Enhancing ecological connectivity and safe passage for wildlife on highways between the southern Santa Cruz Mountains, Gabilan Range, and Diablo Range in California

Pathways for Wildlife

POST

AUGUST 2022

Confluence of San Benito and Pajaro Rivers west of US 101. Photo by William K. Matthias.

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Cover photo: Coyote using a culvert to cross under SR 152.
Report editing and design by Kathy Switky, Switky Communications Group.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

In California, the southern end of the Santa Cruz Mountains has important ecological connections to both the Gabilan Range to the south and the Diablo Range to the east, facilitating wildlife movement, dispersal, and migration of individuals and species. Protecting and restoring ecological connectivity between areas of core habitat in these mountain ranges is a high priority for regional conservation efforts and is essential to sustain ecological processes and allow adaptation to climate change (Hilty et al. 2020, Pörtner et al. 2021).

This study assessed ecological connectivity between these mountain ranges, with a specific focus on the Aromas Hills and Upper Pajaro Valley. We assessed the need for improved permeability of the region's highways and identified specific recommendations for improving connectivity. These findings are intended to inform connectivity conservation efforts, including transportation infrastructure improvements, land acquisition and habitat restoration, and other land use decisions.

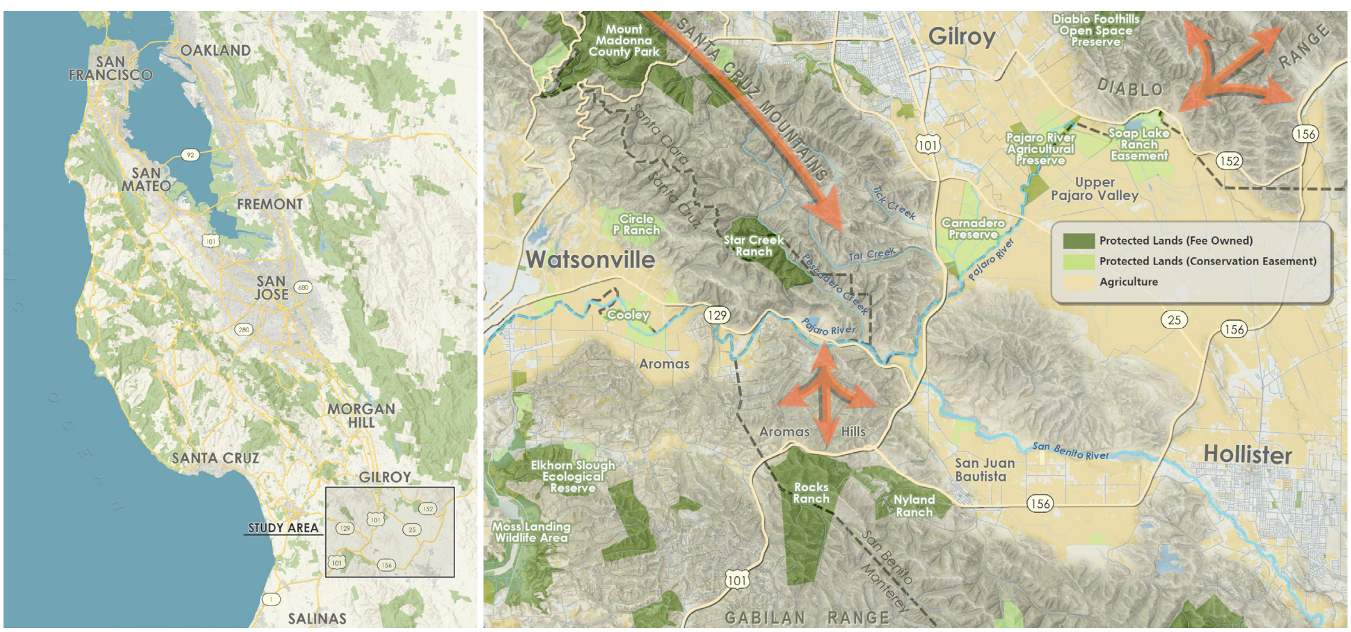


Figure A. The area for this study includes lands in Santa Clara, San Benito, Santa Cruz, and Monterey counties, Caltrans Districts 4 and 5 (including US 101, SR 129, SR 156, SR 152, and SR 25), and CDFW Regions 3 and 4. Arrows denote proposed ecological connectivity through the Aromas Hills connecting the Santa Cruz Mountains to the Gabilan Range and through the Upper Pajaro Valley connecting the Santa Cruz Mountains to the Diablo Range.

APPROACH

Focusing on native terrestrial mammals, this study identified where habitat connectivity is currently supported and could be enhanced using three complementary methods: (1) wildlife camera monitoring of existing highway undercrossings at 42 sites to identify locations of successful crossings for native mammals, (2) roadkill surveys along highways to identify locations of unsuccessful at-grade crossings, and (3) habitat suitability and cost surface modeling to identify important movement areas for a suite of focal species, including American badger, black-tailed deer, bobcat, and mountain lion.

KEY FINDINGS

- The vast majority of sites within the study area (90%) facilitated some degree of movement by medium-sized mammals through existing undercrossings, including American badger, bobcat, coyote, gray fox, raccoon, and striped skunk.
- Native species' use of existing undercrossings and the occurrence of native species at our 42 sites varied widely, with a range of 0 – 376 native animal passages when standardized to 100 trap nights. Three sites recorded no native species passages, while the two sites with the highest use facilitated 226 and 376 passages.
- Only 11 existing undercrossings in the study area (26%) facilitated movement by large mammals, including deer and mountain lion. Of these sites, only one recorded passage by mountain lion (based on tracks).
- The Upper Pajaro Valley along highways US 101, SR 25, and SR 152 had higher rates of native species passages and passage by a greater number of species relative to sites in the Aromas Hills along highways US 101, SR 129, and SR 156. The Upper Pajaro Valley may also be valuable for badger connectivity in the study area, with all recorded detections of badger occurring in this region.
- The Aromas Hills along US 101 had a relatively high concentration of wildlife–vehicle collisions, with half of all deer roadkill detections and all three recorded mountain lion–vehicle collisions occurring in this location. It was also the only location in the entire study area to record mountain lions on camera.
- Habitat suitability and cost surface modeling suggests that the study area is highly fragmented for mountain lion movement, with the Aromas Hills region including more suitable habitat for mountain lion movement than the Upper Pajaro Valley. Modeling and camera trap data suggest that riparian corridors (especially those with large undercrossings) serve as important thoroughfares for deer and bobcat through the Upper Pajaro Valley.

Based on the findings from wildlife camera trapping, roadkill surveys, and habitat suitability and cost surface modeling, the team identified 19 Connectivity Emphasis Sites (CESs) — specific locations with the most opportunities for reducing wildlife–vehicle collisions and improving connectivity for all wildlife, including fragmentation-sensitive species such as mountain lion. This report includes recommendations and next steps to maintain and enhance their connectivity.

RECOMMENDATIONS

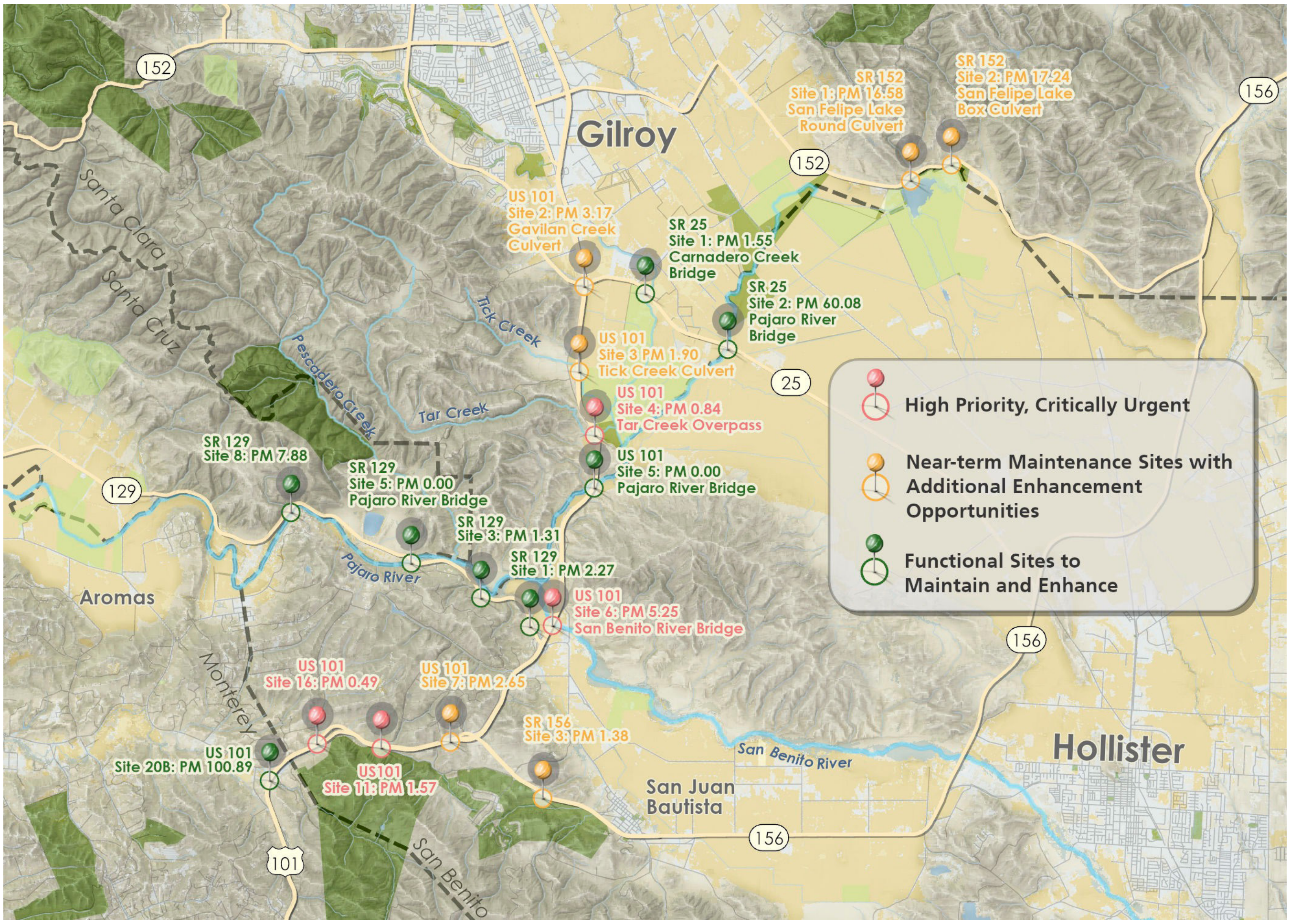


Figure B. Connectivity Emphasis Sites within highways in the study area, organized by category.

We made specific recommendations for each CES. Recommendations include maintaining or retrofitting existing structures, constructing new wildlife crossing structures, maintaining or increasing land-use security, and/or implementing land and infrastructure management actions to enhance connectivity. Land-use security refers to the degree to which lands adjacent to the site are protected from development or land uses not conducive to wildlife movement either legally or de facto. Wildlife-friendly land use management in areas adjacent to the CES, including permanent protections and habitat restoration/enhancement, will be necessary to support any infrastructure enhancements.

Our four highest priority and critically urgent CESs occur along US 101. The highest priority sites in the Upper Pajaro Valley include the Tar Creek overpass near the Carnadero Creek Preserve and the San Benito River Bridge. These are locations where existing structures should be maintained and enhanced. The highest priority sites in the Aromas Hills region include the Eucalyptus Grove and Habitat Island near Rocks Ranch. This stretch of US 101 in the Aromas Hills represents a critical location for one or more new wildlife crossing structures to enhance connectivity for mountain lion and other species. All four of these high priority, critically urgent sites also require increased land protection and management to maintain and enhance connectivity.

Connectivity Emphasis Site	Caltrans postmile	Mean score	Add new wildlife crossing structure	Maintain existing structure	Maintain/increase land-use security (for conservation purposes)	Add or modify fencing	Manage vegetation	Clear blockage
High priority, critically urgent								
US 101 Site 4 Tar Creek overpass	SCL, US 101, PM 0.84	4.3		X	X	X		
US 101 Site 11 (Eucalyptus Grove)	SBT, US 101, PM 1.57	4	X		X	X	X	
US 101 Site 16 (Habitat Island)	SBT, US 101, PM 0.49	4	X		X	X	X	
US 101 Site 6 San Benito River Bridge	SBT, US 101, PM 5.25	4		X	X	X		
Functional sites to maintain and enhance								
SR 25 Site 2 Pajaro River Bridge	SBT, SR 25, PM 60.08	4		X	X			
US 101 Site 5 Pajaro River Bridge	SCL, US 101, PM 0.00	4		X	X			
SR 129 Site 5 Pajaro River Bridge	SBT, SR 129, PM 0.00	3.3		X	X			
SR 129 Site 8	SCR, SR 129, PM 7.88	2.7	X	X (interim)	X			
US 101 Site 20B	MON, US 101, PM 100.89	2.7		X	X	X		
SR 129 Site 3	SBT, SR 129, PM 1.31	2.3	X	X (interim)	X	X		
SR 25 Site 1 Carnadero Creek Bridge	SCL, SR 25, PM 1.55	2		X	X			
SR 129 Site 1	SBT, SR 129, PM 2.27	1.3	X	X (interim)	X	X		
Near-term maintenance sites with additional enhancement opportunities								
SR 152 Site 2 San Felipe Lake box culvert	SCL, SR 152, PM 17.24	4.3	X	X (interim)	X	X	X	
SR 152 Badger hotspot	SCL, SR 152, PM 20.3-21.85	N/A	X	X	X	X		
US 101 Site 7	SBT, US 101, PM 2.65	3.3	X		X	X		
SR 152 Site 1 San Felipe Lake dual round culverts	SCL, SR 152, PM 16.58	3.3	X	X (interim)	X	X		X
US 101 Site 3 Tick Creek culvert	SCL , US 101, PM 1.90	2.7	X	X (interim)	X	X	X	
SR 156 Site 3	SBT, SR 156, PM 1.38	2.3	X*	X	X		X	
US 101 Site 2 Gavilan Creek culvert	SCL, US 101, PM 3.17	1	X*	X	X		X	

* Critter shelves

Figure C. Recommendations for each Connectivity Emphasis Site within highways in the study area, organized by category.

SPECIES REFERENCED IN THIS REPORT

Native	
American badger	*Taxidea taxus*
Barn owl	*Tyto alba*
Black-tailed deer	*Odocoileus hemionus* ssp. *columbianus*
Black-tailed jackrabbit	*Lepus californicus*
Bobcat	*Lynx rufus*
California ground squirrel	*Spermophilus beecheyi*
California kingsnake	*Lampropeltis getula californiae*
California red-legged frog	*Rana draytonii*
California tiger salamander	*Ambystoma californiense*
Coyote	*Canis latrans*
Gray fox	*Urocyon cinereoargenteus*
Long-tailed weasel	*Mustela frenata*
Mountain lion	*Puma concolor*
Raccoon	*Procyon lotor*
San Francisco dusky-footed woodrat	*Neotoma fuscipes annectens*
Striped skunk	*Mephitis mephitis*
Non-native	
Domestic cat	*Felis catus*
Domestic dog	*Canis lupus familiaris*
Red fox	*Vulpes vulpes*
Virginia opossum	*Didelphis virginiana*
Wild pig	*Sus scrofa*

1 INTRODUCTION AND STUDY AREA

Scientists agree that ecological connectivity is critical for healthy ecosystems, including the conservation of biodiversity (Hilty et al. 2020). Connectivity includes daily movement, dispersal, and migration of individuals and species, and is essential to support ecological processes and climate adaptation (Hilty et al. 2020, Pörtner et al. 2021).

Human-caused habitat loss and fragmentation are key factors in the loss of ecological connectivity. In particular, roads and other transportation infrastructure contribute to habitat loss and fragmentation. Roads affect animals' behavior, movement patterns, reproductive success, and physiology, all of which can significantly impact individuals, populations, communities, and ecosystems (Trombulak and Frissell 2000, van der Ree et al. 2011, Shilling et al. 2020).

Within California, roads contribute to habitat fragmentation and isolation of at-risk species such as mountain lion (Yap et al. 2021, Gustafson et al. 2021). In addition, wildlife–vehicle collisions have significant human and financial impacts. In California, an estimated 7,000–23,000 wildlife vehicle collisions occur annually (Shilling et al. 2018b). These crashes result in loss of human life, injuries, emotional trauma, and property damages that cost an estimated $307–600 million per year (Shilling et al. 2018b, Yap et al. 2019).

In California, the southern Santa Cruz Mountains, Gabilan Range, and Diablo Range represent critically important areas of core habitat connected by tenuous habitat linkages that are fragmented by roads and human development. Protecting and restoring ecological connectivity between these areas of core habitat is a high priority for regional conservation efforts as described below (Mackenzie et al. 2011, Penrod et al. 2013, Pajaro Compass 2016). Collaborative, integrated approaches to improving ecological connectivity can help avoid and ameliorate the impacts of roads, and can be one of many broader sustainability actions in this region.

The purpose of this study was to assess ecological connectivity between the southern end of the Santa Cruz Mountains, Gabilan Range, and Diablo Range. Specifically, this study assesses the need for improved permeability of highways in this region and identifies specific recommendations for improving connectivity in this region. The findings are intended to inform connectivity conservation efforts, including transportation infrastructure; land acquisition and habitat restoration; and other land use decisions.

STUDY AREA AND IMPORTANCE FOR CONSERVATION

The study area includes the Santa Cruz Mountains, Gabilan Range, Diablo Range in the central coast of California, and the lands connecting them within the Aromas Hills and the Pajaro River watershed. It includes lands in Santa Clara, San Benito, Santa Cruz, and Monterey counties, Caltrans Districts 4 and 5, California Department of Fish and Wildlife (CDFW) Regions 3 and 4, and US Fish and Wildlife Service's Pacific Southwest Region.

Figure 1.1. The area for this study includes lands in Santa Clara, San Benito, Santa Cruz, and Monterey counties, Caltrans Districts 4 and 5 (including US 101, SR 129, SR 156, SR 152, and SR 25), and CDFW Regions 3 and 4. Arrows denote proposed ecological connectivity through the Aromas Hills connecting the Santa Cruz Mountains to the Gabilan Range and through the Upper Pajaro Valley connecting the Santa Cruz Mountains to the Diablo Range. Agricultural land use is denoted in yellow to illustrate its prominence as a regional land use, though other land uses are also present.

We selected this study area because of its importance for local and regional conservation, as well as its susceptibility to habitat loss and fragmentation. At least 16 plans, assessments, and initiatives have identified the study area as a conservation priority (see box, Relevant conservation plans and assessments). The region includes large expanses of intact habitat representing many ecosystems characteristic of California's Central Coast that support diverse assemblages of plants and animals, including several rare, threatened, and endangered species, along with more widespread species that are important components of healthy ecosystems (CDFW et al. 2015).

RELEVANT CONSERVATION PLANS AND ASSESSMENTS

Many assessments have identified the study area as important for local and regional conservation:

- Pajaro Compass – A Network for Voluntary Conservation (2015–Present, Pajaro Compass 2016)
- California Wildlife Barriers (CDFW 2020)
- Santa Clara County Regional Conservation Investment Strategy (ICF 2019)
- A Petition to List the Southern California/Central Coast Evolutionarily Significant Unit (ESU) of Mountain Lions as Threatened under the California Endangered Species Act (CESA) (Yap et al. 2019)
- Landscape Connectivity using Omniscape (TNC 2018)
- California State Wildlife Action Plan 2015 Update (CDFW 2015) and SWAP 2015 Transportation Planning Companion Plan (CDFW 2016)
- Santa Clara Valley Greenprint (Santa Clara Valley Open Space Authority 2014)
- CA Central Coast Connectivity Project (Diamond and Snyder 2014)
- Critical Linkages: Bay Area and Beyond (Penrod et al. 2013)
- The Nature Conservancy's Pajaro Study 2012–2013 (Diamond and Snyder 2013)
- Santa Clara Valley Habitat Plan (ICF 2012)
- Conservation Blueprint for Santa Cruz County: An Assessment and Recommendations from the Land Trust of Santa Cruz County (Mackenzie et al. 2011)
- California Essential Habitat Connectivity Project: A Strategy for Conserving a Connected California (Spencer et al. 2010)

This study is also relevant to several planning efforts currently underway:

- Office of Administrative Law's Notice ID #Z2019-0716-03 and Z2020-0421-01. Petition to List Mountain Lion (*Puma concolor*) as a Threatened or Endangered Species (State of California, in progress)
- San Benito County Conservation Plan (San Benito County, in progress)
- Santa Cruz County Regional Conservation Investment Strategy (Santa Cruz County Regional Transportation Commission and Santa Cruz County Resource Conservation District, in progress)

This region is also a last-chance landscape for regional connectivity. In addition to other complementary linkages in the San Francisco Bay Area, the study area encompasses areas critical for connecting the Santa Cruz Mountains, Gabilan Range, and Diablo Range, all of which include substantial areas of core habitat. Connectivity among these three ranges has been identified as essential to maintaining biodiversity in California's Central Coast Ecoregion (Penrod et al. 2001, Penrod et al. 2013, Spencer et al. 2010, CDFW 2015). However, connectivity in this region is restricted by two chokepoints occurring within the study area (Penrod et al. 2013):

- **The Santa Cruz Mountains – Gabilan Range chokepoint via the Aromas Hills.** This area includes Highways 156, 129, and 101.
- **The Santa Cruz Mountains – Mount Hamilton (Diablo Range) chokepoint via the Upper Pajaro Valley.** This area includes Highways 101, 25, and 152.

