by plant and invertebrate species: High (H), Moderate (M), Low (L). Crossing type that is improbable for use is indicated using "-"

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Crossing Design Features for Plants and Invertebrates

The following crossing design features proposed for plants and invertebrates are geared toward a vegetated overcrossing as this is the best option for most of the focal species. The vegetation community on both sides of the highway is chamise chaparral at the crossing location, with mixed scrub oak nearby. This, along with the type (and depth) of substrate on the crossing, will exert ultimate control over which plants flourish on the span**.**

The experts stated that transitioning smoothly from habitat leading to the crossing across the span in either direction would prevent abrupt changes in the configuration of habitat that can divert butterflies. This includes the composition, vertical profile, and density of shrubs, the amount of bare ground and rock, etc.

If Timema walking sticks are found in the area, experts suggest creating strips of host plant shrubs down the sides of the overcrossing to act as a "highway" while leaving an open pathway for other taxa in the center. The Timema highway does not need to be dense, but it does need to be relatively contiguous, with some host plants overlapping but not at a density significantly different from surrounding vegetation. Local Timema walking sticks are likely to prefer chamise (*Adenostoma fasciculatum*) over *Ceanothus spp.* as host plants, but this should be confirmed. The Timema highway can be located on either one or both sides of the crossing, provided there are scattered host plants to make a pathway to the crossing.

It is anticipated that the overcrossing cannot support the soil depth necessary for Engelmann oaks (*Quercus engelmannii*) or Rainbow manzanita (*Arctostaphylos rainbowensis*), making both species better suited for planting in the crossing approach area. If pockets of deeper soil can be incorporated in the crossing, it may be possible to incorporate scattered Engelmann oaks, but the depth still may be limiting and result in smaller stature trees. Like Rainbow manzanita and Engelmann oak, chaparral yucca (*Hesperoyucca whipplei*) can be used as part of an upland planting palette in the approach to the overcrossing, and likely will be able to take hold on the span of the crossing as well, at a spacing of not more than 60 feet apart to encourage its pollinator, the chaparral yucca moth (*Tegeticula maculata*), to use the crossing. California buckwheat (*Eriogonum fasciculatum*) is another shrub species that likely will do well on the overcrossing and is attractive to many butterfly species.

Experts proposed out-planting all appropriate butterfly host plants up to and across the crossing structure if soil substrate type and depth allow. Host plants for focal species include:

- Chamise (*Adenostoma fascicularis*)
- Violets (*Viola pedunculata*)
- Oaks (*Quercus* species with large leaves)
- Hollyleaf cherry (*Prunus ilicifolia*), chaparral whitethorn (*Ceanothus leucodermis*) or other members of the Rosaceaeae, Rhamnaceae, and Betulaceae families
- Milkweed (*Asclepias*) species including *A. fascicularis*, *A. erosa*, *A. eriocarpa*

A diverse palette of nectar plants will draw focal butterflies and other pollinators to and over the crossing. California buckwheat as well as native thistles and wallflowers are especially attractive to many butterfly species (Marschalek et al. 2008). Providing flowers year-round would be most effective at attracting focal butterflies and other pollinators.

Plants on the span of the overcrossing will not have access to ground water and may need supplemental water during times of drought. A permanent irrigation system may be required to both establish and maintain plantings on the overcrossing.

Wood and rock piles are attractive cover for Jerusalem crickets and many other species. These would best be positioned within 50 feet (or less) of one another on the overcrossing, while not creating obstacles for other taxa.

A healthy soil community is essential for soil retention and nutrient cycling. In addition, many plant species rely on mutualisms with bacteria and fungi to absorb those nutrients. The top layer of soil (called the “A horizon”) is generally the richest in soil flora (Hartemink et al. 2020). Any topsoil displaced during wildlife crossing construction could be salvaged and re-applied to the crossing structure and approach areas after construction. Using native topsoil will encourage the establishment of beneficial soil biota, including, but not limited to, mycorrhizae.

Jerusalem crickets drum their abdomens on the ground to find mates (Vandergast 2009). Each species has its own unique song. Because vibration and noise from the highway could drown out this drumming, noise barriers on the edges of the vegetated overcrossing may benefit the species.