The urgency of restoring and protecting ecological connectivity in the study area is underscored by research documenting the isolation of mountain lion populations in the Santa Cruz Mountains and neighboring ranges, attributed to anthropogenic habitat fragmentation (Gustafson et al. 2019). Mountain lions in the Santa Cruz Mountains have genetic diversity estimates that are as low as those of mountain lions in southern California, which are highly isolated by urbanization and transportation infrastructure (Gustafson et al. 2022). With the exception of the endangered Florida panther (a subspecies of mountain lion, *Puma concolor coryi*), the central coast and southern California populations, which make up a proposed Evolutionary Significant Unit (ESU), have the lowest genetic diversity observed for the species throughout its range (Ernest et al. 2014, Riley et al. 2014, Gustafson et al. 2019, Benson et al. 2019, Yap et al. 2019). This mountain lion ESU is now a candidate for listing under the California Endangered Species Act (CESA) and is afforded the same protection as a listed species (see box, Focal species in the study area).

Any continued habitat fragmentation and isolation may lead to genetic drift, inbreeding, and in turn, local extinctions of mountain lions within the study area (Gustafson et al. 2022). It is essential that connectivity is enhanced between the Santa Cruz Mountains, Gabilan Range, and Diablo Range to ensure the persistence of mountain lion populations along the central coast of California and to facilitate movement of other wildlife species — among the many other ecological and economic benefits of improving connectivity and reducing wildlife–vehicle collisions.

FOCAL SPECIES IN THE STUDY AREA

We selected a suite of terrestrial mammals as our focal species. These species have different habitat requirements and collectively use and travel through a large range of different habitats within the study area. Together, these species can help identify important core habitat locations and locations important for species movement.

American badger

A grassland specialist, this California Species of Special Concern is sensitive to human disturbance and tends to reside in relatively undisturbed habitats. Because badgers are relatively slow, have poor eyesight, and are unable to climb over road median barriers, they are particularly susceptible to collisions with vehicles.

Black-tailed deer

Black-tailed deer movement in the study area is impeded by highways, urban development, and high fences. Deer are vulnerable to habitat fragmentation by roads and are particularly susceptible to wildlife–vehicle collisions, which poses a public safety risk given their large body size. Because deer is a primary prey species for mountain lion, enhancing connectivity for deer may also support connectivity for mountain lion.

Bobcat

A habitat generalist, bobcat uses a wide range of habitats within the study area. Research on bobcat populations within the study area indicates that roads are a significant challenge to this species (Serieys et al. 2021). These animals — and likely other species — face additional challenges from various types of residential development, agricultural uses, and exposure to poisons such as anticoagulant rodenticides.

Mountain lion

Mountain lion is a wide-ranging species that occurs at naturally low densities, making it an excellent indicator of broad-scale landscape connectivity (Riley et al. 2006). However, mountain lion populations within the study area exhibit high levels of inbreeding because of extreme isolation caused by roads and development (Gustafson et al. 2019). In April 2020, the California Fish and Game Commission found that listing the central coast and southern California mountain lion population may be warranted, and designated mountain lion within this proposed Evolutionarily Significant Unit (ESU) as a candidate species under CESA. A status review process is currently underway by the California Department of Fish and Wildlife in order to make a final decision as to whether to list these populations as threatened or endangered under CESA. Under CESA, species classified as a candidate species are afforded the same protection as listed species. As a result, mountain lions in this proposed ESU are CESA-protected during the review period.

CURRENT AND FUTURE LAND USE

The study area encompasses complex and varied land uses, including rural residential, commercial, industrial, and agricultural uses in addition to natural habitats, and is subject to ongoing human population growth and development. Land uses differ between the Aromas Hills and Upper Pajaro Valley chokepoints. The Aromas Hills includes a mix of rural residential, commercial, industrial, and some agricultural uses. Natural habitats in the Aromas Hills include coastal conifer forests, woodlands grasslands, and some wetland and riparian areas. In contrast, the Upper Pajaro Valley is largely agricultural, with the majority of lands used for row crop cultivation (Pajaro Compass 2016). The Upper Pajaro Valley is also bisected by several streams with narrow riparian areas and canals that were designed to more efficiently drain water from the Upper Pajaro floodplain to accommodate agriculture (Pajaro Compass 2016). Remnant natural habitats in the Upper Pajaro Valley include riparian forests, alkali marsh, and seasonal and permanent freshwater marshes, with grasslands and oak woodlands present in the hills surrounding the agricultural bottomlands. Protected lands in the Upper Pajaro Valley may include a mix of agricultural and natural land uses (such as riparian buffers alongside agricultural fields), and some are subject to both fee title ownership by a conservation organization/agency and conservation easement (for example, the Carnadero Preserve).

Transportation corridors, along with human development and agriculture, have important influences on ecological connectivity and wildlife movement in both the Aromas Hills and Upper Pajaro Valley (CDFW 2015). Of particular relevance to ecological connectivity in the study area are the interactions between wildlife and US and state highways, which are the primary focus of this study. Understanding the impact of these highways on connectivity is essential to regional biodiversity conservation and climate resilience efforts. Highways in the study area include US Highway 101 (four to five lanes, depending on location), State Route (SR) 152 (spanning two or three lanes, depending on location), SR 25 (two lanes), SR 129 (two lanes) and SR 156 (four lanes) (Figure 1.1). Vehicular traffic on the five highways of interest is significant, though traffic is heaviest on US 101 at SR 25 and lightest on US 129 at Rogge Lane (Figures 1.1 and 1.2).

Annual average daily traffic (vehicles per day) in the study area	
US 101 at SR 25	63,000–84,000
SR 152 at Bloomfield Avenue	28,400–30,500
SR 25 at the Santa Clara County/San Benito County line	27,300
SR 129 at Rogge Lane	10,000–10,100
SR 156 at US 101 (south junction)	33,500–37,100

Figure 1.2. Average vehicles/day in the study area. Data from Caltrans 2017 traffic census.

Future plans include the widening of SR 25 (Caltrans 2022) and the proposed SR 152 New Trade Corridor (Santa Clara Valley Transportation Authority 2020). In addition, the San Jose to Merced Project Section of the California High-Speed Rail is planned through the study area. The proposed alignment of High-Speed Rail is through Pacheco Pass and the upper Pajaro River floodplain (Soap Lake area).

The study area is also subject to development pressure. The site of a proposed sand and gravel mine (Sargent Quarry) is located within the study area, including project features along Tar Creek and new transportation infrastructure along US 101. The study area includes four sites adjacent to the US 101 corridor known as San Benito County development nodes (San Benito County 2015), located at the Betabel Road and SR 129/Searle Road interchanges in San Juan Bautista; and the Rocks Ranch and 101 Livestock Market interchanges in Aromas. All of these would likely cause loss and degradation of wildlife habitat, as well as increased traffic.

Human population in the study area is expected to grow, which will likely increase traffic on these highways and contribute to development pressure. The Monterey Bay Area — which includes Santa Cruz, Monterey, and San Benito counties — is expected to grow 17% from 755,403 people in 2015 to 883,300 in 2040. More than 42,000 more housing units are expected to be added by 2040, growing from 262,660 housing units in the region as of 2015. More than 57,000 jobs are expected to be created in the 2015–2040 timeframe (Association of Monterey Bay Area Governments 2018). In Santa Clara County, Gilroy is expected to grow from 57,000 in 2020 to 65,000 by 2025.

GOALS AND OBJECTIVES

Given the importance of the study area for regional connectivity and ongoing human population growth and development, this study sought to evaluate the region's current ecological connectivity and identify opportunities to improve regional connectivity. Specifically, the study assessed the permeability of five highways in the study area which occur within the Aromas Hills and Upper Pajaro Valley chokepoints: US 101, SR 129, SR 156, SR 152, and SR 25.

Our goals for this study were as follows:

- Identify where habitat connectivity is currently supported and should be maintained, using medium- and large-sized terrestrial mammals as focal species.
- Identify locations where maintenance and/or upgrades for existing transportation infrastructure could increase the permeability of the landscape and reduce wildlife–vehicle collisions.
- Identify locations where new wildlife passage infrastructure may be beneficial to increase the permeability of the landscape and reduce wildlife–vehicle conflict.

Our specific objectives for this study were as follows:

- Document species passages and occurrences at existing below-grade passages (undercrossings)
- Identify areas of roadkill occurrence
- Identify suitable habitat for focal species' movement via modeling
- Develop a list of site-specific recommendations to protect and/or enhance connectivity for wildlife

We addressed these goals and objectives using three complementary methods: wildlife camera trapping at existing highway undercrossings, roadkill surveys along highways within the study area, and habitat suitability and cost surface modeling for a suite of focal species. We then synthesized and integrated data from these three methods to develop recommendations to improve ecological connectivity in the study area.

REPORT STRUCTURE

This report is structured as follows. Chapter 2 discusses wildlife camera trapping of existing highway undercrossings in the study area, showing how wildlife used undercrossings during the study period. Chapter 3 discusses roadkill surveys on highways within the study area, showing areas where wildlife was hit and killed by vehicles while crossing the road at-grade during the study period. Chapter 4 discusses habitat suitability and cost surface modeling used to identify areas important for maintaining or enhancing habitat connectivity for focal species. Chapter 5 synthesizes data from wildlife camera trapping, roadkill surveys, and habitat suitability and cost surface modeling to identify 19 Connectivity Emphasis Sites (CESs) that we believe present the best opportunities for reducing wildlife–vehicle collisions and improving wildlife connectivity. Chapter 6 includes specific recommendations for each CES to improve connectivity and motorist safety in the study area. The report ends with conclusions, next steps, and future research needs as outlined in Chapter 7.

Additional information can be found in the report appendices. Appendix A includes information about a Wildlife Permeability and Infrastructure Database (WPID) created for this study. The WPID includes information on all potential undercrossings (culverts 3′ diameter and greater; bridge underpasses) and all potential barriers (fencing, medians) for medium- to large-sized mammal movement along focal highways within the study area region and is available upon request. Appendix B includes camera monitoring site assessments for each highway undercrossing monitored in the study. Appendix C includes crossing infrastructure information sheets (after Clevenger and Huijser 2011), which provide an overview of each of the main methods to support wildlife road crossings and reduce wildlife–vehicle collisions. Appendix D provides hot sheets for each CES identified in Chapters 5 and 6. These hot sheets serve as quick references summarizing opportunities and site-specific information relevant to connectivity, target species, wildlife objectives, and recommendations to improve safe passage opportunities for wildlife at each CES. An additional spreadsheet (Supplemental Information) available for download on the POST website (openspacetrust.org/connectivity-study) includes camera monitoring data on native and non-native species passages through undercrossings.

2 CAMERA MONITORING DATA AT HIGHWAY UNDERCROSSINGS

INTRODUCTION

Wildlife is known to travel under roadways using features such as culverts and underpasses designed for water conveyance and/or other uses. Motion-activated cameras can serve as a non-invasive tool to assess the use of such structures by wildlife. While there can be variation within and between species willing to approach a roadway and use existing structures based on light, noise, and biophysical characteristics, camera data can help provide a baseline perspective of wildlife interactions with transportation infrastructure, including use, non-use, and investigation of existing structures (Shilling et al. 2018a). This information can be used to identify structures and/or locations that are important to maintain or enhance for wildlife passage.

METHODS

CAMERA MONITORING SITES

We used wildlife camera monitoring to document wildlife passages through existing highway undercrossings in the study area. To select potential wildlife camera monitoring sites, we identified all known locations with an existing undercrossing >3′ diameter (for round culverts) or >3′ width (for box culverts), which are the minimum dimensions that other studies have found to be suitable for passing small and medium-sized mammals (Ruediger and DiGiorgio 2007). These included culverts as well as bridge underpasses and road overpasses. During ground truthing and camera setup, we found four culverts smaller than these criteria that we determined should be included because of the quality of adjacent habitat and suspected potential for wildlife use.

In total, we monitored 42 sites (Figure 2.1) over the course of two years. Once the study was underway, we discovered additional culverts that met the 3′+ diameter/width criteria, but we did not monitor these because of fieldwork capacity constraints (see Appendix B).

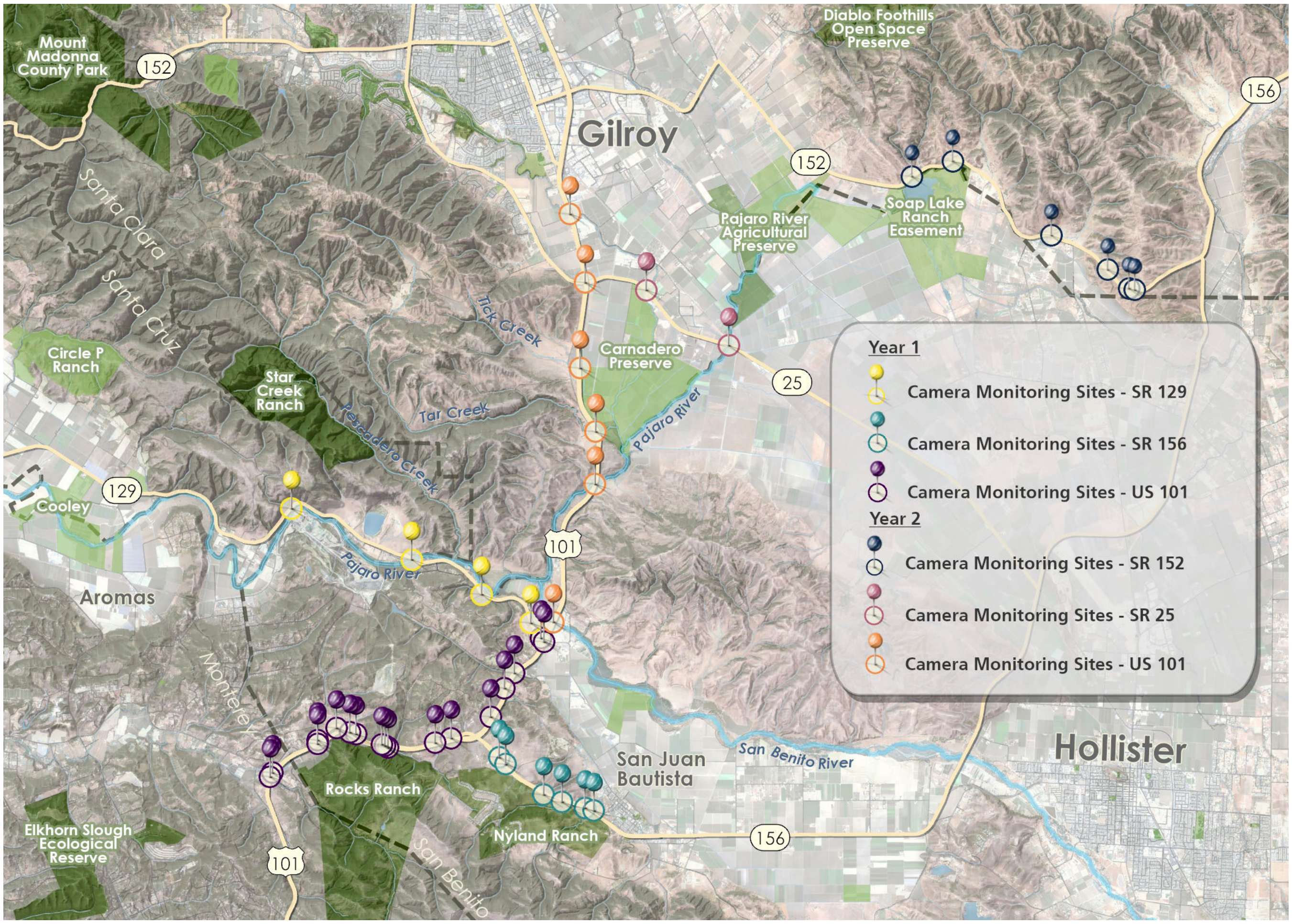


Figure 2.1. Map of all 42 camera monitoring sites. We monitored the Aromas subarea in year 1 of the study (2018-2019), and the Pajaro Valley subarea in year 2 (2019-2020). Darker green protected lands are fee-owned; lighter green lands are protected by conservation easements.

As indicated by the site numbering, seven known culverts were ultimately excluded from camera monitoring because of camera theft, site safety, or other constraints. We divided the study area into two subareas, each of which had three sections:

Aromas subarea

- SR 129 section (four camera monitoring sites); Caltrans District 5, San Benito and Santa Cruz counties
- SR 156 section (six camera monitoring sites); Caltrans District 5, San Benito County
- US 101 Aromas Hills section (18 camera monitoring sites); Caltrans District 5, San Benito and Monterey counties

Pajaro Valley subarea

- SR 152 section (six camera monitoring sites); Caltrans District 4, Santa Clara County
- SR 25 section (two camera monitoring sites); Caltrans Districts 4 and 5, Santa Clara and San Benito counties
- US 101 Pajaro Valley section (six camera monitoring sites); Caltrans Districts 4 and 5, Santa Clara and San Benito counties

Each site was also identified by a site name, postmile marker, and latitude and longitude (Figure 2.2). Additional information on each site can be found in Appendices A and B.

Caltrans District	County	Highway	Caltrans postmile	Site name	Crossing type	Data collected	Latitude	Longitude
AROMAS SUBAREA								
SR 129 section								
D5	San Benito	SR 129	SBT PM 2.27	**SR 129 Site 1**	culvert	2018-19	36.88695	-121.56503
D5	San Benito	SR 129	SBT PM 1.31	**SR 129 Site 3**	culvert	2018-19	36.89307	-121.57847
D5	San Benito	SR 129	SBT PM 0.00	**SR 129 Site 5 Pajaro River Bridge**	underpass	2018-19	36.90051	-121.5976
D5	Santa Cruz	SR 129	SCR PM 7.88	**SR 129 Site 8**	culvert	2018-19	36.91135	-121.63035
SR 156 section								
D5	San Benito	SR 156	SBT PM 0.41	**SR 156 Site 1**	culvert	2018-19	36.85751	-121.57321
D5	San Benito	SR 156	SBT PM 0.57	**SR 156 Site 2**	culvert	2018-19	36.85603	-121.57142
D5	San Benito	SR 156	SBT PM 1.38	**SR 156 Site 3**	culvert	2018-19	36.84949	-121.56099
D5	San Benito	SR 156	SBT PM 1.64	**SR 156 Site 4**	culvert	2018-19	36.84798	-121.55598
D5	San Benito	SR 156	SBT PM 2.01	**SR 156 Site 5**	culvert	2018-19	36.8467	-121.54977
D5	San Benito	SR 156	SBT PM 2.14	**SR 156 Site 6**	culvert	2018-19	36.84612	-121.54734
US 101 Aromas Hills section								
D5	San Benito	US 101	SBT PM 4.92	**US 101 Site 1**	culverts	2018-19	36.8837	-121.56221
D5	San Benito	US 101	SBT PM 4.91	**US 101 Site 2**	culverts	2018-19	36.88288	-121.5614
D5	San Benito	US 101	SBT PM 4.26	**US 101 Site 4 Anzar Road underpass**	underpass	2018-19	36.87599	-121.56935
D5	San Benito	US 101	SBT PM 4.00	**US 101 Site 5**	culvert	2018-19	36.87264	-121.57197
D5	San Benito	US 101	SBT PM 3.52	**US 101 Site 6**	culvert	2018-19	36.86636	-121.57565
D5	San Benito	US 101	SBT PM 2.65	**US 101 Site 7**	culvert	2018-19	36.86161	-121.58629
D5	San Benito	US 101	SBT PM 2.38	**US 101 Site 8**	culvert	2018-19	36.86055	-121.59062
D5	San Benito	US 101	SBT PM 1.66	**US 101 Site 9** (Eucalyptus Grove)	culvert	2018-19	36.85943	-121.60339
D5	San Benito	US 101	SBT PM 1.62	**US 101 Site 10** (Eucalyptus Grove)	culvert	2018-19	36.85977	-121.60423
D5	San Benito	US 101	SBT PM 1.57	**US 101 Site 11** (Eucalyptus Grove)	culvert	2018-19	36.86008	-121.60507
D5	San Benito	US 101	SBT PM 1.12	**US 101 Site 13**	culvert	2018-19	36.86226	-121.61215
D5	San Benito	US 101	SBT PM 1.02	**US 101 Site 14**	culvert	2018-19	36.86262	-121.61382
D5	San Benito	US 101	SBT PM 0.82	**US 101 Site 15** (Habitat Island)	culvert	2018-19	36.86353	-121.61749
D5	San Benito	US 101	SBT PM 0.49	**US 101 Site 16** (Habitat Island)	culvert	2018-19	36.86084	-121.62256
D5	San Benito	US 101	SBT PM 0.43	**US 101 Site 17** (Habitat Island)	culverts	2018-19	36.86003	-121.62255
D5	Monterey	US 101	MON PM 100.95	**US 101 Site 19**	culverts	2018-19	36.85359	-121.63467
D5	Monterey	US 101	MON PM 100.89	**US 101 Site 20A and 20B**	culverts	2018-19	36.85271	-121.63529

Caltrans District	County	Highway	Caltrans postmile	Site name	Crossing type	Data collected	Latitude	Longitude
PAJARO VALLEY SUBAREA								
SR 152 Pajaro Valley section								
D4	Santa Clara	SR 152	SCL PM 16.58	**SR 152 Site 1 San Felipe Lake dual round culverts**	culverts	2019-20	36.98539	-121.46276
D4	Santa Clara	SR 152	SCL PM 17.24	**SR 152 Site 2 San Felipe Lake box culvert**	culvert	2019-20	36.98883	-121.45172
D4	Santa Clara	SR 152	SCL PM 19.32	**SR 152 Site 3 Ortega Creek Bridge**	underpass	2019-20	36.97282	-121.42469
D4	Santa Clara	SR 152	SCL PM 20.32	**SR 152 Site 4 Coyote and Badger culvert**	culvert	2019-20	36.96545	-121.40928
D4	Santa Clara	SR 152	SCL PM 20.74	**SR 152 Site 5 Coyote Puppy culvert**	culvert	2019-20	36.96143	-121.40347
D4	Santa Clara	SR 152	SCL PM 20.85	**SR 152 Site 6 Tree round culvert**	culvert	2019-20	36.96109	-121.40189
SR 25 Pajaro Valley section								
D4	Santa Clara	SR 25	SCL PM 1.55	**SR 25 Site 1 Carnadero Creek Bridge**	underpass	2019-20	36.95997	-121.53468
D5	San Benito	SR 25	SBT PM 60.08	**SR 25 Site 2 Pajaro River Bridge**	underpass	2019-20	36.94805	-121.51211
US 101 Pajaro Valley section								
D4	Santa Clara	US 101	SCL PM 4.21	**US 101 Site 1 Carnadero Creek Bridge**	underpass	2019-20	36.97637	-121.55564
D4	Santa Clara	US 101	SCL PM 3.17	**US 101 Site 2 Gavilan Creek culvert**	culvert	2019-20	36.96145	-121.55131
D4	Santa Clara	US 101	SCL PM 1.90	**US 101 Site 3 Tick Creek culvert**	culverts	2019-20	36.94274	-121.55243
D4	Santa Clara	US 101	SCL PM 0.84	**US 101 Site 4 Tar Creek overpass**	underpass	2019-20	36.9289	-121.54797
D4	Santa Clara	US 101	SCL PM 0.00	**US 101 Site 5 Pajaro River Bridge**	underpass	2019-20	36.91745	-121.54797
D5	San Benito	US 101	SBT PM 5.25	**US 101 Site 6 San Benito River Bridge**	underpass	2019-20	36.88724	-121.55888

Figure 2.2. List of camera monitoring sites. Some site numbers are non-consecutive, as originally planned (and numbered) sites were ultimately not monitored due to camera theft, site safety, or other constraints.

CAMERA SURVEYS

With Caltrans encroachment permits to access the culverts and other undercrossings, we placed digital infrared ("no-glow") camera(s) at each site in such a way that they were non-invasive to animals. The cameras were motion-activated. We checked the cameras every one to two weeks and tabulated all animals passing through the site by species.

Because of the labor-intensive nature of camera monitoring, we monitored the Aromas subarea (SR 129, SR 156, and US 101 Aromas Hills sections) in year 1 of the study, August 1, 2018 – July 31, 2019, and the Pajaro Valley subarea (SR 152 Pajaro Valley, SR 25 Pajaro Valley, and US 101 Pajaro Valley sections) in year 2, October 1, 2019 – September 30, 2020.

CAMERA DATA ANALYSIS

Records across the camera monitoring sites varied, and over the course of the year, not all sites recorded 365 nights. To compare data of successful passages from all sites, we standardized data for each site to represent 100 trap nights by summing all detections for each species over all days, dividing by the total number of days the camera was operational, and then multiplying by 100 (Jenks et al. 2011).

Our data analysis totaled the frequency and type of use (investigation, successful passage) of each undercrossing by native and non-native species. When possible, we also noted additional information such as use by individual animals, animals traveling with juveniles, species interactions, and presence of non-native species.

We categorized the sites by the size of native mammals using the undercrossings to cross highways. Large-sized mammals included black-tailed deer and mountain lion. Medium-sized mammals included American badger, bobcat, coyote, gray fox, raccoon, and striped skunk. Small mammals included long-tailed weasel.

Documenting passages for some small mammals (rodents and rabbits) was difficult, as the vast majority foraged in front of culverts or under bridges, used the structures for shade, and/or accessed an entrance and then traveled right back out. It seems that for these species, many of these structures are within their home range, and they use the structures for daily activities such as foraging or access to shade or water. Given the difficulties in accurately assessing successful passage by small mammal species, we do not describe these species further in the report, although small mammals were observed throughout the study area.

We also detected several non-native species using the undercrossings, including domestic cat, domestic dog, red fox, Virginia opossum, and wild pig. Though red fox and wild pig are associated with detrimental ecological impacts (Bidlack et al. 2008, Barrios-Garcia and Ballari 2012), their habitat needs and preferences are similar to those of native mammals, thus understanding their use of wildlife crossing structures is valuable. Mountain lions also prey on wild pigs in regions where wild pigs are abundant (as reviewed in Sweitzer 1998), suggesting that understanding wild pig occurrences across the landscape may provide insights into potential areas where mountain lion might occur. Similarly, opossum use of crossing structures can be valuable for understanding which structures might be suitable for other small mammals. In general, understanding how non-native species utilize crossings can help provide information about the inherent limitations of the existing wildlife crossing infrastructure for animals and may also help provide insights into native species detections.

We added records of special-status species into the California Natural Diversity Database (CNDDB) maintained by California Department of Fish and Wildlife (CDFW). We also analyzed data by season to determine whether movement patterns might change seasonally, for example, contemporaneously with flooding events.

RESULTS AND DISCUSSION

Here we first describe general patterns in the frequency of use of undercrossings by native and non-native species and how use of these structures varied by type of mammal. We then provide specific results and discussion for sites in each section. The online Supplemental Information contains the total and standardized passage data for camera trap monitoring, and is available upon request (please visit openspacetrust.org/connectivity-study for more details).

FREQUENCY AND SEASONALITY OF USE

Our analyses demonstrated a huge range in the frequency of use of undercrossings by native wildlife, with a range of 0 – 376 recorded individual passages by native species over 100 trap nights (Figure 2.3). When standardized over 100 trap nights, there was an average of 58 native species passages recorded per site. Eight sites had 100 or more passages by native individuals over 100 trap nights; the majority of these sites were in the Pajaro Valley subarea (Figure 2.4). The two sites with the highest use (SR 152 Site 2 and US 101 Pajaro Valley Site 5) had 376 and 226 passages, respectively. Ten sites had very low rates of native species passages (10 or fewer) over 100 trap nights, including three sites with no recorded native species passages (Figures 2.3 and 2.5).

The SR 152 section had the highest average rate of passage by native individuals when standardized to 100 trap nights, followed by the US 101 Pajaro Valley section (Figure 2.6). Both of these highway sections are within the Pajaro Valley subarea. In contrast, the US 101 Aromas Hills section had the lowest average rate of passage by native individuals when standardized to 100 trap nights, followed by the SR 156 section (Figure 2.6). Both of these highway sections are in the Aromas subarea.

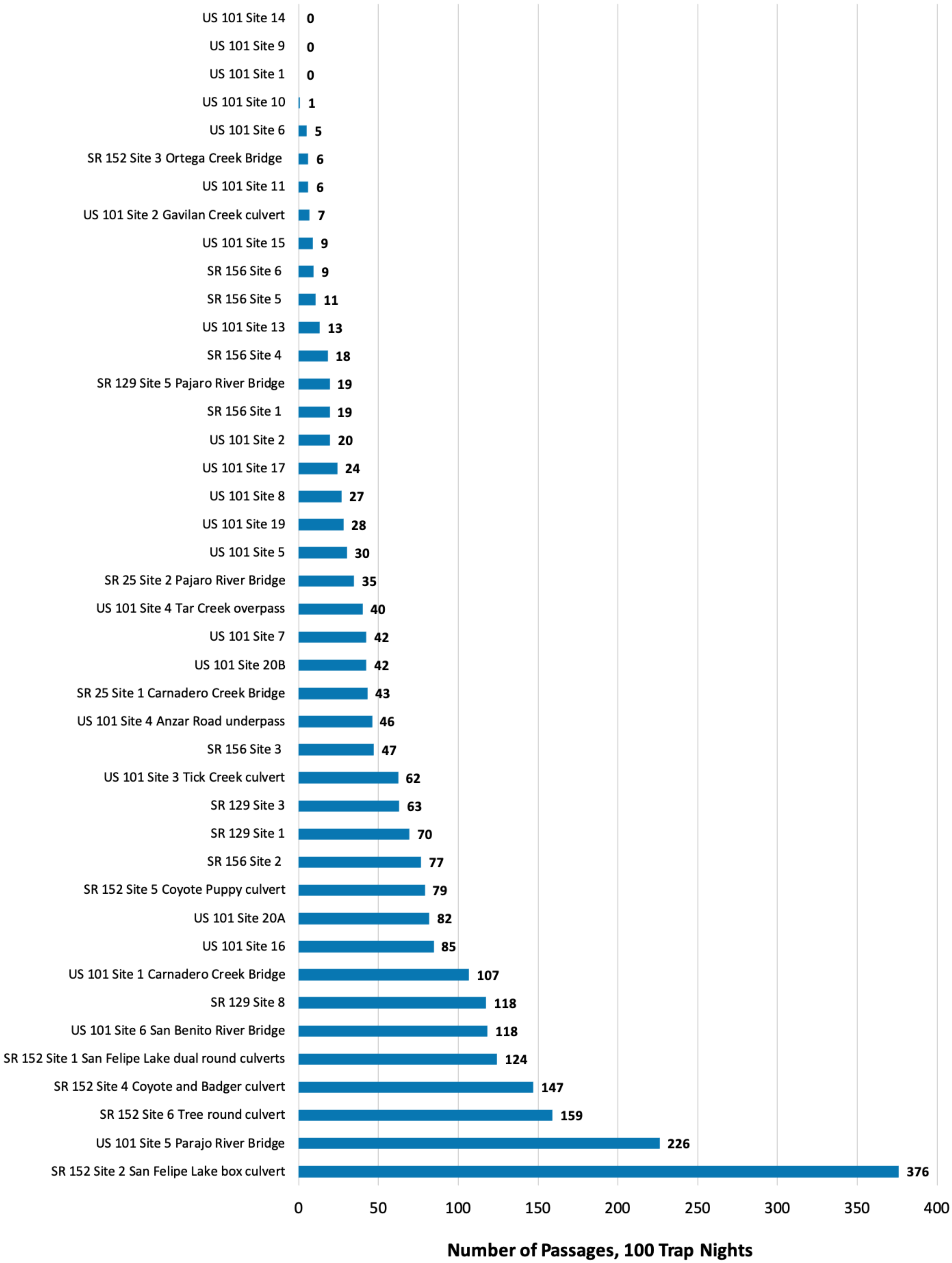


Figure 2.3. Total number of native animals passing through each camera monitoring site over 100 trap nights.

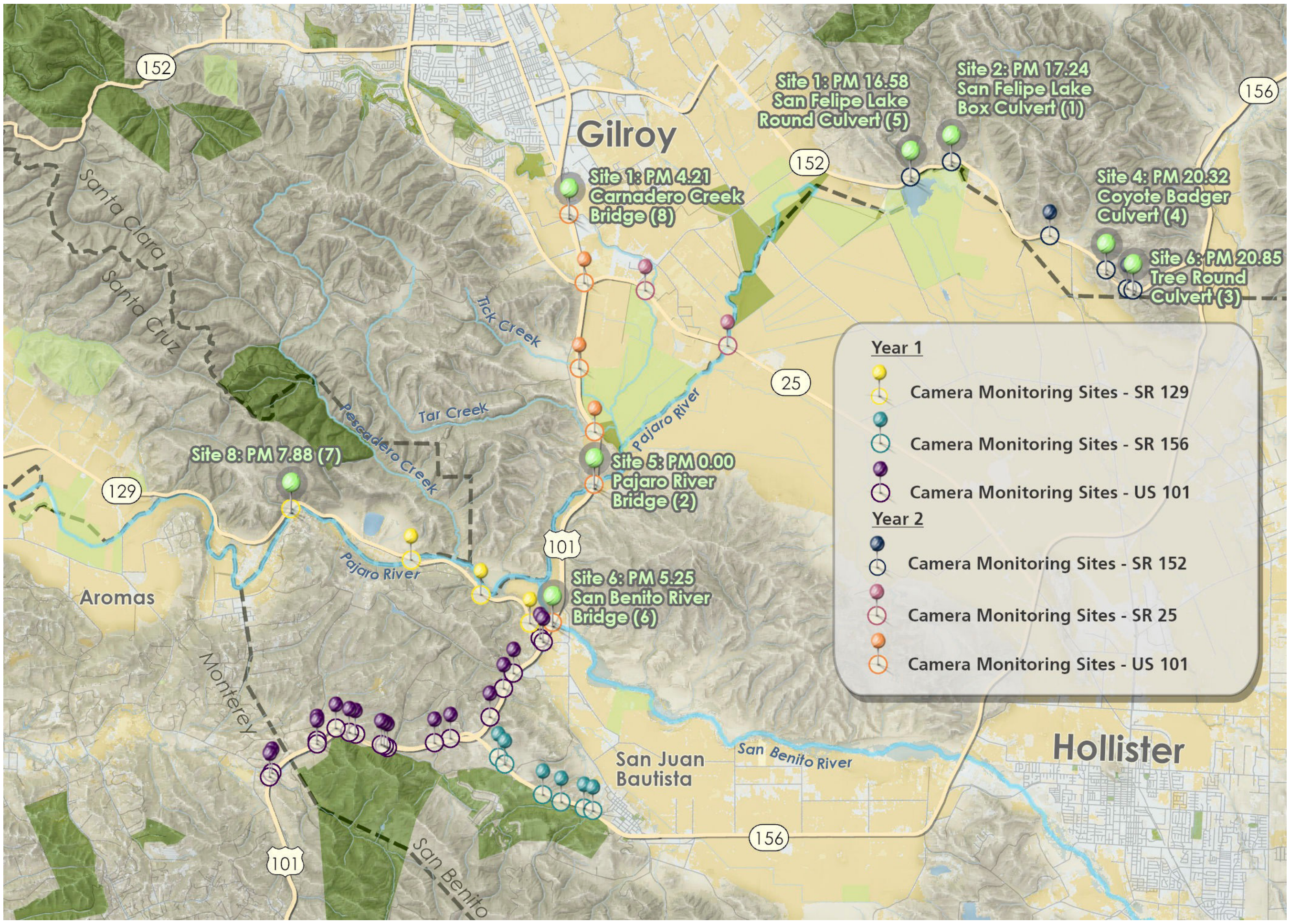


Figure 2.4. Eight camera monitoring sites (green circles and text) had 100 or more native species passages over 100 trap nights.

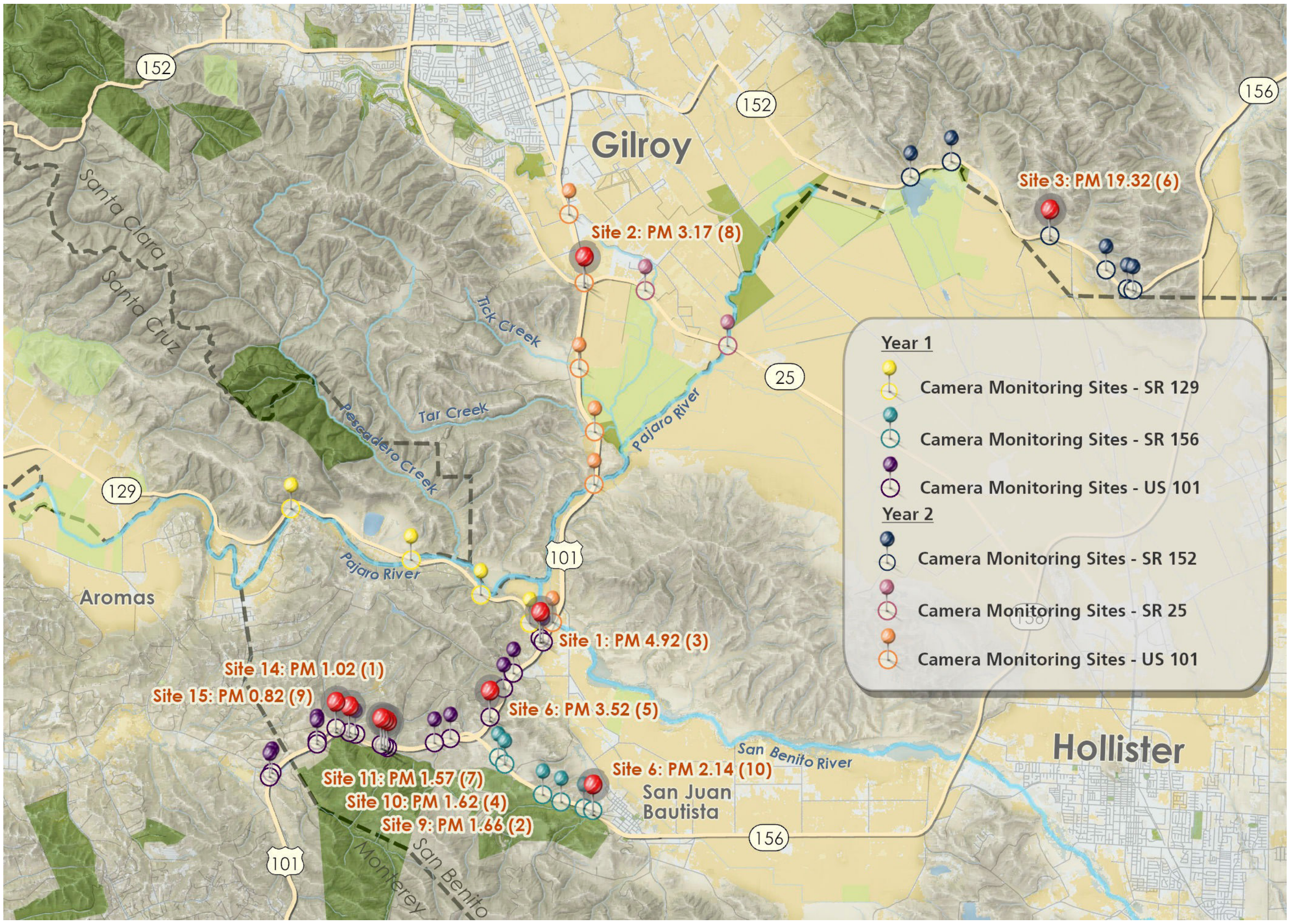


Figure 2.5. Ten monitoring sites (red circles and text) had the lowest numbers of native species passages (10 passages or less).

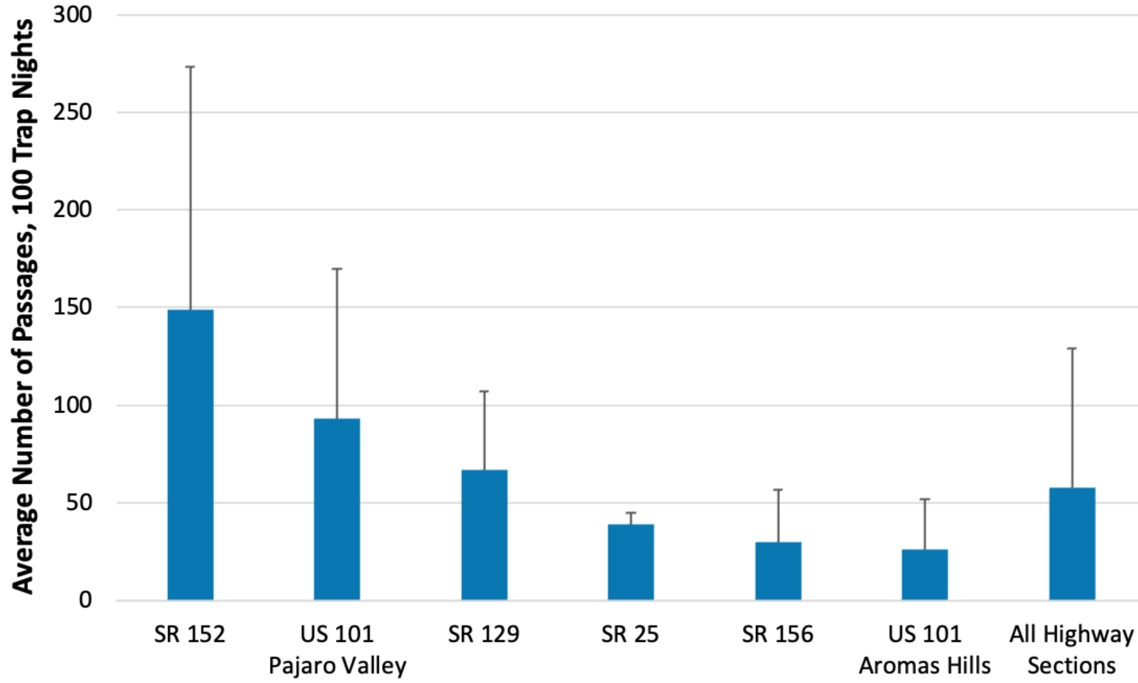


Figure 2.6. The average number of native animals passing through each camera monitoring site (with standard deviation), standardized on a 100 trap night basis.