It is unclear if a windbreak and/or light shield at the edges of the overcrossing is necessary for focal arthropods. Blocking direct light at night is important to the recruitment of chaparral yucca moths. Artificial light at night is detrimental to nocturnal insects in general (Wilson et al. 2021). The extent to which wind and vortices from vehicles influence butterfly flight should be investigated (Damschen et al. 2014).

To maximize their effectiveness, wind or light barriers at the edge of the crossing structure would:

1. Not be climbable by Timema walking sticks;
2. Not block daylight from vegetation and arthropods on the overcrossing; and
3. Obscure direct artificial light sources at night.

Crossing Approach Features to Promote Use by Plants and Invertebrates

It may not be necessary to place Rainbow manzanita or Engelmann oak directly on or in the vegetated overcrossing to encourage dispersal. If the crossing is designed to facilitate the dispersal of animals that transport acorns (e.g., birds, squirrels, coyotes, and other mammals), adequate dispersal may occur. Rainbow manzanita and Engelmann oak can be considered for placement in the approach areas for all crossing types, if conditions are appropriate, to increase the chance that animals will move their propagules from one side to the other.

The host and nectar plants identified for establishment on the overcrossing could also be considered for planting in the overcrossing approach areas if conditions are appropriate. Violets and some milkweed species may not do well in a chamise chaparral environment in the approach areas, but it may be worth planting a small number of test plantings in the approach area in advance of crossing construction to confirm this.

Areas for Additional Study

- Conduct baseline arthropod studies to document the presence of focal invertebrates and their host plants in proximity of the proposed crossings. Specific data are needed for Comstock's fritillary (*Speyeria callippe comstocki*) and its host plant, *Viola pedunculata*, Timema walking stick, Jerusalem cricket, and yucca moth.
- Examine the rooting depth of Rainbow manzanita and Engelmann oak to determine whether the overcrossing can be designed to incorporate the rooting depth needed to support these and other deep-rooted host plants such as *Ceanothus* and *Prunus* species.
- Conduct research to determine how wind and vortices from vehicles are likely to affect butterflies (and other taxa) attempting to fly over I-15, including:
    a. What is the strength and direction of the prevailing wind?
    b. Are windbreaks necessary?
    c. How far above the highway does an overcrossing need to be to avoid vortices coming off the freeway?

4. Summary and Discussion

A summary of the probability of crossing use by focal species and crossing type is provided in Table 10. Of the three crossing types, the **vegetated overcrossing** has a high or moderate probability of use by 26 of the 36 species assessed, while **Temecula Creek Bridge** has high or moderate probability of use by 27. The vegetated overcrossing could serve a subset of taxa from all species groups, while Temecula Creek Bridge was suitable for a subset of taxa from all species groups but invertebrates. When combined, Temecula Creek Bridge and the vegetated overcrossing have a moderate or high probability of use for 34 of the 36 species. The **wildlife culvert** has a moderate or high level of expected use by 10 of the 36 focal species and could serve connectivity needs for representative species from all but the bird and plant species groups. The wildlife culvert was only suitable for one invertebrate species, the Jerusalem cricket. Existing culverts may also be suitable for occasional coyotes, gray fox, and ringtail as shown by camera trap data, but more information is needed. The tree frog had the lowest likelihood of use of any of the crossing types.

Species	Temecula Creek Bridge	Wildlife Culvert	Vegetated Overcrossing
Mammals			
American badger	M	M	L
Bobcat	H	H	H
Coyote	H	H	H
Gray fox	M	H	H
Mountain lion	H	H	M
Ringtail	M	H	M
Southern mule deer	H	L	M
Small Animals			
Big-eared woodrat	H	H	H
Western gray squirrel	M	L	-
Arroyo toad	M	-	-
Blainville's horned lizard	M	L	H
California tree frog	L	-	-
Red diamond rattlesnake	H	H	H
Western pond turtle	M	-	-
Western spadefoot toad	L	L	H
Western toad	H	L	L
Bats			
Big brown bat	H	M	M
Pallid bat	H	L	M
Birds			
California gnatcatcher	H	-	H
Cactus wren	M	-	H
California quail	H	-	H
California thrasher	M	-	H
Greater roadrunner	H	-	H
Hawks/Owls	-	-	-
Least Bell's vireo	H	-	-
Oak titmouse	H	-	-
Wrentit	M	-	H
Yellow warbler	H	-	-
Plants and Invertebrates			
California sister	-	-	H
Chaparral yucca	-	-	H
Comstock's fritillary	-	-	H
Engelmann oak	M	-	H
Jerusalem cricket	L	H	H
Pale swallowtail	-	-	H
Rainbow manzanita	M	-	H
Timema walking stick	-	-	H

Table 10: Summary of probability of use of each crossing type for all focal species assessed by experts. High (H), Moderate (M), Low (L).