Eight of the 42 camera monitoring sites consistently facilitated passages by large- or medium-sized mammals. Sixteen of the sites consistently facilitated movement of medium-sized mammals (Figure 2.7). Only 11 of the 42 camera monitoring sites recorded deer traveling through an undercrossing. The Pajaro Valley subarea facilitated the highest rate of passages and passage by the greatest number of species, along highways US 101, SR 25, and SR 152 (Figure 2.8).

The US 101 Aromas Hills section had the highest proportion of non-native species passages, driven largely by domestic cat passages (Figure 2.9). At several US 101 culverts, the majority of passages were by domestic cats. The US 101 Pajaro Valley section had the second-highest proportion of non-native species passages, also driven primarily by domestic dog and domestic cat passages (Figure 2.9). The SR 25 and SR 152 sections had the lowest proportion of non-native species. The only non-native species detected traveling through undercrossings in the SR 25 section was opossum. The majority of passages by non-native animals in the SR 152 section was wild pig. These data are relevant because of the potential impact of domestic and non-native species on native wildlife. Additionally, the ability of non-native mammals to successfully pass through undercrossings may indicate whether an undercrossing might be suitable for native mammals of similar size.

We also observed seasonal differences in site use. Each site had a decrease in passages during winter flooding events, with passages resuming in the spring. This was especially notable at the sites in the SR 156 and SR 25 sections. Such flood events may coincide with the breeding season for some species (e.g., bobcats). If sites are inaccessible during this time period, it may make it more difficult for males to find mates or result in more animals crossing at-grade where they could potentially be hit by vehicles.

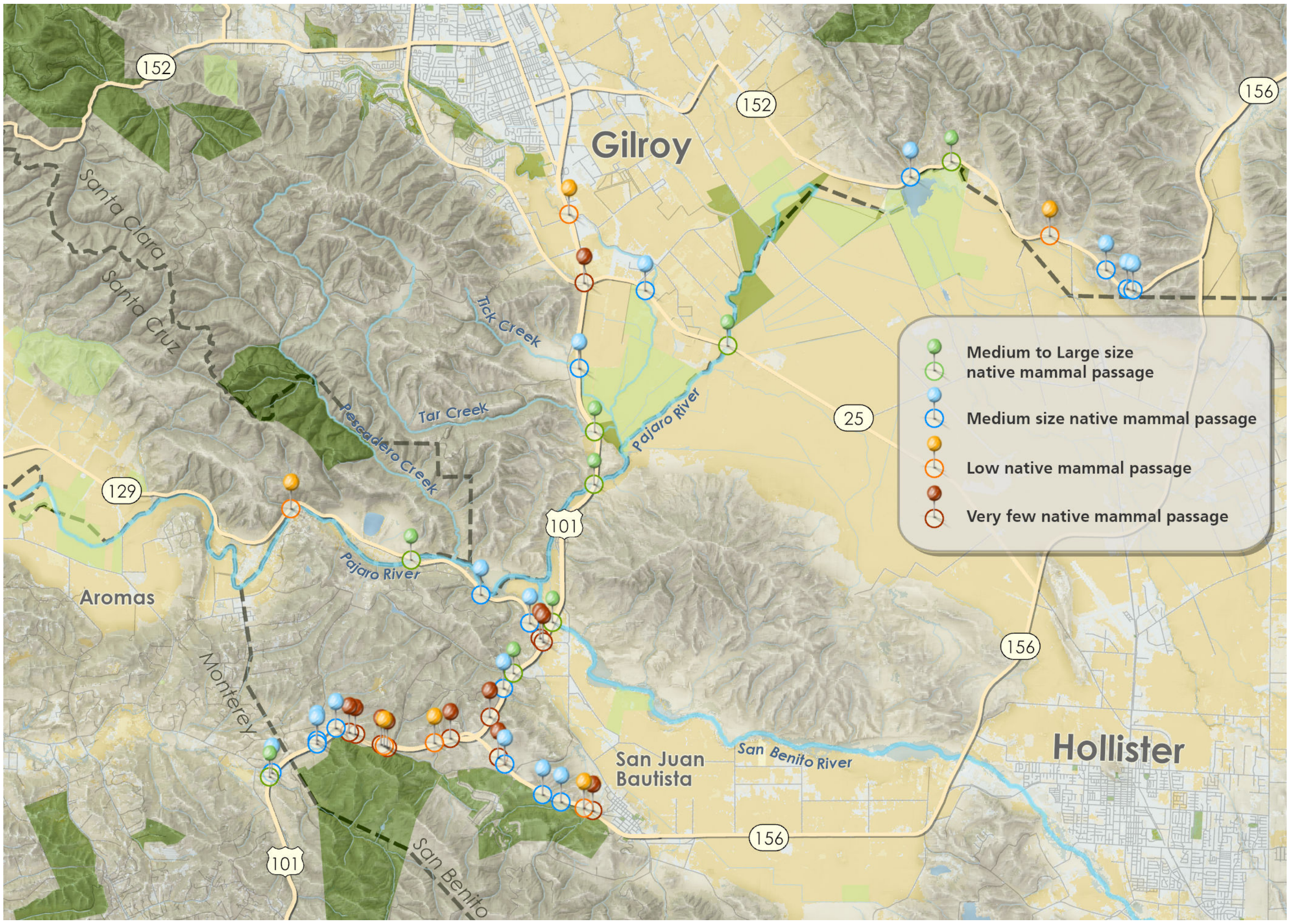


Figure 2.7. Size of mammals in relation to passages at each site.

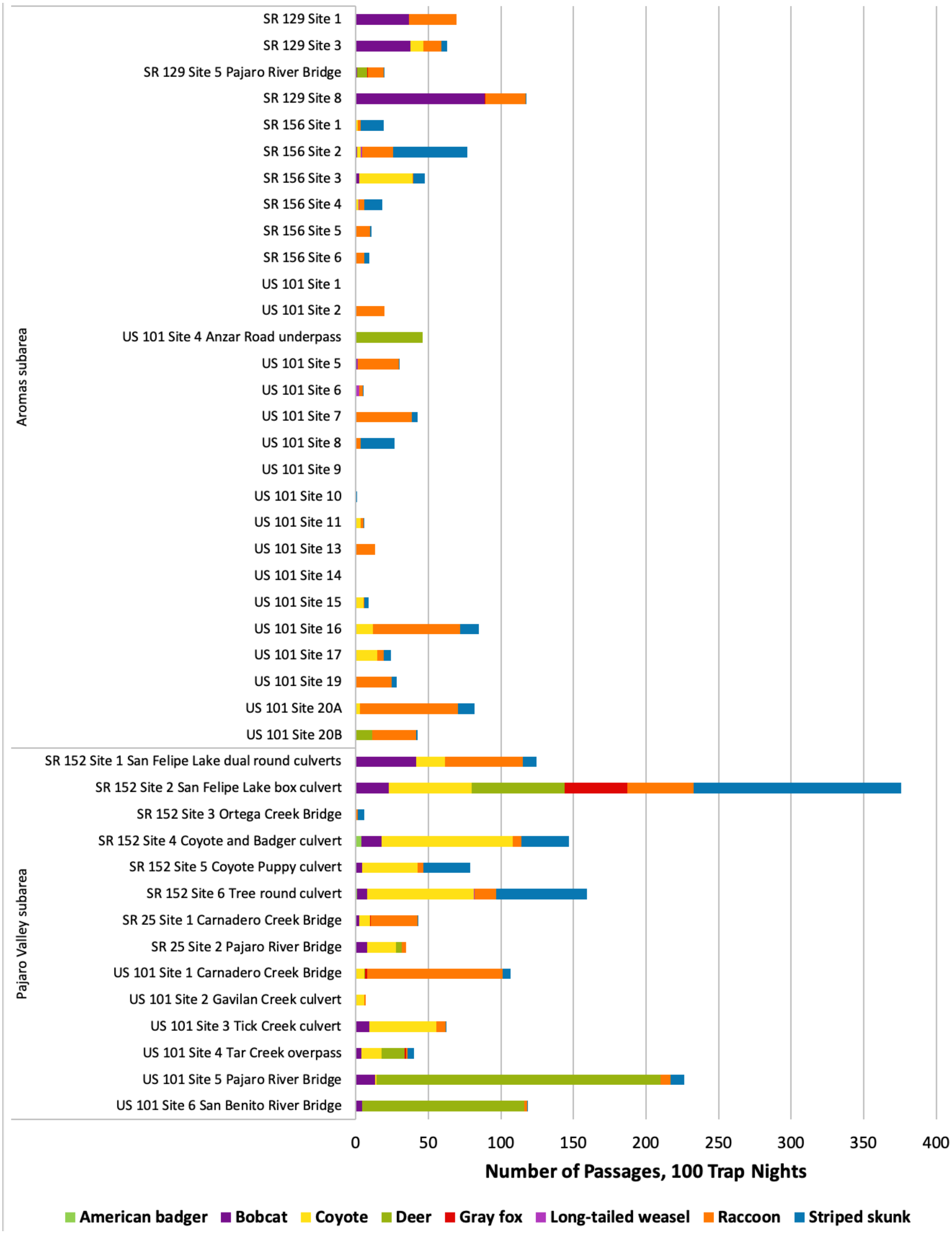


Figure 2.8. Total passages by native species at all sites standardized on a 100 trap night basis.

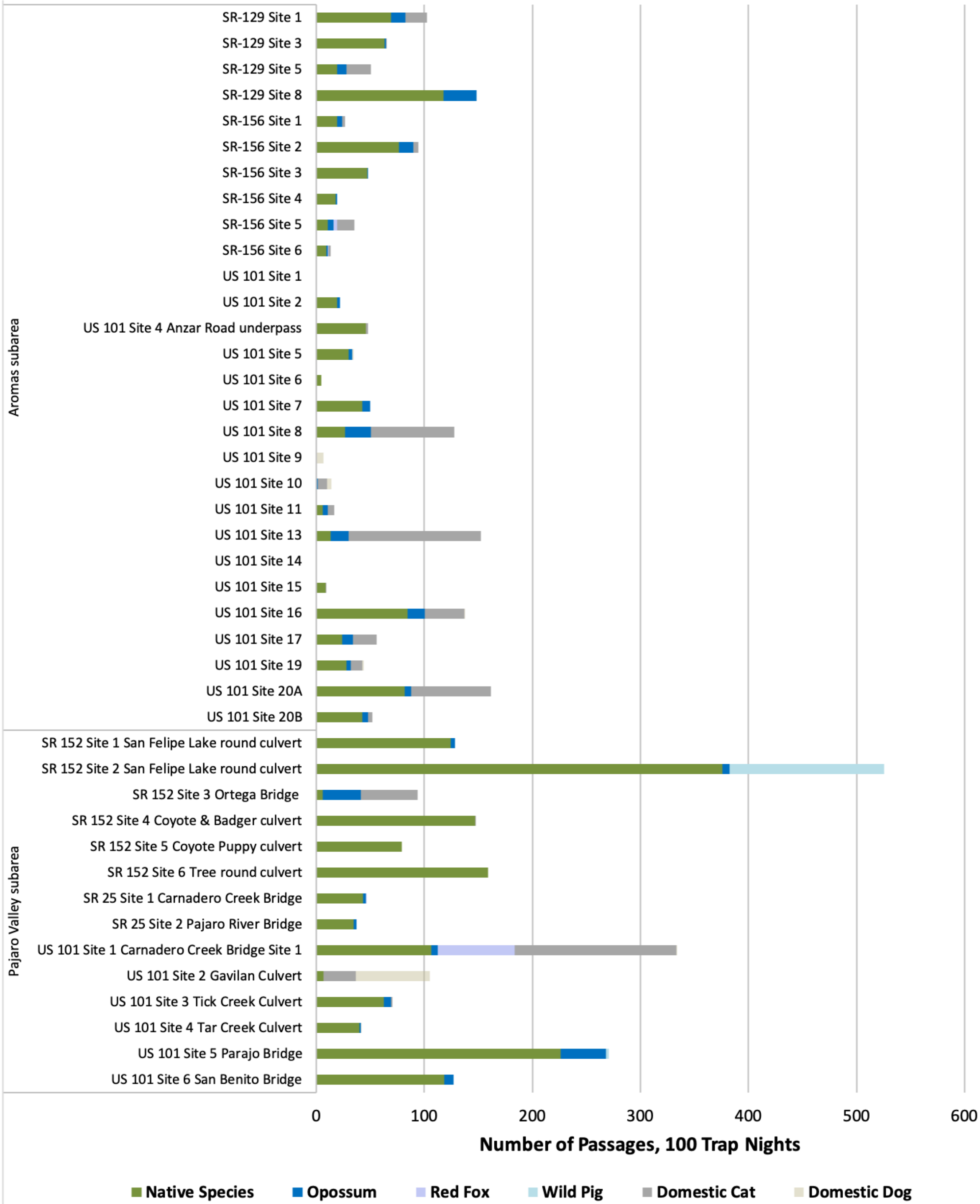


Figure 2.9. Total passages by native and non-native species (opossum, red fox, wild pig, domestic cat, and domestic dog) at all sites standardized on a 100 trap night basis.

AROMAS SUBAREA

The Aromas subarea includes 28 sites in the SR 129, SR 156, and US 101 Aromas Hills sections. The species with the most recorded passages in this subarea included domestic cat, raccoon, opossum, bobcat, and skunk, each with more than 500 passages detected across the 28 sites across all trap nights. Species passage at each site is detailed below, organized by section.

SR 129 SECTION

The SR 129 section has four undercrossings, including three culverts and the Pajaro River Bridge underpass (Figure 2.10). These undercrossings were all monitored for the same number of trap nights. We recorded a total of 984 native species passages across all trap nights in this section, with seven native species detected. When standardized, this section recorded a total of 270 native species passages, with an average of 67 passages. The species with the highest passage rates when standardized were bobcat (164), raccoon (84), and opossum (55) (Figures 2.11 and 2.12). Notable species detected included gray fox (Sites 1, 5, and 8) and long-tailed weasel (Site 8). We also recorded a female bobcat traveling with a juvenile at the SR 129 Site 8 culvert and a bobcat with severe mange at the SR 129 Site 3 culvert. Domestic cats were detected at SR 129 Sites 1, 3, and 5 (Figure 2.12).

Figure 2.10. Map of camera monitoring sites in the SR 129 section.

Male deer traveling under SR 129 Site 5, the Pajaro River Bridge.

SR 129 Site 5 Pajaro River Bridge is the only undercrossing beneath SR 129 big enough to facilitate passage of large animals such as deer and mountain lions, though mountain lions were not detected. This site had five native species detected, but also had the lowest number of native species passages in this section when standardized in the 100 trap night analysis (19) (Figure 2.11). Domestic cats and opossums were also recorded at this site (Figure 2.12). A juvenile male deer investigated, but did not pass through, SR 129 Site 3, which is a box culvert that is likely too small for deer passage. This indicates the need for additional structures in this highway section (besides SR 129 Site 5 Pajaro Bridge) that can facilitate passage by large mammals.

SR 129 Site 8 had the highest number of native species passages in this section when standardized in the 100 trap night analysis (118) (Figure 2.11), with five species detected. This may be because of the presence of riparian habitat on both sides of this culvert, including on the north side which leads to the Pajaro River. The three culverts (SR 129 Sites 1, 3, and 8) consistently facilitated movement of medium-sized mammals throughout the study period.

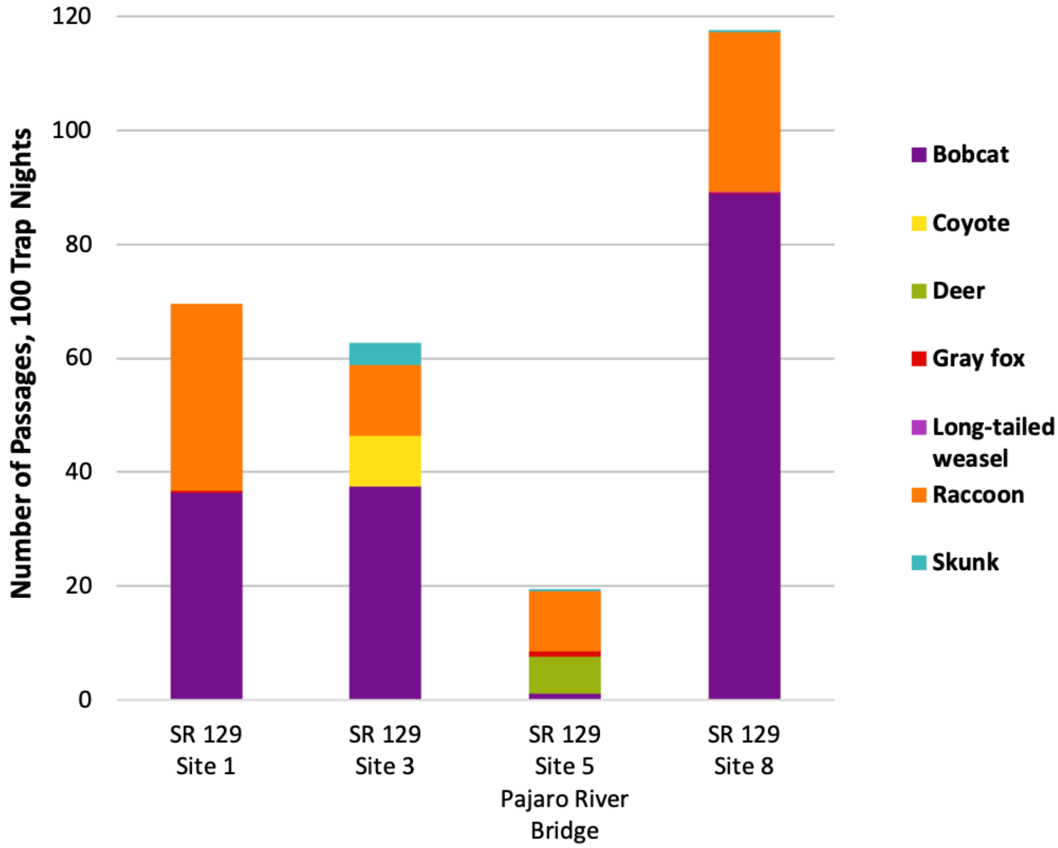


Figure 2.11. Passages of native species in the SR 129 section standardized on a 100 trap night basis.

Bobcat traveling through the SR 129 Site 3 culvert on September 4, 2018.

Coyote traveling through the SR 129 Site 3 culvert on May 4, 2019.

Adult (left) and juvenile (right) bobcats traveling through the SR 129 Site 8 culvert on September 18, 2018 and June 24, 2019, respectively.

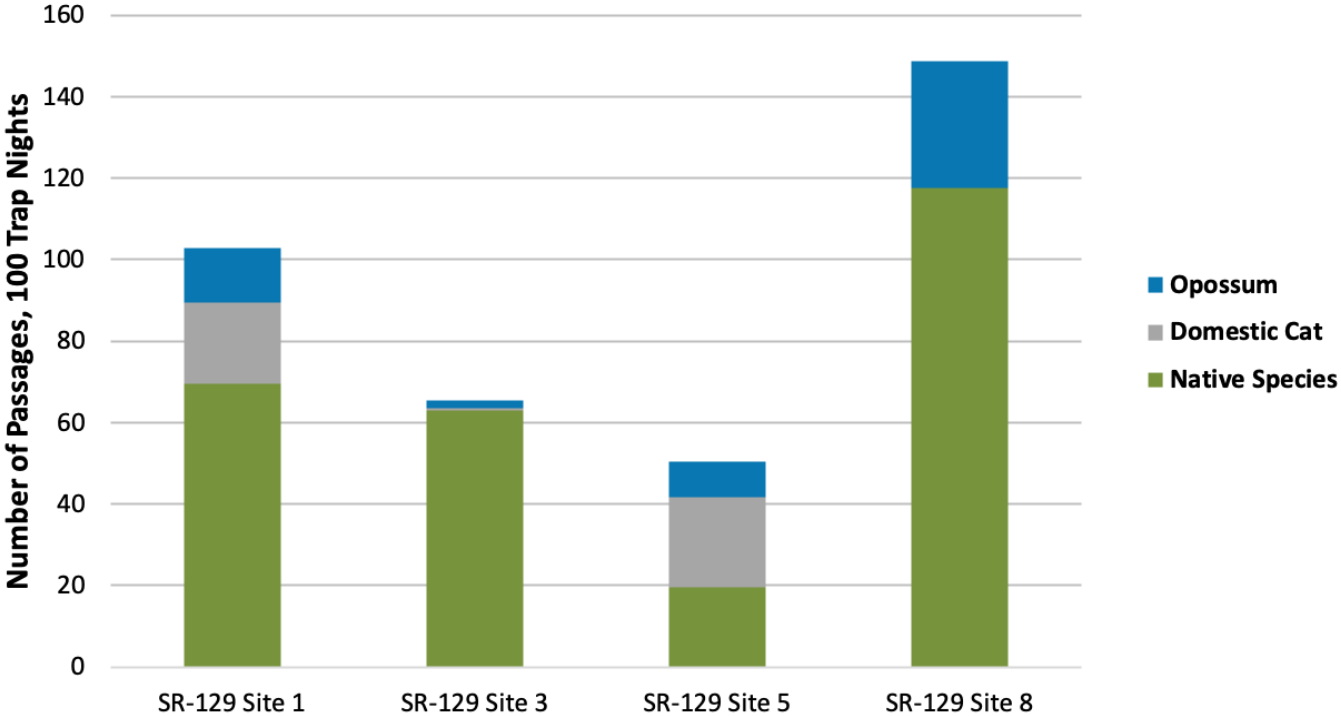


Figure 2.12. Passages of native species and non-native species (opossum and domestic cat) in the SR 129 section standardized on a 100 trap night basis.

SR 156 SECTION

We had six monitoring sites along SR 156, all culverts (Figure 2.13). Across the six sites, we recorded a total of 606 passages by native species, with a total of five native species detected. When standardized, this site recorded a total of 182 native species passages, with an average of 30 passages. The native species with the highest passage rates when standardized were skunk (93), raccoon (42), and coyote (43). We also detected passages by non-native red fox at Sites 5 and 6 (Figure 2.14). Opossums were detected at all sites in this section.

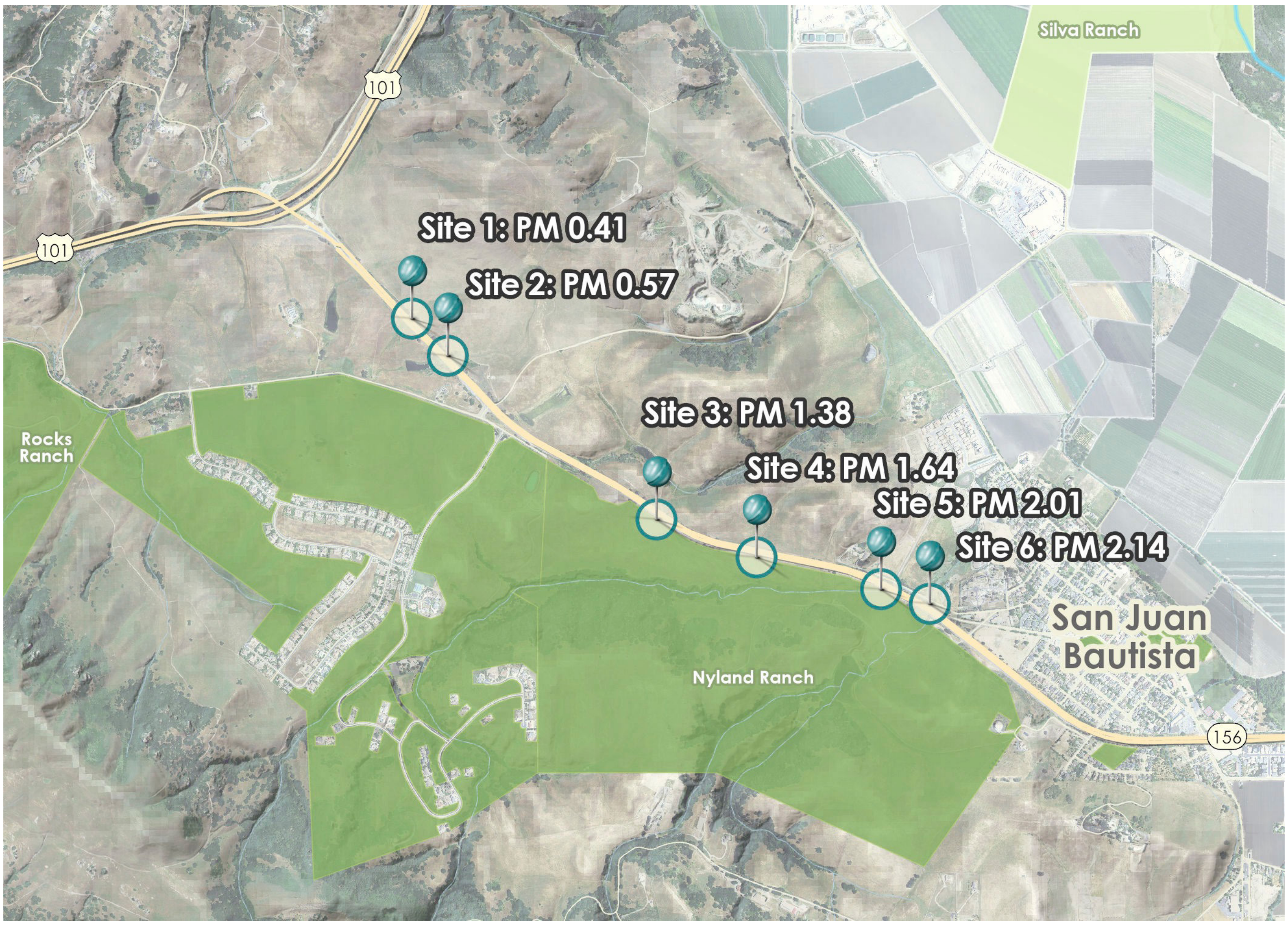
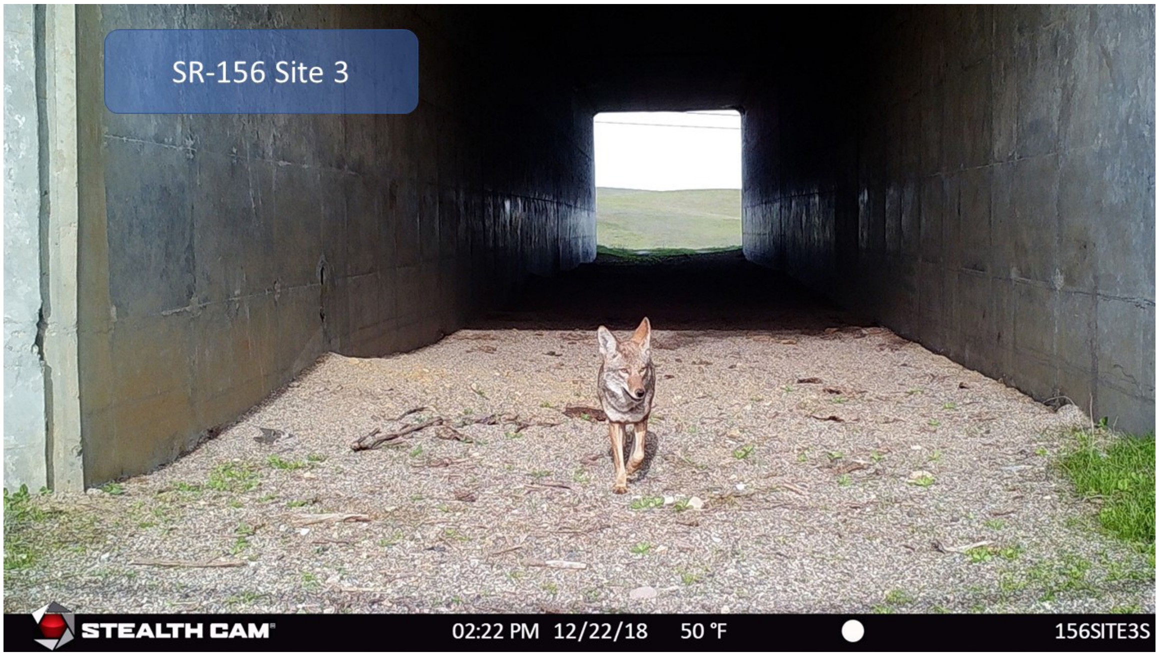


Figure 2.13. Map of camera monitoring sites in the SR 156 section.

Notable species detected included long-tailed weasel (SR 156 Sites 2 and 4). Throughout the study period, a coyote family was routinely recorded traveling through the large SR 156 Site 3 culvert. A very emaciated male bobcat with severe mange was also recorded traveling through this culvert as well as through SR 156 Site 2. These sites are in close proximity to San Juan Bautista and agricultural lands where bobcats might have secondary exposure to anticoagulant rodenticides, which can result in mange (Serieys et al. 2021).



Coyote traveling through SR 156 Site 3 on December 22, 2018.

Bobcat with mange traveling through SR 156 Site 2.

Of importance, we did not record deer or mountain lion at any of the undercrossings on SR 156, including SR 156 Site 1 and SR 156 Site 3, both of which are large enough to facilitate passage by large mammals. Though SR 156 Site 3 borders recently protected land with recorded detections of mountain lion, we suspect that the lack of passage at both sites may be in part due to the sparsity of vegetative cover directly adjacent to these sites (Suraci et al. 2020).

SR 156 Site 2 facilitated the highest species richness of native wildlife passages in this section, with five species detected (Figure 2.15). This site also had the highest number of native species passages in this section when standardized in the 100 trap night analysis (77) (Figure 2.15). Other culverts in this area (SR 156 Sites 4 and 6) experienced major flooding throughout the year, while SR 156 Site 2 stayed dry. SR 156 Sites 5 and 6 had the lowest species richness of native wildlife passages and had the lowest number of native species passages in the section (11 and 9 passages, respectively, in the 100 trap nights analysis). This may be because they are located near San Juan Bautista. Species detected at these sites are those that tend to be associated with development, including domestic cat, red fox, raccoon, skunk, and opossum (Figure 2.14) (Bidlack et al. 2008, Wang et al. 2015).

The presence of pooled water during and after storm events at SR 156 Sites 4 and 6 resulted in a notable decrease in wildlife passages (Figure 2.16). During the months of January to March, we did not record any wildlife passages through these two culverts, likely because they were inundated with water; wildlife resumed passage through these culverts in the spring once the waters had receded (Figure 2.16).

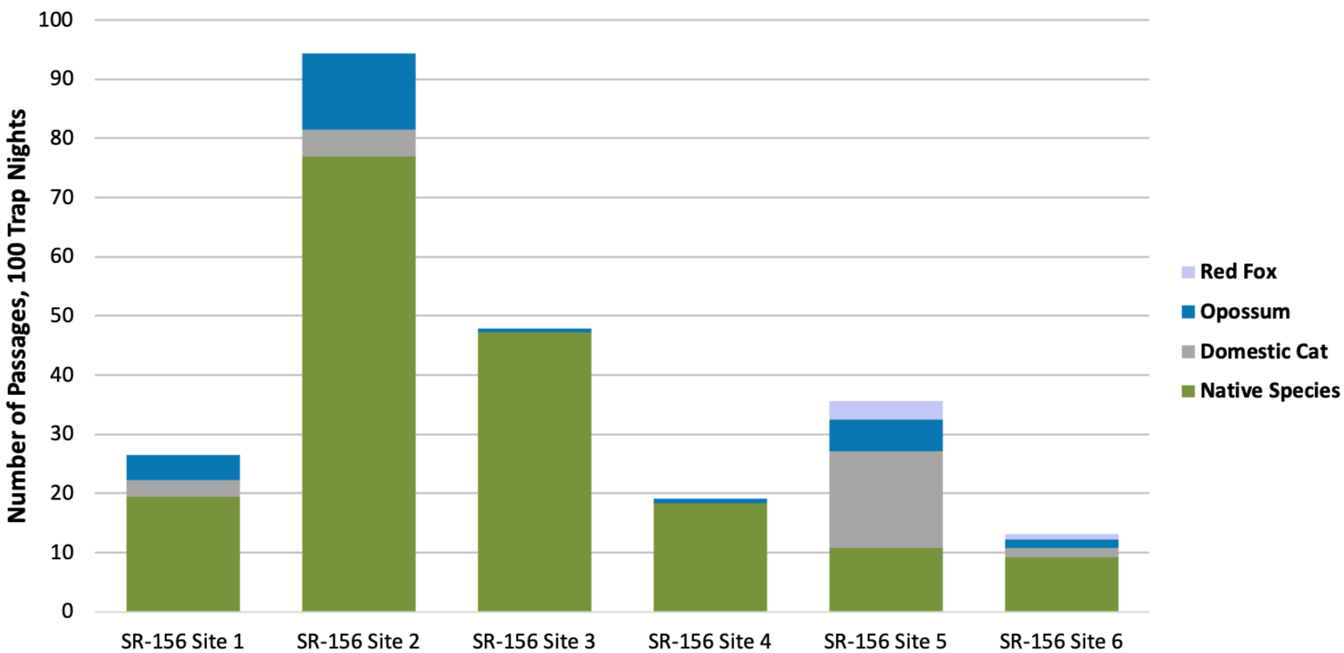


Figure 2.14. Passages of native species and non-native species (red fox, opossum, and domestic cat) in the SR 156 section standardized on a 100 trap night basis.

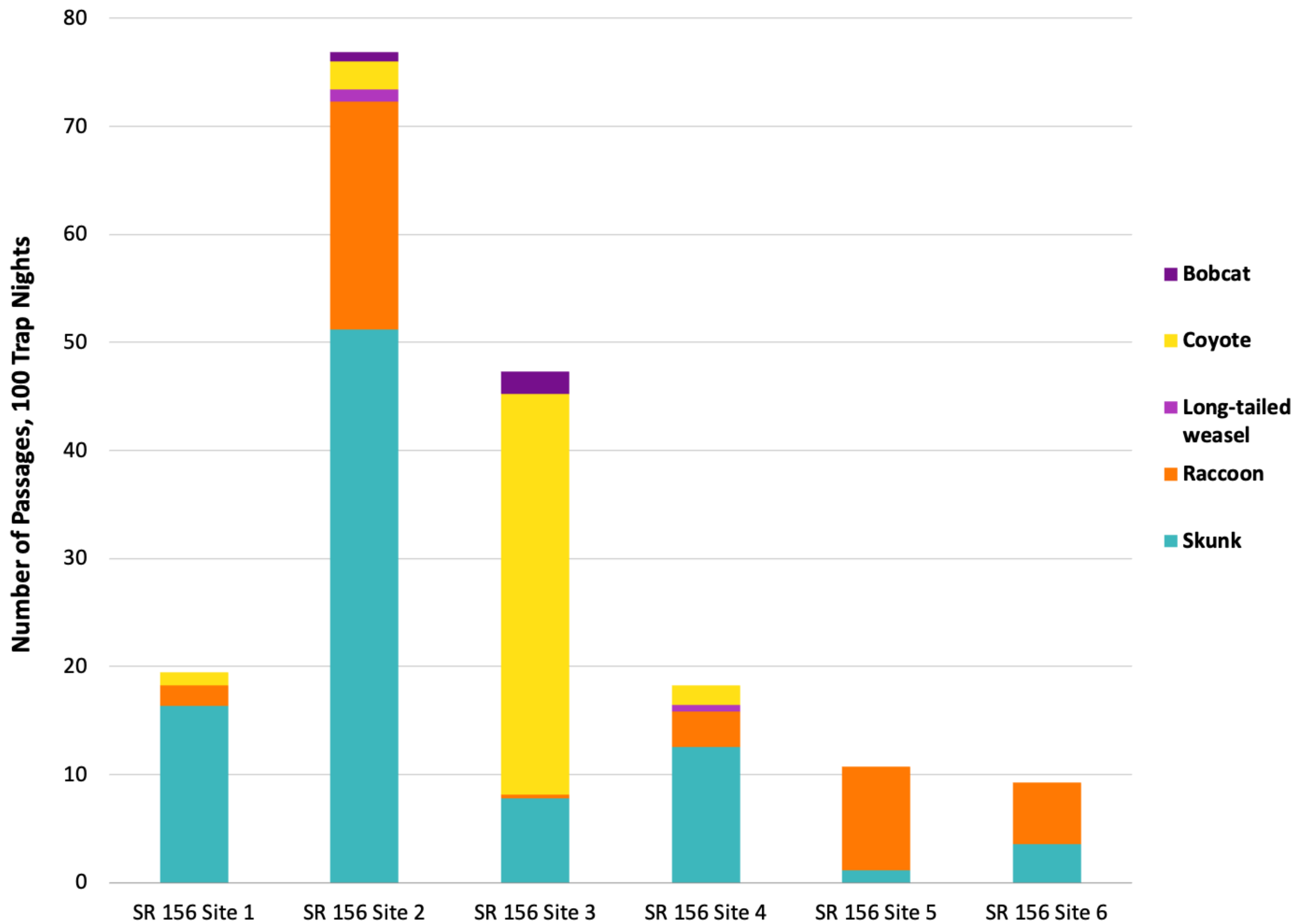


Figure 2.15. Passages of native species in the SR 156 section standardized on a 100 trap night basis.

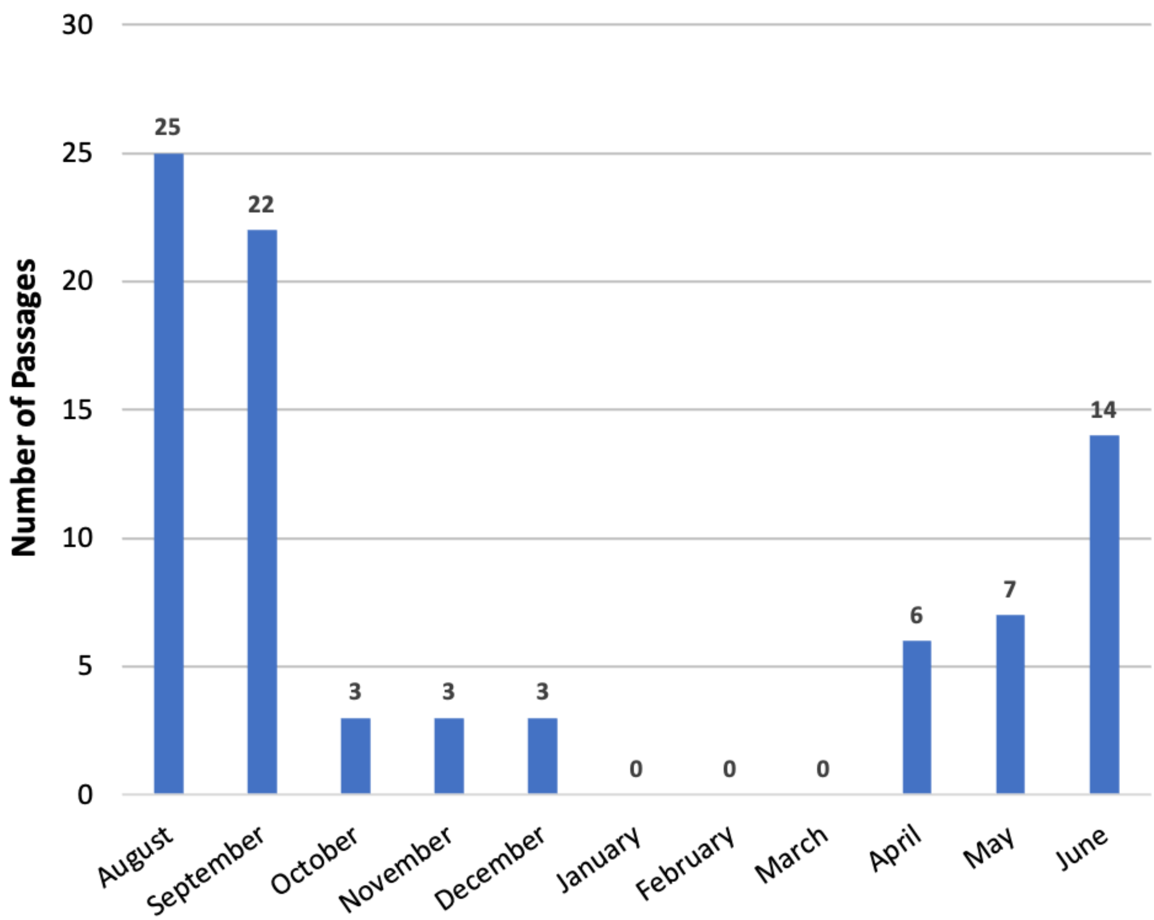


Figure 2.16. Number of passages by month at SR 156 Site 4. This trend of seasonal use was also apparent at SR 156 Site 6 and SR 25 Site 1.

US 101 AROMAS HILLS SECTION

The US 101 Aromas Hills section consists of 18 sites (Figure 2.17). Seventeen of these sites featured culverts, and one site featured an underpass. Several undercrossings that are near one another are treated as units in the discussion below, including the Eucalyptus Grove culverts (US 101 Sites 9, 10 and 11) and the Habitat Island culverts (US 101 Sites 15, 16, and 17). We describe the findings at these two culvert systems in more detail below.