4.1 Summary of Proposed Design Features for Crossing Structures

The following summarizes design features identified as compatible for all focal species for each of the proposed crossing structures. Potential conflicts are also identified, with proposals on how to resolve such conflicts.

Temecula Creek Bridge

Experts agreed trespass management would best be the focus of any restoration of the creek corridor. Management of trespass through the construction of walls or durable fencing at least 8 feet in height is proposed along the northern edge of Temecula Creek where it abuts urban land uses. The barrier could extend eastward beyond Pechanga Parkway approximately 0.5 mile where commercial land uses are directly adjacent to the creek. If fencing is installed, it could incorporate fine mesh barriers on the lower 2-4 feet to prevent small wildlife from entering urban areas.

Experts also agreed that maintaining trees and associated native understory under the bridge and between spans will be important to encourage wildlife passage, particularly bird species. Removal of invasive plants in both the approach and structure areas was proposed as the primary vegetation management action to improve visibility and facilitate movement through the structure. The proposal by bat and large mammal experts to thin riparian trees around the bridge structure would best be undertaken only if future bat surveys identify that the trees inhibit bat movement under the bridge. Vegetation within different spans of the bridge could be managed to meet different species needs. For example, the vegetation within the southern span could be managed for high cover, while the vegetation in the more northerly span could be managed for high visibility.

Where conditions are appropriate, experts proposed the incorporation of upland plant species in the approach area, including cactus (*Opuntia oricola*) to attract cactus wren to the crossing, as well as upland focal plant species such as Engelmann oak and Rainbow manzanita.

The bridge structure would best incorporate elevated areas along north and south edges to allow passage for terrestrial wildlife when the undercrossing is inundated with water.

Experts proposed that the addition of flight elevators to the exterior of the bridge structure be investigated to direct birds and bats to fly up and over the structure to reduce potential roadkill. Crevice and cavity features suitable for use by day-roosting and night-roosting bats can be added to the Temecula Creek Bridge by bolting on structures made from concrete or a material with similar thermal properties.

Vegetated Overcrossing

In terms of native plant cover for the vegetated overcrossing, a combination of sparse and dense cover types would serve the needs of the widest range of focal species. A continuous band of *Adenostoma* for a portion of the bridge would be needed to encourage use of the structure by Timema walking sticks. Elsewhere, cover that is representative of natural conditions, e.g., dense habitat with openings of bare ground and sparse habitat would benefit most other species.

Soil depth is the limiting factor for the establishment of most plants, and the proposed 4 feet of topsoil on the overcrossing will likely only be able to support shallower rooted plant species found in nearby chaparral and coastal sage scrub, including California buckwheat, black sage (*Salvia mellifera*), chamise, *Opuntia*, and chaparral yucca. If larger pockets of soil can be accommodated, such as raised planters, taller native shrubs and trees could be planted in strategic locations on the bridge.

While the created habitat on the overcrossing and approach area would best mimic adjacent intact native habitat as much as possible, slight modifications could be included to attract habitat specialists. For example, planting taller species such as Rainbow manzanita and Engelmann oaks in the middle and approach areas of the structure could both attract birds to use and elevate their flight across the crossing, while small pockets of native forbs and grasses could be established to attract pollinators, if conditions allow.

Rock piles as well as downed wood/logs and brush piles spaced throughout the overcrossing and approach area will provide cover for ground dwelling species and may create moister microclimates. Artificial rock structures that are lighter in weight may suffice to reduce additional weight burden on the structure.

Barriers, including walls and native plantings of at least 10 feet in height on the edges of the overcrossing and parallel to the highway in the approach area would shield wildlife from artificial night lighting and noise and could help funnel birds and bats across the structure. Walls on the overcrossing structure could include ledges to provide elevated passage for small wildlife.