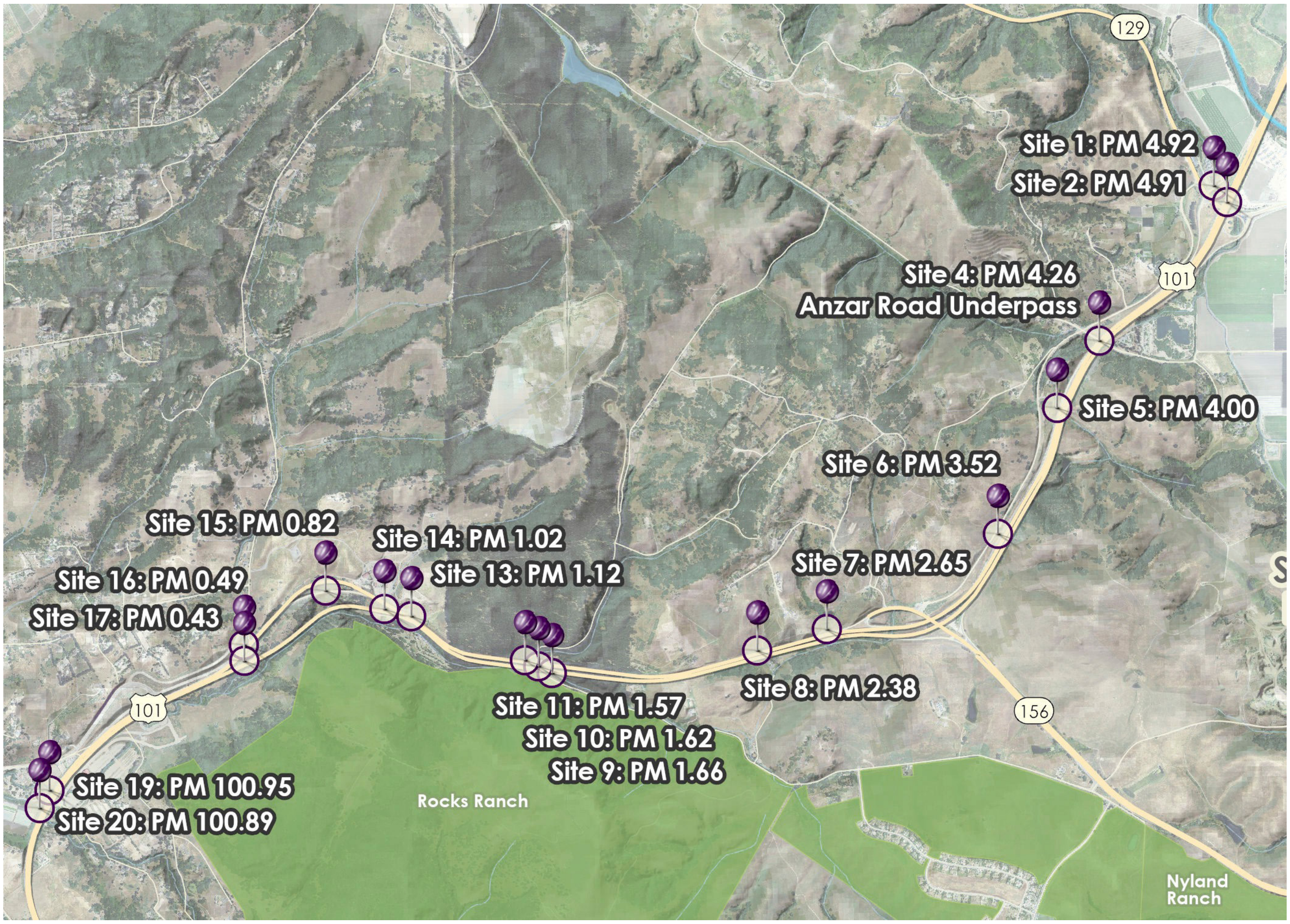


Figure 2.17. Map of camera monitoring sites in the US 101 Aromas Hills section. Sites 9, 10, and 11 are the Eucalyptus Grove culverts, and Sites 15, 16, and 17 are the Habitat Island culverts.

We recorded a total of 1,534 passages by native species, with a total of six native species detected. When standardized, this section recorded a total of 461 passages by native species, with an average of 26 passages. The species with the highest passages in this section when standardized were raccoon (294), domestic cat (126), and opossum (99) (Figures 2.18 and 2.19). Though the Aromas Hills section has the most culverts of any of the highways in the study area, we measured relatively few passages by deer and coyote, and only three passages by bobcat for this entire section. This is discussed in more detail below.

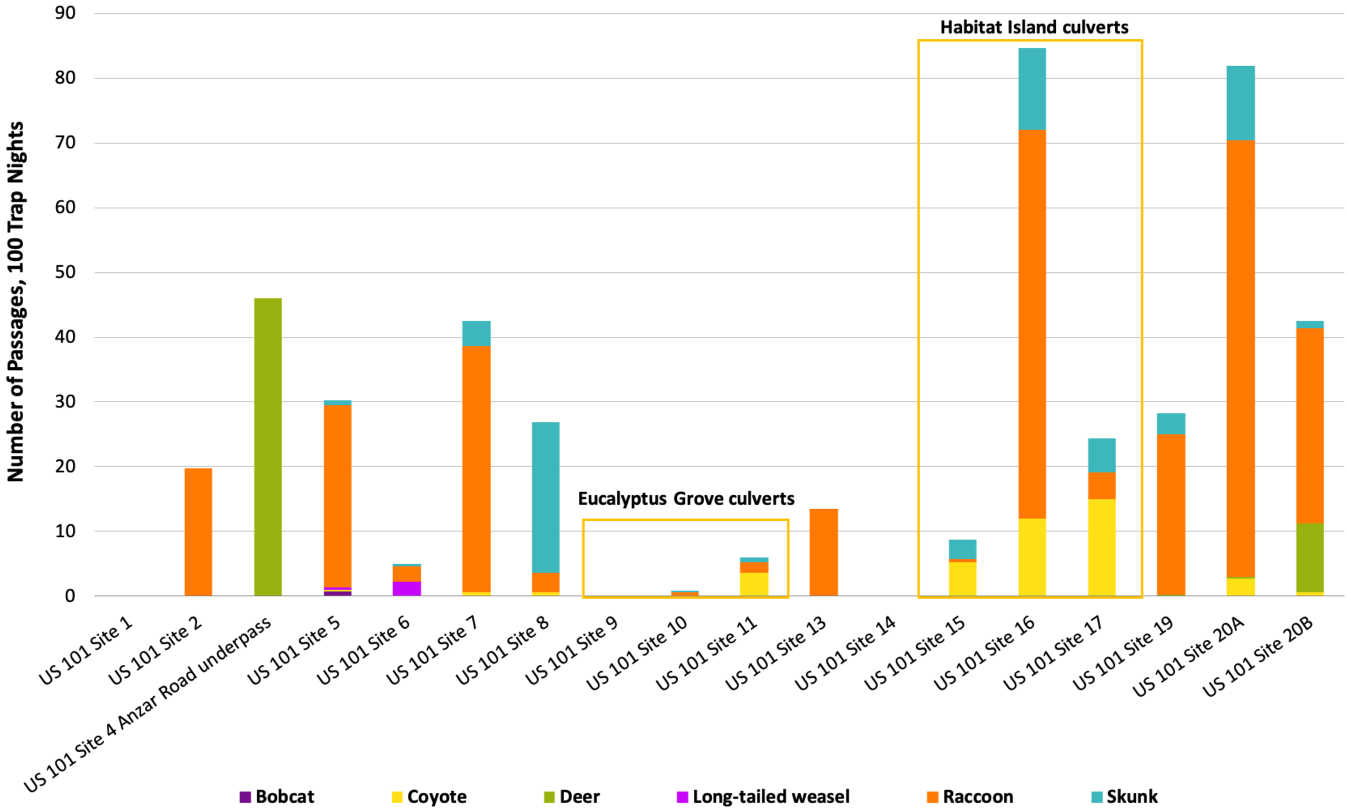


Figure 2.18. Passages of native species in the US 101 Aromas Hills section standardized on a 100 trap night basis.

The US 101 Site 5 culvert facilitated the highest species richness of native wildlife passages, with five species detected, though passages were dominated by raccoon (Figure 2.18). In contrast, the culverts at US 101 Sites 1, 9, and 14 had no passages of native wildlife (Figure 2.18). US 101 Site 9 recorded only domestic dog, while US 101 Sites 1 and 14 had no detections of either native or non-native species (Figure 2.19). US 101 Site 1 is a triple box culvert with standing water, while US 101 Site 14 has dense vegetation at its southern opening and is adjacent to development on either side of US 101, all of which might have deterred use of these culverts by native wildlife. Of note, US 101 Site 7 had the highest species richness in detections without passages within the study area.

US 101 Site 16 had the highest number of native species passages in this section and the ninth highest overall in the study area, with 85 passages detected in the 100 trap night analysis (Figure 2.18). This site consistently facilitated the movement of medium-sized mammals, including skunk, raccoon, opossum, and coyote (Figure 2.18). It connects open habitat to the north side via a small riparian strip and opens into the habitat median island.

Very few large mammal passages were recorded in US 101 Aromas Hills section (Figure 2.18). Deer were recorded at only four sites in this section, with the highest deer passages at US 101 Site 4; the other sites in this section where deer were recorded had very low rates of passage. Of note, mountain lions were detected at US 101 Sites 7 and 11 without passage through either culvert. This is significant because no other section recorded mountain lions on camera. We provide more detail about mountain lion, deer, and bobcat detections below.

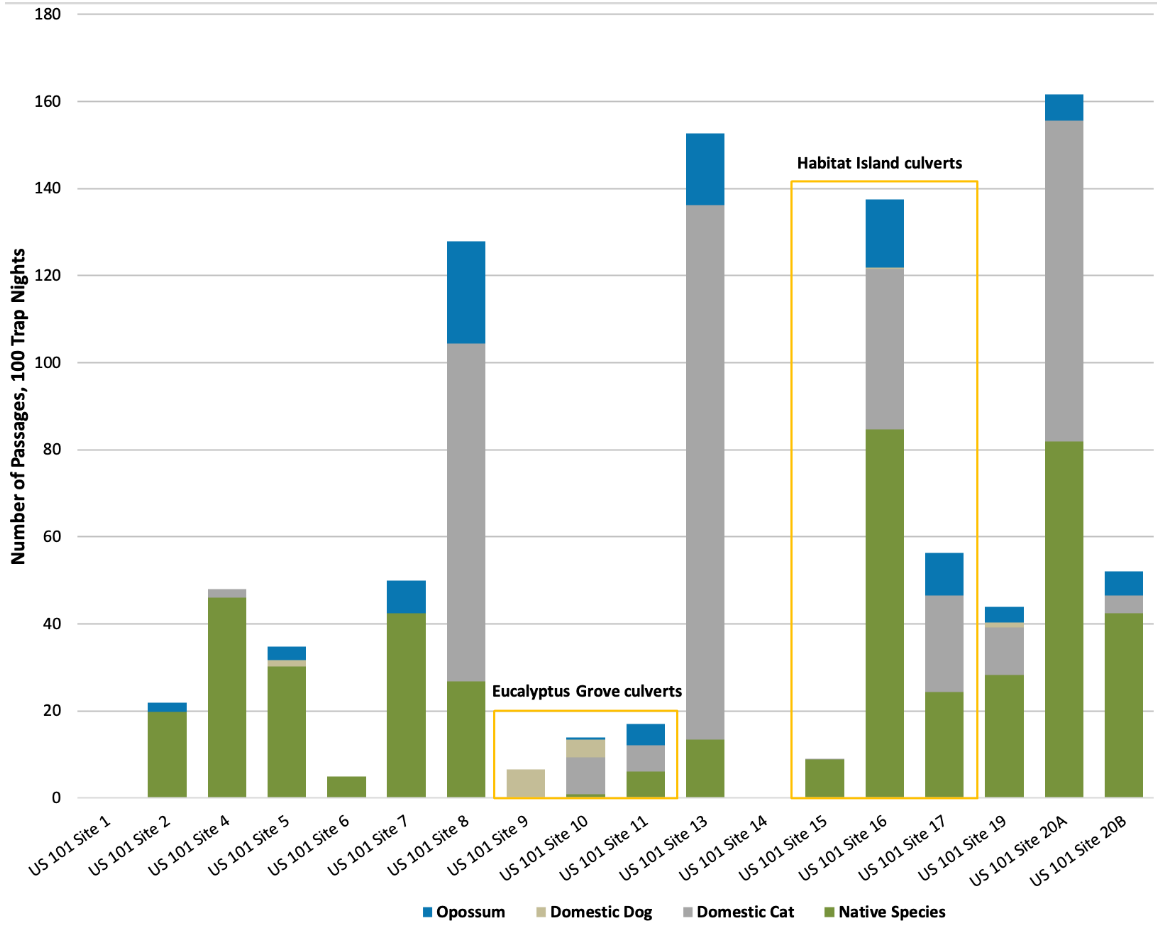


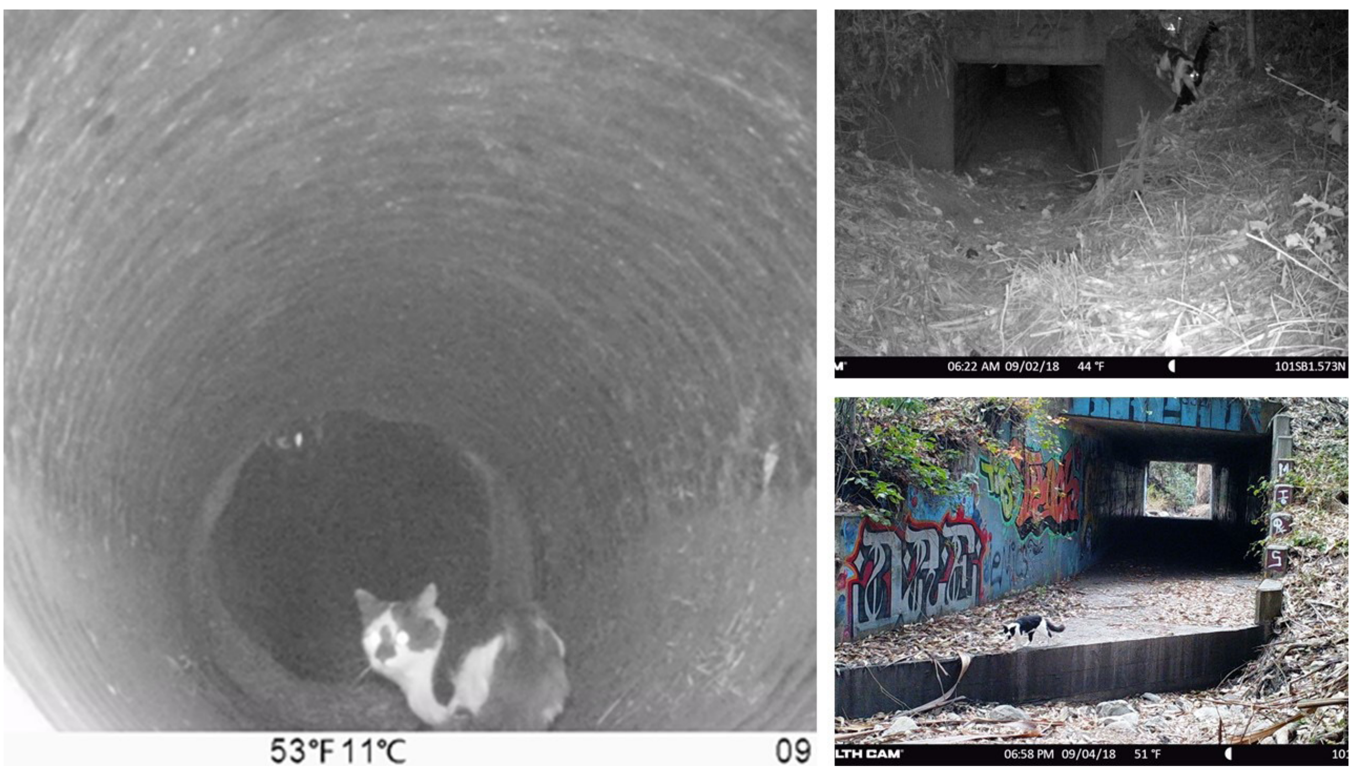
Figure 2.19. Passages of native species and non-native species (opossum, domestic cat, and domestic dog) in the US 101 Aromas Hills section standardized on a 100 trap night basis.

Coyotes traveling through US 101 Sites 15, 16, and 17.

THE EUCALYPTUS GROVE CULVERTS AND HABITAT ISLAND CULVERTS

The Eucalyptus Grove culverts (US 101 Sites 9–11), had a very low rate of passages compared to the Habitat Island culverts (US 101 Sites 15–17) (Figure 2.18). Though cameras detected the same native species at both the Eucalyptus Grove culverts and the Habitat Island culverts, the total number of passages by native species was much higher at the Habitat Island culverts (Figure 2.18). Passages through the Eucalyptus Grove culverts were mainly by domestic cats (Figure 2.19).

There are no large culverts spanning the entire highway in the Eucalyptus Grove region of the US 101 Aromas Hills section, creating challenges for wildlife movement. US 101 Site 9 spans only the northbound lanes. The US 101 Site 11 culvert spans only the southbound lanes. An animal emerging from this culvert must travel along the highway median to reach US 101 Site 10 culvert, which spans the median. An animal must then travel further east to reach another large culvert, US 101 Site 9, to cross under the northbound lanes. We did not record any native species successfully traveling across the entire span of US 101 through these three Eucalyptus Grove culverts. The only animal recorded using all three Eucalyptus Grove culverts to successfully cross US 101 was a single domestic cat. This meandering design and lack of native species traveling through the Eucalyptus Grove culverts suggests that this portion of US 101 poses a serious barrier for mammal movement and dispersal.



Domestic black-and-white cat at US Aromas Hills Sites 10, 11, and 13.

CONNECTIVITY FOR MOUNTAIN LION AND DEER

A mountain lion was recorded on camera at US 101 Site 7 on October 1, 2018. The animal looked into the culvert, but then headed west towards the Eucalyptus Grove. The individual appears to be a young adult, perhaps dispersing from its parental home range (Chris Wilmers, personal communication October 3, 2018). The next day (October 2, 2018), a young mountain lion was recorded looking into but not entering the US 101 Site 11 culvert before heading west through the Eucalyptus Grove. This appears to be the same young adult mountain lion recorded at US 101 Site 7. The mountain lion may have been traveling adjacent to the highway passing by the culverts.

Mountain lion approaching US 101 Site 7 on October 1, 2018.

Mountain lion heading west towards the Eucalyptus Grove on October 1, 2018. This recording was immediately following the inspection of US 101 Site 7.

Mountain lion approaching US 101 Site 11 on October 2, 2018.

Mountain lion heading west through US 101 Site 11 at the Eucalyptus Grove on October 2, 2018.

Of importance, a collared mountain lion, 54M, was hit at the Eucalyptus Grove near US 101 Site 11 in 2016 (Chris Wilmers, personal communication 2016). This mountain lion had been recorded in the area when its collar stopped sending data, and the lion's body was recovered at its last known GPS point. Another mountain lion was recorded as roadkill by CDFW on August 4, 2021, not far from where 54M was hit five years earlier (D. Hacker, personal communication 2021). This reinforces the idea that the Eucalyptus Grove portion of US 101 is a significant barrier for movement and dispersal of mountain lion and other mammals.

Deer traveling under the US 101 Site 4 Anzar Underpass. This is a busy road with a small habitat strip.

Deer traveling though US 101 Site 20B at the Monterey County line.

We recorded deer passage at four sites in the US 101 Aromas Hills section. Deer regularly used US 101 Site 4 Anzar Road underpass and US 101 Site 20B. Anzar Road is a busy road with high vehicular traffic, with only a small strip of habitat available for deer to travel safely through the Site 4 Anzar Road underpass. We detected a male and female deer and a fawn traveling through US 101 Site 20B. The other sites in this section where deer were detected had very low passage rates.

Deer approached and investigated but did not travel through the Habitat Island culverts (US 101 Sites 15–17), though Sites 16 and 17 were both large enough to accommodate deer passage. The lack of deer passage at Site 17 is likely because there is no clear line of vision through to the other side because of the angle of the culvert. Site 16 had a clear line of sight through the culvert, but no deer passages were recorded, suggesting another factor was limiting deer use of this structure, such as fencing, development, and/or habitat quality. Site 15 is likely slightly undersized to facilitate deer passage (3′ 10″ wide and 4′ high) although deer were observed using culverts at San Felipe Lake of similar height (6′ wide and 4′ high).

These data show that there is a need for safe wildlife crossing structures in the US 101 Aromas Hills section, particularly for large mammals such as deer and mountain lion.

Deer approaching US 101 Site 15, but not traveling through the culvert.

Deer approaching but not traveling through the pair of box culverts at US 101 Site 17.

RELATIVE PRESENCE OF BOBCAT AND DOMESTIC CAT

We recorded very different data in the SR 129 section than we did in the nearby US 101 Aromas Hills section, which is just to the south of SR 129 within the Santa Cruz Mountains–Gabilan linkage (Figure 2.20). In the SR 129 section, 45% of the passages were by bobcats, whereas 40% of the passages in US 101 Aromas Hills were by domestic cats, with few bobcats detected (Figure 2.21). In the US 101 Aromas Hills section, bobcat passages were recorded only at Site 5, with two passages detected (Figure 2.20).

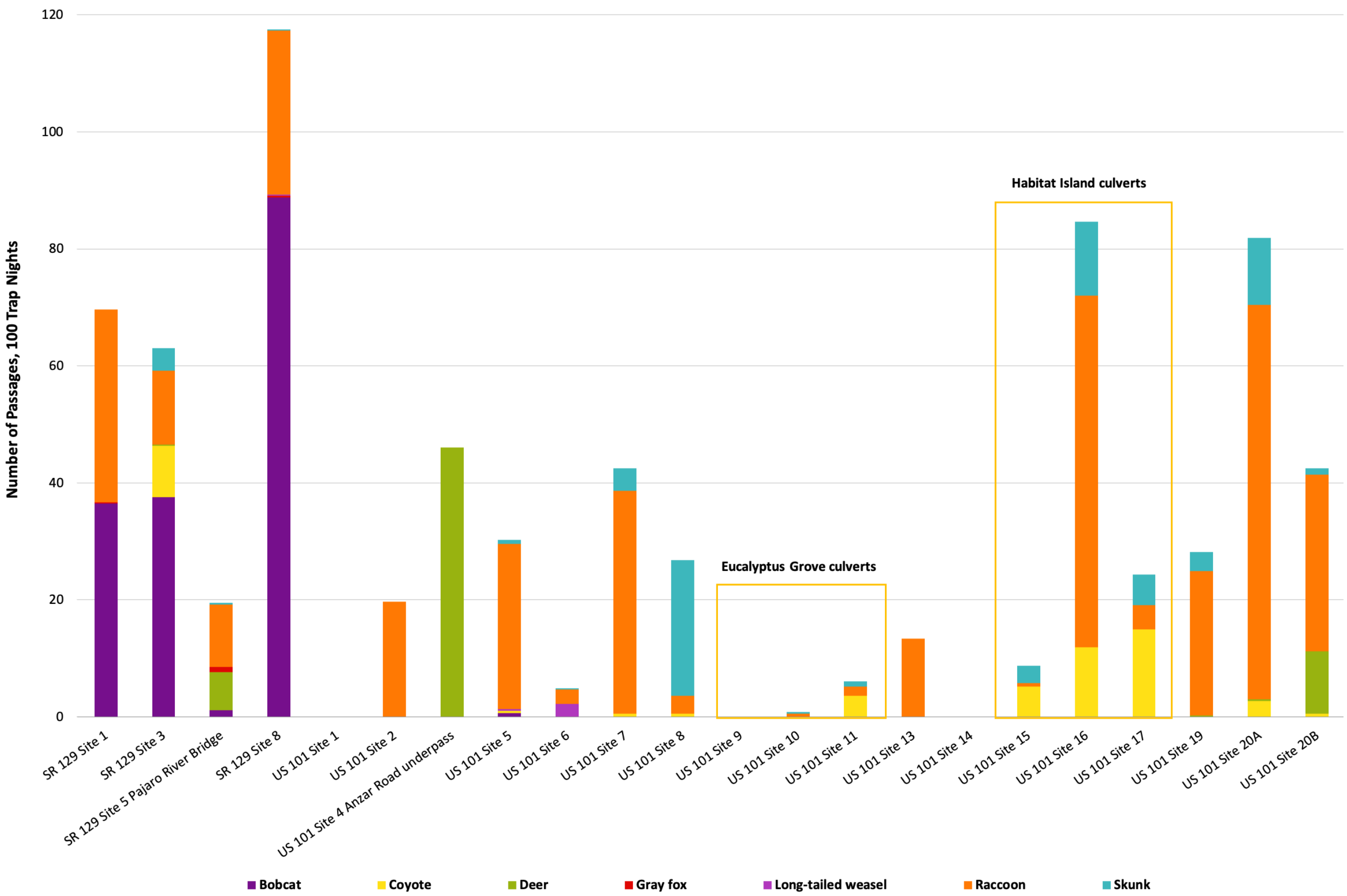


Figure 2.20. Native species passages by site in the SR 129 (left) and US 101 Aromas Hills (right) sections standardized on a 100 trap night basis.

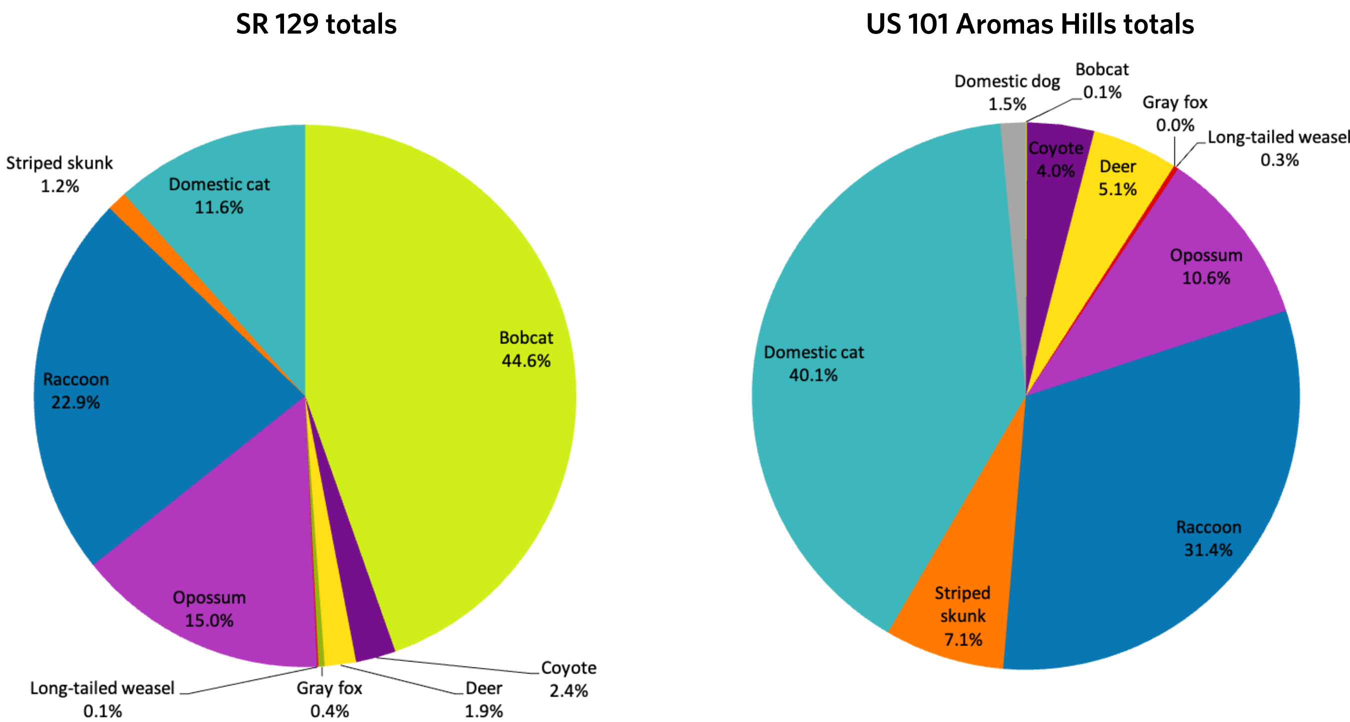


Figure 2.21. Relative frequency of passage by all species (native and non-native) in the SR 129 and US 101 Aromas Hills sections (not standardized).

Bobcats were recorded approaching and investigating the culvert at US 101 Site 7 (including entering the culvert but emerging shortly after) but did not use it to travel under the highway. A bobcat with severe mange was recorded at this site several times. A juvenile bobcat was also recorded at this site. We also detected a collared bobcat at this site that had been part of a telemetry study conducted by UC Santa Cruz (Serieys et al. 2021).

In a previous study (the 2013–2014 CA Central Coast Connectivity Project), bobcats were consistently recorded using US 101 Sites 11, 15, and 17 (which includes two of the Habitat Island culverts) to travel under US 101 (Diamond and Snyder 2014). We did not record any bobcats at these sites during this study period, including non-passages, though a bobcat telemetry study with a similar time period found bobcats active in the immediate vicinity (Serieys et al. 2021). One possible explanation of this decrease in observed passages is that bobcats are ingesting rodents exposed to anticoagulant rodenticides, leading to mange and subsequent depletion of the population (Serieys et al. 2021). A recent bobcat telemetry study found that mange was the leading source of mortality for bobcats in the Aromas Hills (Serieys et al. 2021).

The US 101 Aromas Hills section had a very high rate of domestic cat passages (1,286 total), including by domestic kittens, with only two passages by bobcat. The only animal recorded using all three Eucalyptus Grove culverts to successfully cross US 101 was a single domestic cat. At US 101 Aromas Hills sites 17, 19, and 20, an individual tabby domestic cat was recorded using this system of culverts until the culverts were flooded with water, when the animal was found dead on the highway.

Wildlife approaching but not traveling through the culvert at US 101 Site 7. This culvert is angled and obscured by brush, and visibility is poor.

Domestic tabby cat at US 101 Aromas Hills Sites 17, 19, and 20.

Bobcats were not detected at any of these culverts used by these two individual domestic cats. At the SR 152 culverts, where we recorded consistent bobcat passages, we did not record any domestic cats using these culverts. Similarly, where we recorded domestic cats at SR 152 Ortega Bridge (Site 3), we did not record bobcats. With a low presence overall of carnivores detected, the presence of domestic cat might be an indicator of a lack of predators that would typically control a domestic cat population and/or degraded habitat for native predators. The presence of domestic cats in this highway section may be because of nearby rural residential development, which may not provide good habitat for native predators. Detections of domestic cat have been found to increase with development at sites where mountain lion is absent (Wang et al. 2015).

PAJARO VALLEY SUBAREA

The Pajaro Valley subarea includes the SR 152, SR 25, and US 101 Pajaro Valley sections. The species with the most recorded passages in this subarea included deer, coyote, skunk, domestic cat, and raccoon, all with more than 500 passages detected across the 14 sites.

SR 152 PAJARO VALLEY SECTION

The SR 152 Pajaro Valley section consists of six sites (Figure 2.22). Five of these sites featured culverts, and one site featured an undercrossing at the Ortega Creek Bridge underpass. We recorded a total of 1,804 passages by native species, with a total of eight species detected. When standardized, this section recorded a total of 892 native species passages, with an average of 149 passages — the highest of any highway section. The native species with the highest passage rates when standardized were skunk (285), coyote (279), and raccoon (125).

Figure 2.22. Map of camera monitoring sites in the SR 152 section.

SR 152 Site 2 San Felipe Lake box culvert was by far the most-utilized undercrossing in this section and facilitated the highest number of native species passages in the entire study area, with 594 passages recorded across all trap nights (376 passages in the 100 trap nights analysis) (Figure 2.23). This site had the highest species richness in this section (tied with SR 152 Site 6), with six native species detected (Figure 2.23). SR 152 Site 2 was the only site in this section where passage by gray fox and deer were recorded. The deer observations were surprising because the culvert is relatively small (4′ height). A coyote pair and juvenile along with a raccoon family were also consistently recorded using this culvert throughout the year. This site was only one of two sites in the study area that recorded passage by wild pig, with 225 total passages detected across all trap nights (Figure 2.24). This culvert is close to San Felipe Lake, which is likely an important year-round source of water for animals. It also connects to expansive open grassland habitat to the north.

Male deer traveling through the SR 152 Site 2 San Felipe Lake box culvert toward the lake.

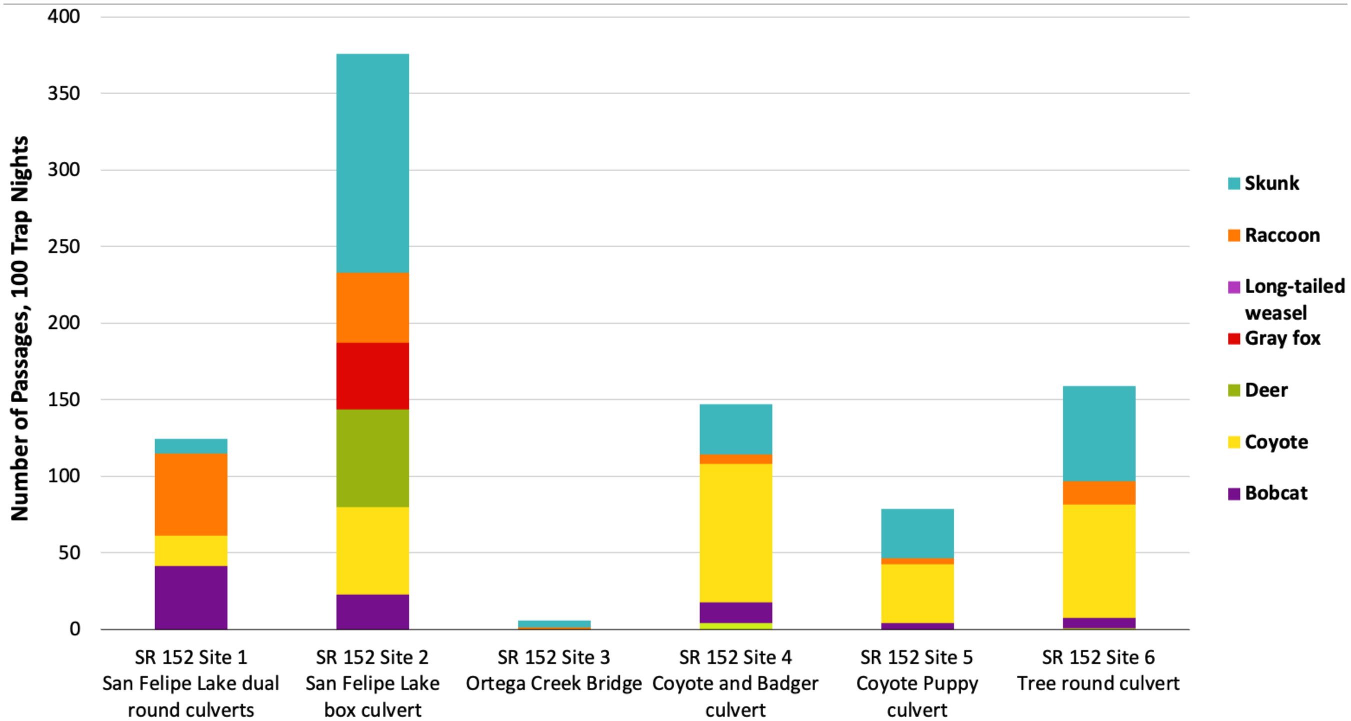


Figure 2.23. Passages of native species in the SR 152 section standardized on a 100 trap night basis.

Frequent users of the SR 152 Site 2 San Felipe Lake box culvert included an adult and juvenile coyote (top), bobcat (bottom L), and gray fox (bottom R).

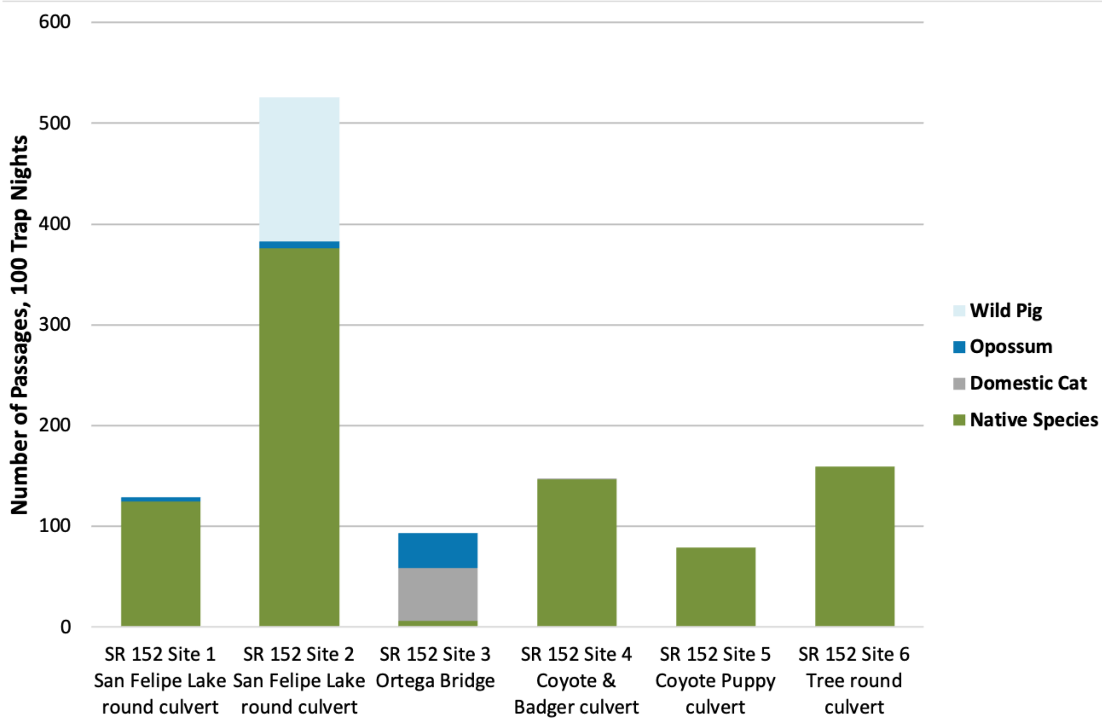


Figure 2.24. Passages of native species and non-native species (wild pig, opossum, and domestic cat) in the SR 152 section standardized on a 100 trap night basis.

SR 152 Site 6 had the second-highest native species passages in this section, with 471 passages across all trap nights (159 passages in the 100 trap nights analysis) (Figure 2.23). It also tied with SR 152 Site 2 for the highest species richness in this section, with six native species detected (Figure 2.23). A long-tailed weasel was recorded looking into the culvert, but no passages were recorded at this or any other site in the SR 152 Pajaro Valley section. This site recorded three successful passages by badger, with grassland habitat present on both sides of this culvert.

Bobcat traveling through SR 152 Site 6 Tree round culvert

Coyote pair traveling through SR 152 Site 6 Tree round culvert.

Long-tailed weasel looking into the SR 152 Site 6 Tree round culvert.

SR 152 Site 3 at Ortega Creek Bridge recorded the lowest number of native species passage in this section, with 18 passages across all trap nights (six passages in the 100 trap nights analysis) and the lowest species richness (Figure 2.23). Although this is the only large undercrossing in this section, we recorded no large animals at this site. The passages at this site were dominated by domestic cat (159 total passages across all trap nights), with raccoon, opossum, and skunk also detected (Figure 2.24). The adjacent land use is rural residential, which may explain the presence of domestic cat and human-adapted native species (Wang et al. 2015). As with the US 101 Aromas Hills undercrossings, the presence of domestic cats here may also indicate a lack of predators and/or degraded habitat for native predators such as bobcat, coyote, gray fox, and mountain lion because of development (Grubbs and Krausman 2010, Kays et al. 2015, Wang et al. 2015).

SR 152 Site 1 San Felipe Lake dual round culverts recorded 209 native individuals across all trap nights (124 passages in the 100 trap nights analysis). This site saw consistently high rates of passage by coyote, bobcat, raccoon, and skunk throughout the study period (Figure 2.23). With San Felipe Lake holding water even during the height of the drought season, the water source could be attracting wildlife from the hillsides; this could account for the high rate of passages.

Medium-sized mammals used SR 152 Site 1 San Felipe Lake dual round culverts throughout the year, including bobcat (top L and R),coyote (bottom L) and a raccoon family (bottom R).

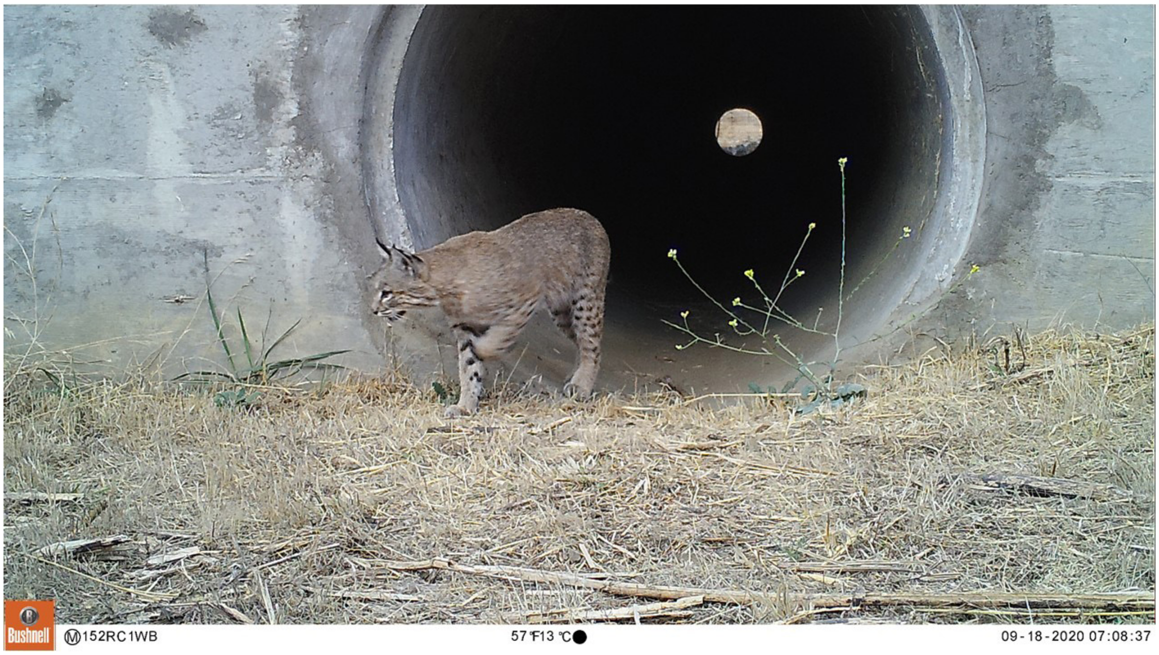
NOTABLE SPECIES DETECTIONS AND INTERACTIONS

At SR 152 Site 4, we recorded an American badger and coyote traveling together through the culvert in both directions. This is the first known documentation of a badger and coyote traveling together through a highway culvert. Nine months later, we documented what appeared to be the same individuals traveling together, with the coyote passing through first, followed by the badger eight minutes later. Cameras at this site also routinely recorded a family of three coyotes traveling through the culvert in both directions throughout the study period. Because we recorded so few coyotes at this site, it's possible that one of these coyotes — in particular the sub-adult — was the coyote traveling with the badger. Other species detected traveling through this culvert regularly throughout the study period included bobcat, raccoon, and skunk.

American badger and coyote traveling north through the culvert at SR 152 Site 4 Coyote and badger culvert on November 23, 2019.

American badger and coyote traveling back south through SR 152 Site 4 Coyote and badger culvert on November 23, 2019.

American badger and coyote traveling north through SR 152 Site 4 Coyote and badger culvert eight minutes apart.



Bobcat traveling through SR 152 Site 4 Coyote and badger culvert.