The approach areas could be studied for the placement of seasonal pools, which would attract and benefit many of the focal species. Pools would best be a minimum of 700 square feet, incorporate a liner covered with native soil to hold water, and be designed so that they are filled by natural rainfall. Figures 4 and 5 present an illustration of the various design elements proposed by species experts for the vegetated wildlife overcrossing.

Wildlife Culvert

The wildlife culvert design will require several added features to improve its use by a wide array of wildlife species. If possible, the structure would best measure at least 15 x 15 feet to enhance visibility through the structure for medium and large mammals. In addition, a natural soil bottom is preferred for all or at least half of the longitudinal portion of the structure. The structure would best be designed to prevent inundation or major flows during rainfall events, possibly by retaining a nearby drainage culvert to handle storm flows and elevating the wildlife culvert on the west side of the highway to prevent regular water flows into the culvert. Keeping water flows separate may eliminate the need for riprap as an energy dissipater at the culvert exit, as riprap can inhibit small animal access to the crossing. To facilitate both aquatic and terrestrial wildlife passage, culverts would best be designed to allow for some dry ground or a ledge at least 4 feet in height and 8 to 12 inches wide inside the culvert on one or both sides.

All species expected to use the wildlife culvert would benefit from the incorporation of sound dampening treatments on the interior of the structure as well as noise and light barriers where the culvert adjoins the highway to reduce noise, vibration, and light associated with vehicle traffic.

The placement of skylights or grates to improve light and moisture conditions within the culvert for small animals will need to be carefully examined in relation to the placement of bat roosts to eliminate any conflicts in light conditions. Providing roosting habitat in recessed areas in the ceiling, which would be effective in creating areas of darkness and trapping heat, may help reduce conflict if skylights or grates are used to increase light and airflow. Evaluation of potential noise issues related to the incorporation of skylights and grates will also be beneficial. Grates will likely increase vehicle noise transmission from the roadway into the culvert, thus skylights with a transparent sound-absorbing covering may be preferred.

As with the vegetated overcrossing, the approach areas to the wildlife culvert would best incorporate logs, rock piles and seasonal pools to attract wildlife to the structure. In addition, the construction of the culvert is anticipated to result in significant vegetation removal and disturbance related to boring and grading activities. Habitat restoration of areas disturbed by grading could incorporate large native trees and boulders to mimic pre-existing conditions as much as possible. Large trees, boulders, brush piles and native topsoil removed during construction could be salvaged and used in post-construction habitat restoration.

While native boulders and rock piles would best be incorporated in the approach area, riprap is best not used in front of or on the slopes adjacent to the wildlife culvert entrances, as it is difficult for wildlife to traverse. If riprap is required, then it is best buried, backfilled with topsoil, and planted with native vegetation.

Finally, adding structure to the interior of the culvert in the form of rocks, brush piles, or logs will benefit small animals and their medium/large mammal predators by providing needed cover. Ongoing maintenance of added structure will be necessary to clear debris and sediment build-up that could impact water drainage or openness. Figures 6 and 7 present an illustration of the various design elements proposed by species experts for the wildlife culvert.

4.2 Proposed Upgrades to Existing Exclusion Fencing

The existing 8-foot exclusion fencing installed along a 3-mile stretch of I-15, while a much-needed improvement, would benefit from some upgrades to increase its utility in reducing roadkill of focal species.

Currently, the overhangs that were incorporated into the exclusion fencing to prevent wildlife from climbing over the fence are composed of 3-strand smooth wire. The smooth wire would best be replaced with fine mesh to prevent wildlife from breaching the fence. Fine mesh barrier fencing with a small overhang could also be attached to the lower 2-4 feet of the fence to guide small animals to the crossings and prevent roadkill. This feature would also reduce roadkill of hawks and owls that hunt for small animals in the roadway. If the entire fence alignment cannot be lined with the shorter barrier fencing (e.g., due to cost, maintenance or other Caltrans prohibitions), small barrier fencing could extend for at least 0.6 mile beyond the crossing structure in either direction, with small barrier fence ends angled away from the road.

Trees or large shrubs that are adjacent to the exclusion fencing (but not in the approach areas to the crossings) that could facilitate an animal climbing over the fence are best minimized, where possible, by modifying vegetation or adjusting fencing alignment. Once the wildlife crossings and associated noise/light barriers are constructed, the exclusion fencing would best be tied into the barrier walls.

4.3 Adaptive Management Considerations

Long-term monitoring and management will be key to the successful function of any wildlife crossing. Monitoring the effectiveness of the various design features in enhancing wildlife use of the crossing structures will be critical to informing management. Regular inspections of design features for crossings, approach areas and barrier fencing would also be beneficial. Experts agreed that funding for long-term management and monitoring in the form of an endowment would best be prioritized and incorporated into project implementation cost or acquired, perhaps through a separate fundraising effort.

Experts agreed that preventing unauthorized human access to the crossing structures and approach areas will ensure wildlife use of the crossing structures over the long-term. Several studies conducted in

California have documented that human and domestic dog presence can deter wildlife use of wildlife crossings and protected areas, with species such as bobcat, coyote, gray fox, and mule deer avoiding areas with recreational use (Murphy-Mariscal et al. 2015, Reed and Merenlender 2008, Jennings and Lewison 2013, George and Crooks 2006). An integrated trespass monitoring and management program could detect and manage trespass and would best include measures such as fencing and signage at likely human access points, camera trap monitoring, and frequent patrols and public outreach by landowners.

Experts were concerned that it may be difficult to maintain sufficient native cover on the vegetated wildlife overcrossing to promote wildlife use, given proposed shallow soil conditions. A permanent irrigation system was proposed for plantings on both the crossing and in the approach areas, with the irrigation system only operated during extended drought periods or to supplement natural rainfall. The water source could also be used to fill the proposed seasonal pools during drought periods to attract wildlife to the crossing.

Experts also proposed implementing a stepwise approach to some design features to ascertain the need prior to implementation. For example, medium/large animal experts identified the potential need for the creation of wildlife trails to the vegetated overcrossing and wildlife culvert to ensure that wildlife can more easily access the crossing. This treatment raised the concern that it might attract human trespass. It was suggested that the treatment could be delayed until after monitoring wildlife use for a certain period following construction to determine if needed. Prior to full implementation, the creation of game trails to the crossing could be performed on one side of the highway to evaluate if it is enhancing wildlife approach to the crossing prior to full implementation on both sides of the highway. Experts also theorized that seasonal pools, if incorporated on either side of the highway for the overcrossing or wildlife culvert, might provide an additional benefit by promoting the creation of natural trails to the crossing structure.

Thinning of native vegetation around Temecula Creek Bridge to enhance movement of focal species such as deer and bats would best only be undertaken after other enhancement measures (invasive plant control, fencing, noise abatement measures) and monitoring are in place to determine if the thinning is warranted. Some experts suggested that invasive plant control may be enough to improve the openness conditions of Temecula Creek Bridge for wildlife, but monitoring could be in place to evaluate if there is improved passage. In addition, experts agreed that it is important to understand patterns of wildlife approach to the crossings when designing and implementing fencing or other barriers to abate human trespass.

5.0 Conclusions

Design, construction, and long-term management of the wildlife crossings as envisioned here presents a new concept in protected area management that will require innovation, experimentation and monitoring to evaluate effectiveness, management of threats (e.g., human trespass), and refinement of design elements over time. While emphasis has been placed on the design and construction of wildlife crossing structures, more information is needed regarding how animals use these structures and how to maximize their effectiveness over the long term. The success of this effort will be dependent on securing public and private funds for wildlife crossing construction and for the implementation of a long-term adaptive management framework. Success will also depend on landowner engagement and participation in all stages of the process, from helping to develop cooperative adaptive management strategies, to identifying short- and long-term goals and objectives, to engaging in public outreach and education to develop community support for wildlife crossing construction and management.

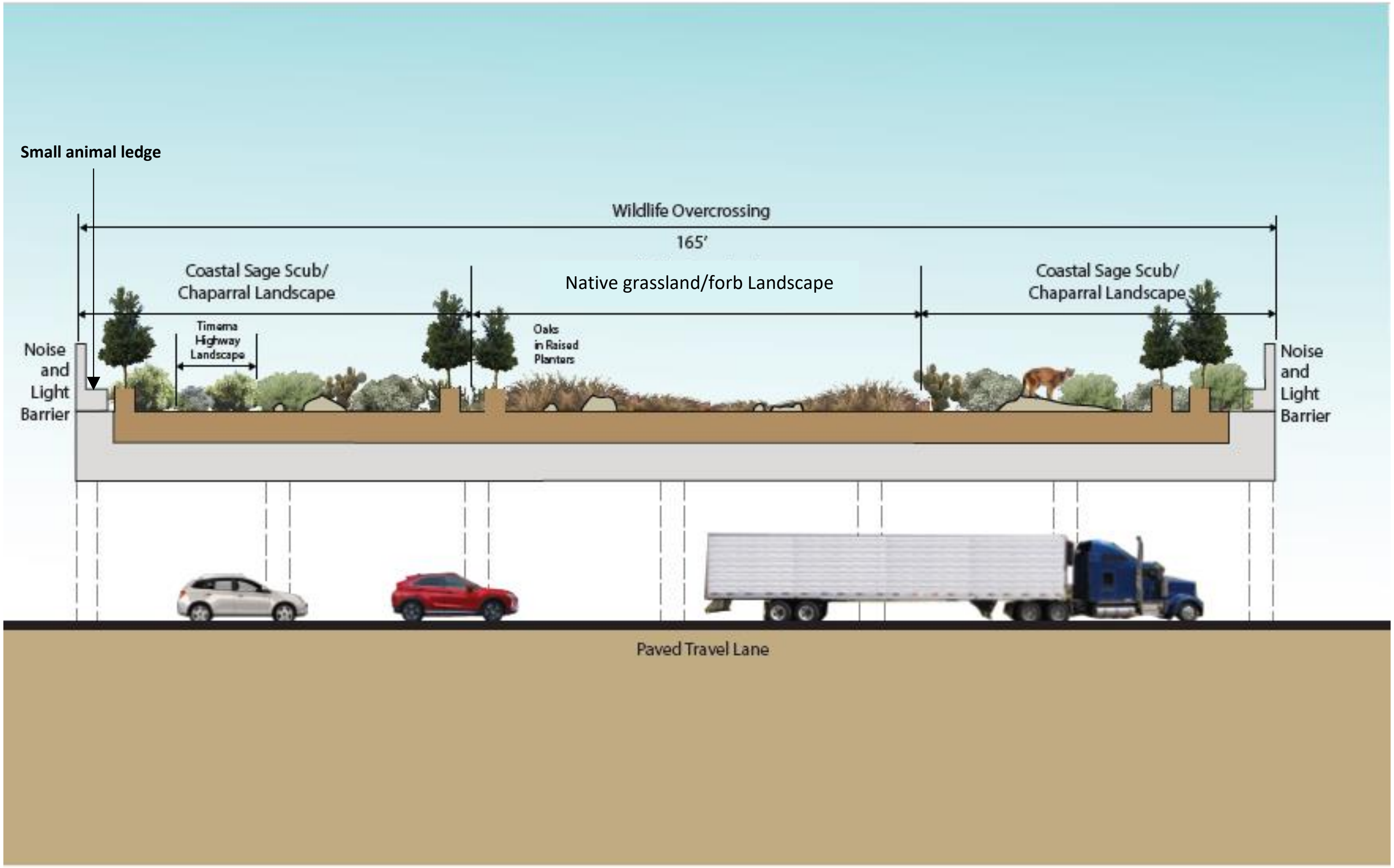

Figure 4: Cross-Section of Vegetated Overcrossing Concept (Lance Vallery).

Figure 5: Illustration of Vegetated Wildlife Overcrossing Design Concept (Lance Vallery).

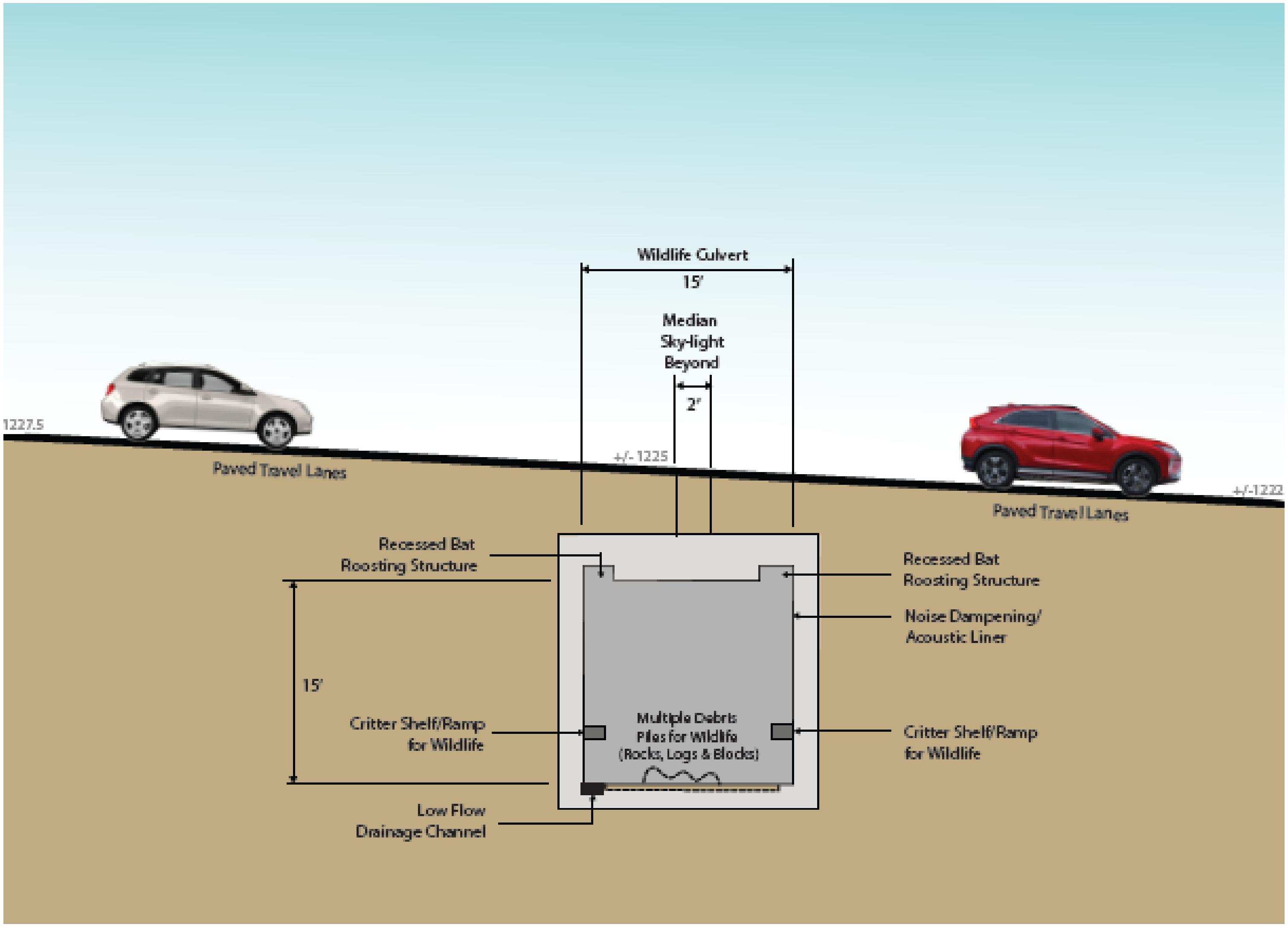

Figure 6: Cross-Section of Wildlife Culvert Design Concept (Lance Vallery).

Figure 7: Illustration of Wildlife Culvert Design Concept (Lance Vallery). Adapted from concept drawing by Cheryl Brehme.

6.0 References

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APPENDIX A
Species Experts and Organizational Affiliations

Name	Affiliation
Adam Backlin	U.S. Geological Survey
Alisha Curtis	Caltrans
Allison Anderson	U.S. Fish and Wildlife Service
Barbara Kus	U.S. Geological Survey
Barry Martin	Wildlife Tracking Inc.
Brock Ortega	DUDEK
Calvin Duncan	UC Davis Wildlife Health Center
Carlton Rochester	U.S. Geological Survey
Cheryl Brehme	U.S. Geological Survey
Dan Marschalek	University of Central Missouri
David Lipson	San Diego State University
Debra Shier	San Diego Zoo
Denise Clark	U.S. Geological Survey
Devin Adsit-Morris	U.S. Geological Survey
Drew Stokes	San Diego Natural History Museum
Dustin Pearce	California Department of Fish and Wildlife
Eric Abelson	University of Texas
Eric Porter	U.S. Fish and Wildlife Service
Fraser Shilling	UC Davis Road Ecology Center
Gjon Hazard	U.S. Fish and Wildlife Service
Gordon Pratt	UC Riverside
Greg Ballmer	UC Riverside
Greg Tatarian	Independent Biologist
Jessica Sanchez	San Diego Zoo
Jessie Vinje	Conservation Biology Institute
Jill Carpenter	LSA Associates
John Taylor	U.S. Fish and Wildlife Service
JP Montagne	San Diego Zoo
Julie King	Santa Clara Valley Habitat Agency
Justin Dellinger	California Dept of Fish and Wildlife
Katy Delaney	U.S. Geological Survey
Kevin Crooks	Colorado State University
Kris Preston	U.S. Geological Survey
Kristeen Penrod	Center for Large Landscape Conservation
Lauren Jonker	SDSU SMER
Liz Fairbank	Center for Large Landscape Conservation
Megan Jennings	San Diego State University
Melanie Madden	U.S. Navy
Melody Aimar	Santa Ana Watershed Association
Michelle Mariscal	Puente-Chino Hills Habitat Authority
Nancy Frost	Caltrans

Species Experts and Organizational Affiliation (continued)

Name	Affiliation
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Paul Beier	Northern Arizona University
Peter Beck	U.S. Fish and Wildlife Service
Phil Unitt	San Diego Natural History Museum
Robb Hamilton	Hamilton Biological
Robert Fisher	U.S. Geological Survey
Rulon Clark	San Diego State University
Sally Brown	U.S. Fish and Wildlife Service
Scott Tremor	San Diego Natural History Museum
Seth Riley	National Park Service
Spring Strahm	Wildspring Ecology
Stephanie Remington	Independent Biologist
Steve Montgomery	Independent Biologist
Susan Wynn	U.S. Fish and Wildlife Service
Tim Dillingham	California Dept of Fish and Wildlife
Trish Smith	The Nature Conservancy
Will Miller	U.S. Fish and Wildlife Service
Winston Vickers	UC Davis Wildlife Health Center
Zach Principe	The Nature Conservancy

APPENDIX B
Special Status Focal Wildlife and Plant Species
Santa Ana-Palomar Mountains Linkage

Common Name	Scientific Name	Federal	State	CNPS
Medium/Large Mammals				
American badger	*Taxidea taxus*		SSC	
Mountain lion	*Puma concolor*		C	
Ringtail	*Bassariscus astutus*		FP	
Small Animals				
Arroyo toad	*Anaxyrus californicus*	E		
Blainville's horned lizard	*Phrynosoma blainvillii*		SSC	
Red diamond rattlesnake	*Crotalus ruber*		SSC	
Western pond turtle	*Actinemys pallida*		SSC	
Western spadefoot toad	*Spea hammondii*		SSC	
Bats				
Pallid bat	*Antrozous pallidus*		SSC	
Birds				
California gnatcatcher	*Polioptila californica*	T	SSC	
Cactus wren	*Campylorhyncus brunneicapillus*		SSC	
Golden eagle	*Aquila chrysaetos*	BGEPA	FP	
Least Bell's vireo	*Vireo bellii pusillus*	E	E	
Yellow warbler	*Setophaga petechia*		SSC	
Invertebrates				
Monarch butterfly	*Danaus plexippus*	C		
Plants				
Engelmann oak	*Quercus engelmannii*			4.2
Rainbow manzanita	*Arctostaphylos rainbowensis*			1B.1

Sources: USFWS 2022; CDFW 2022; CNPS 2022.

Status Key
BGEPA = Federal Bald and Golden Eagle Protection Act
C = Candidate for Listing (Threatened or Endangered)
E = Endangered
FP = California Fully Protected Species
SSC = California Species of Special Concern
T = Threatened

<u>CNPS California Rare Plant Rank</u>
1B – Plants rare or endangered in California or elsewhere
.1 – Plants seriously endangered in California
.2 – Plants common elsewhere, fairly endangered in California
.3 – Plants not very threatened in California

U.S. Fish and Wildlife Service (USFWS). 2022. Information for Planning and Consultation.
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California Native Plant Society (CNPS). 2022a. Inventory of Rare and Endangered Plants of California (online edition, v8-03 0.45). Available: http://www.rareplants.cnps.org. Accessed: August 8, 2022.