At the middle culvert east of the Ortega Creek Bridge, SR 152 Site 5 Coyote Puppy culvert, we recorded a coyote family traveling through the culvert in spring of 2020. Badgers were also recorded passing through this site, as well as through the culvert to the east (SR 152 Site 6 Tree round culvert). Based on a badger's home range size and the face and back markings, these recordings are most likely of the same individual. This site connects grassland habitat on either side of the highway.

Adult coyote traveling with pups through SR 152 Site 5 Coyote puppy culvert.

Coyote pups traveling through SR 152 Site 5 Coyote puppy culvert.

American badger traveling by SR 152 Site 5 Coyote puppy culvert.

SR 25 PAJARO VALLEY SECTION

SR 25 Pajaro Valley consists of two camera monitoring sites: SR 25 Site 1 Carnadero Creek Bridge and SR 25 Site 2 Pajaro River Bridge (Figure 2.25). Both are bridge underpasses. We recorded a total of 252 passages at these two sites, with seven native species detected. When standardized, this section recorded a total of 78 native species passages, with an average of 39 passages. The native species with the highest passage rates when standardized were raccoon (36), coyote (28), and bobcat (10).

Figure 2.25. Map of camera monitoring sites in the SR 25 Pajaro Valley section.

SR 25 Site 1 Carnadero Creek Bridge had slightly more native species passages (43 passages in the 100 trap nights analysis) than SR 25 Site 2 Pajaro River Bridge when standardized on a trap night basis (Figure 2.26). While we initially recorded coyotes and bobcats traveling along the bank on a consistent basis, there was a substantial decrease in the number of passages at this site in the months of December through April. During this period, increased water levels in the creek decreased the amount of dry bank available for wildlife to use in the middle section of the bridge. When water was high and there was very little bank left, we only recorded raccoons swimming across the creek to access the other side of the bridge through the middle section. The westernmost section of the bridge was along an agricultural field, and tractors were driven back and forth under the bridge through this western section, which might have deterred wildlife use. This site also had one recorded passage by non-native red fox (Figure 2.27).

Coyote, deer, and racoon traveling beneath the bridge at SR 25 Site 2 Pajaro Bridge.

Although both sites in this section are large enough to accommodate large animals, deer were not recorded at the Carnadero Creek Bridge and mountain lions were not recorded at either site. This may be due to inadequate vegetative cover for mountain lion (Suraci et al. 2020).

Deer were recorded only under SR 25 Site 2 Pajaro River Bridge, with a total of 14 passages (Figure 2.26). We also recorded more passages by coyotes and bobcats at SR 25 Site 2 Pajaro River Bridge relative to SR 25 Site 1 Carnadero Creek Bridge (Figure 2.26), including a coyote family routinely traveling under this bridge. SR 25 Site 1 Carnadero Creek Bridge was one of only two camera monitoring sites (along with SR 129 Site 8) of the 42 we monitored in this study where we recorded a bobcat traveling with two kittens.

The presence of juvenile and adult coyotes and bobcats at these two sites as well as the presence of deer indicates that these narrow riparian corridors may be important for species' movement through the largely agricultural Upper Pajaro Valley and reflects results found in a previous study (Diamond and Snyder 2013).

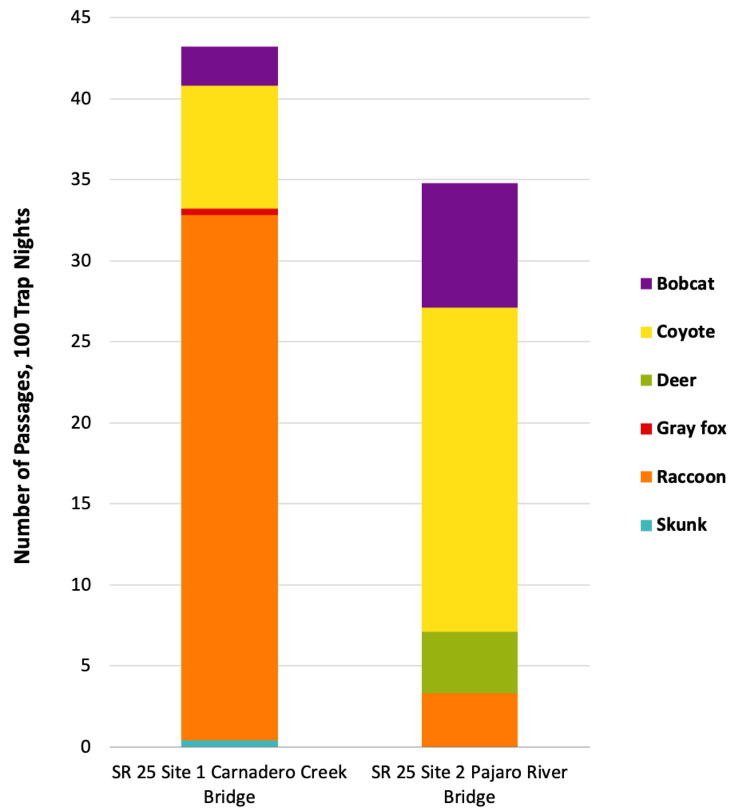


Figure 2.26. Passages of native species in the SR 25 Pajaro Valley section standardized on a 100 trap night basis.

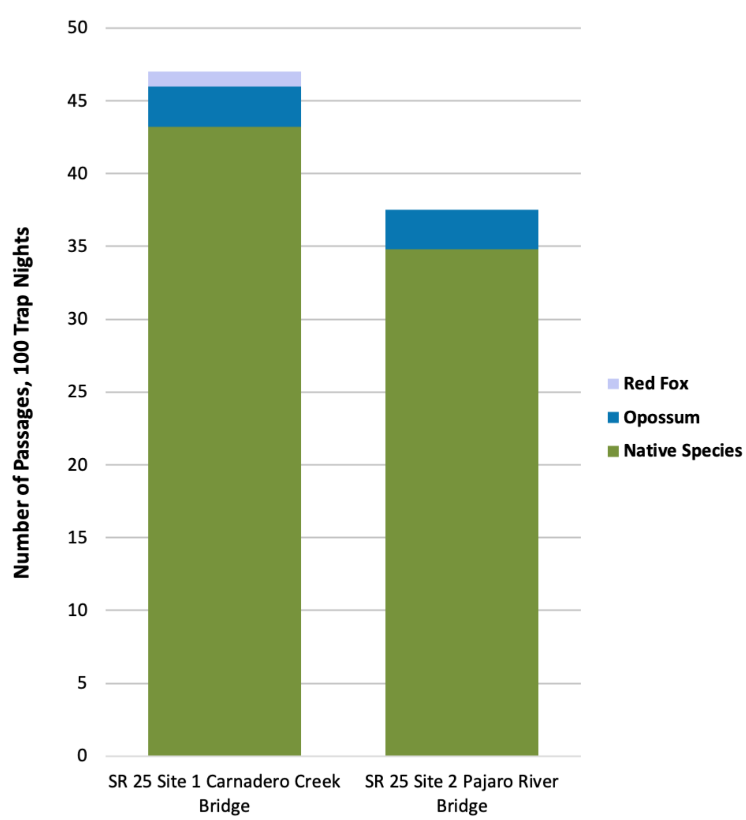


Figure 2.27. Passages of native species and non-native species (red fox and opossum) in the SR 25 section standardized on a 100 trap night basis.

A coyote family of three traveled both north and south through the SR 25 Site 2 Pajaro Bridge undercrossing on January 28, 2020.

At SR 25 Site 1 Carnadero Creek Bridge, we recorded a female bobcat traveling with two kittens.

US 101 PAJARO VALLEY

The US 101 Pajaro Valley section consists of six camera monitoring sites: four crossings beneath bridges or overpasses, and two culverts (Figure 2.28). We recorded a total of 1,564 passages by native species in this section. When standardized, this section recorded a total of 561 native species passages with an average of 93 passages, the second highest in the study area. We detected eight native species in this section, the highest of any section. The native species with the highest passage rates when standardized were deer (323), raccoon (110), and coyote (73) (Figure 2.29). Notably, 91 total bobcat passages were recorded in this section. The presence of several bridges and one highway overpass suitable for passage by a variety of mammals as well as this highway's interface core habitat in the southern Santa Cruz Mountains may have contributed to the high native species richness. This section had the highest number of passages by non-native red fox within the entire study area (168), all recorded at US 101 Site 1 Carnadero Creek Bridge (Figure 2.30).

Figure 2.28. Map of camera monitoring sites in the US 101 Pajaro Valley section.

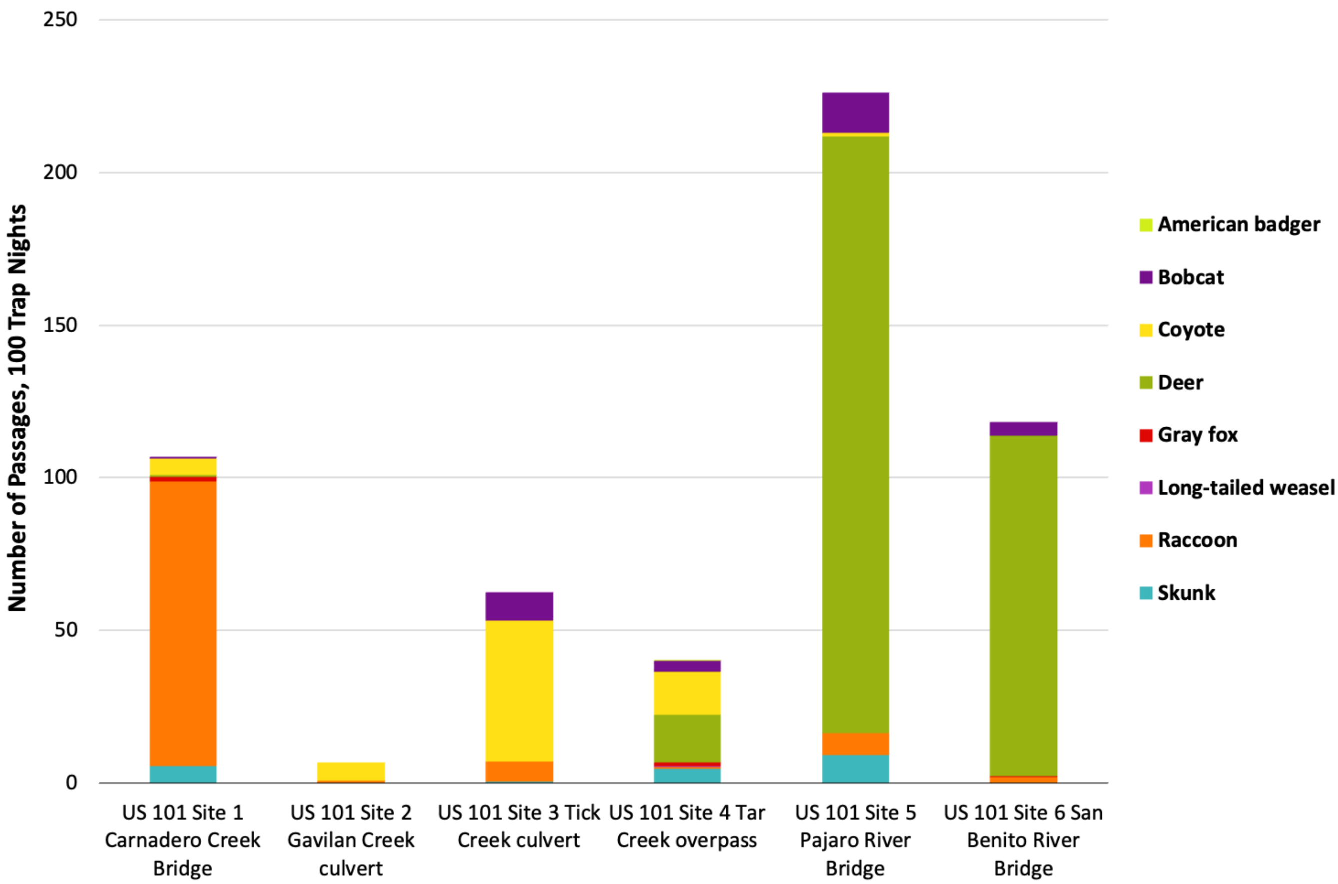


Figure 2.29. Native species recorded in the six sites in the US 101 Pajaro Valley section standardized on a 100 trap night basis.

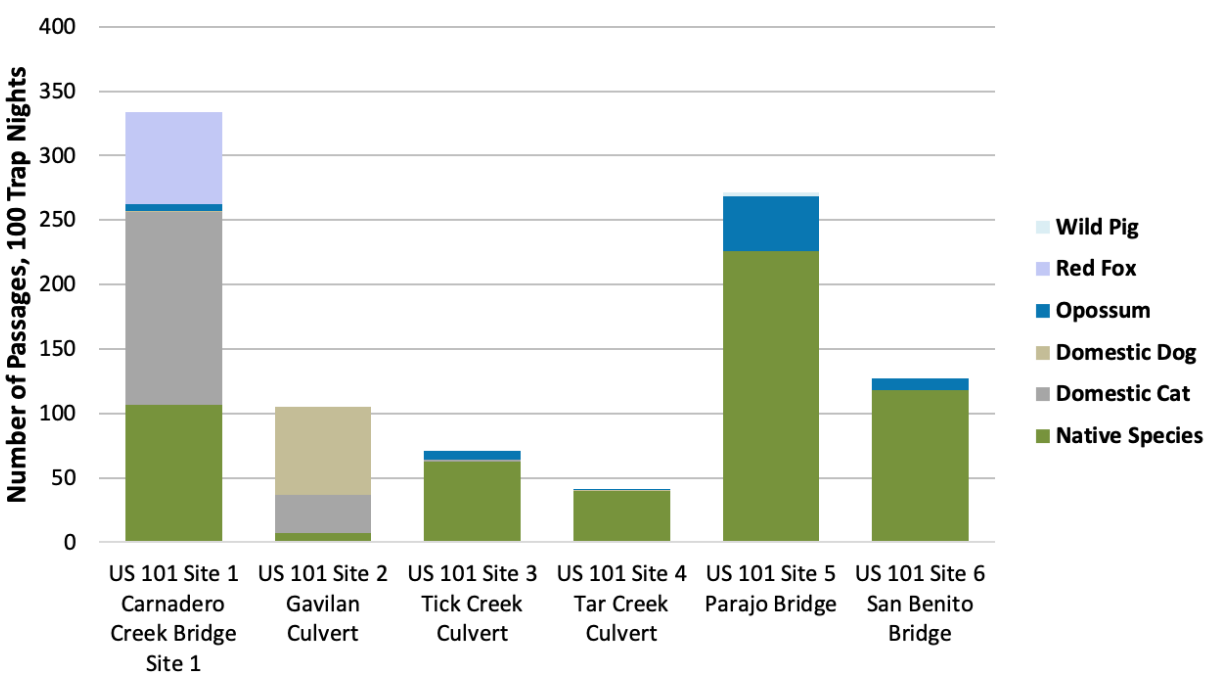


Figure 2.30. Passages of native species and non-native species (wild pig, red fox, opossum, domestic dog, and domestic cat) in the US 101 Pajaro Valley section standardized on a 100 trap night basis.

US 101 Site 5 Pajaro River Bridge facilitated the highest number of native species passages in this section, with a total of 502 passages across all trap nights (226 passages in the 100 trap nights analysis) (Figure 2.29). Bobcat, deer, skunk, and raccoon were routinely recorded traveling under the bridge. This site had five native species recorded (Figure 2.29) and was also only one of two in the entire study area where wild pig passages were recorded (six total passages) (Figure 2.30). US 101 Site 6 San Benito River Bridge had the second-highest number of documented passages by native wildlife in this section, with a total of 421 passages across all trap nights (118 passages in the 100 trap nights analysis) (Figure 2.29). Both of these bridges feature a wide riparian corridor with high-quality habitat, which likely contributed to high passages by native wildlife and high species richness.

Various wildlife crossing at US 101 Site 5 Pajaro Bridge.

Female deer with two fawns traveling under the US 101 Site 6 San Benito Bridge.

The US 101 Site 4 Tar Creek overpass had the highest species richness in native species passages within the entire study area, with eight species detected (Figure 2.29). This site is described in more detail below. In contrast, the US 101 Site 2 Gavilan Creek culvert had the lowest number of native species passages in this section and one of the lowest overall in the entire study area. Though the Gavilan Creek culvert was previously used by bobcat and coyote (Diamond and Snyder 2013), passages recorded in the current study were dominated by domestic dog and cat (Figure 2.30). This site was inundated with water for part of the study period and is adjacent to a private residence and row crop agriculture, which may have contributed to low native species passage at this site and the presence of domestic animals.

US 101 Site 3 Tick Creek culvert recorded the most bobcat passages within the section (Figure 2.29). Two bobcats with ear tags (from another study) were recorded heading both into Carnadero Preserve and from the preserve into the Sargent Hills. A family of four coyotes was also consistently recorded using this culvert. These data suggest this is an important culvert for facilitating movement of medium-sized mammals.

Passages at the US 101 Site 1 Carnadero Creek Bridge were dominated by raccoon (220 passages), domestic cat (353 passages) and non-native red fox, with the highest rates of red fox passage in the study area (168 passages) (Figure 2.30). This site is near the southern end of Gilroy and has some development nearby, which may explain the presence of more human-adapted species at this location (Bidlack et al. 2008, Wang et al. 2015).

Bobcat in US 101 Site 3 Tick Creek culvert. The animal in the left photo has two yellow ear tags.

Coyote family traveling west into the Sargent Hills through the US 101 Site 3 Tick Creek Culvert.

Connectivity for deer and mountain lion

US 101 Site 5 Pajaro River Bridge and Site 6 San Benito River Bridge had the highest rates of deer passage in the entire study area (both standardized and non-standardized), with 434 and 397 passages over all trap nights, respectively (Figure 2.29). The majority of passages under the San Benito River Bridge were by deer (Figure 2.29). Site 6 is also the only site where we recorded mountain lions traveling on the Upper Pajaro Valley floor. Though mountain lions were not detected on camera, when we arrived to set up cameras, we discovered and recorded mountain lion tracks spanning the entire southwest portion of the bridge. The high rate of deer detections at this site suggests that readily available prey could be attracting mountain lion to this area. The ample riparian cover at the bridge provides good cover for predators.

US 101 Site 4 Tar Creek overpass

The US 101 Site 4 Tar Creek overpass had the highest species richness in the entire study area, with eight species detected (Figure 2.29). Native species detected with successful passage included badger, bobcat, coyote, deer, gray fox, long-tailed weasel, raccoon, and skunk. We also detected a coyote family and opossum at this site, along with ground squirrels, rabbits, San Francisco dusky-footed woodrats, and other unidentified rodents, though we did not calculate the number of passages by these small mammals.

Wildlife recorded in the US 101 Site 4 Tar Creek overpass included coyote (top L), badger (top R), deer (bottom L) and gray fox (bottom R).

This site provides an important connection between high-quality habitat in the upland hills (Sargent Hills) and the Carnadero Preserve, a 480-acre section of agricultural land and riparian habitat protected by a conservation easement. The Nature Conservancy Pajaro Valley Wildlife Connectivity Study (Diamond and Snyder 2013), conducted from 2012–2013, documented a high amount of movement by multiple species throughout the Carnadero Preserve. That study also documented multiple species family units residing in and traveling throughout the preserve. That study consistently recorded a deer herd, a coyote family, and bobcats with kittens traveling throughout the preserve.

We also recorded bobcat (top), coyote (bottom L), and deer (bottom R) in the US 101 Site 4 Tar Creek overpass.

As evaluated in the aforementioned studies, the Tar Creek overpass is of particular value in supporting existing connectivity. This site facilitates movement by adults and juveniles (deer, coyote, and bobcat) between core habitat in the Santa Cruz Mountains through the Upper Pajaro Valley and supports a diverse assemblage of native wildlife, the highest recorded in the study area. Though the Upper Pajaro is largely agricultural, past studies have documented species such as deer, coyote, and bobcat using this landscape for movement, including in the Carnadero Preserve, which is adjacent to the Tar Creek overpass (Diamond and Snyder 2013).

Narrow (<25m) riparian strips have been found to be critical to connectivity for bobcat within these fragmented agricultural landscapes (Serieys et al. 2021), and animals may be using Tar Creek as a movement corridor. The detection of juveniles at this site is important to note, as we did not document juveniles traveling with adults in the US 101 Aromas Hills section. The Tar Creek overpass is critical for safe passage beneath US 101 and may provide connections for wildlife to the Diablo Range along narrow riparian corridors in the Upper Pajaro Valley.

3 OCCURRENCE OF WILDLIFE–VEHICLE COLLISIONS

INTRODUCTION

Roadkill data represent wildlife–vehicle collisions (WVC) and can indicate where wildlife attempt to cross roads at-grade and are hit and killed by vehicles. These data, along with movement data such as that from radio telemetry, can also indicate where wildlife might have crossed successfully in the past. WVC data together with camera monitoring data of undercrossings and connectivity modeling can help inform where new or improved wildlife crossing structures could facilitate safe passages under or over roads. Data on where animals are killed on roads can also inform placement and extent of directional fencing to guide wildlife to crossing structures or culverts and bridges where wildlife have been recorded traveling safely under the road.

METHODS

ROADKILL SURVEYS AND DATA COLLECTION

Pathways for Wildlife conducted roadkill surveys once every two weeks in the Aromas subarea (SR 129, SR 156, and US 101 Aromas Hills sections) in year 1 of the study (August 1, 2018 – July 31, 2019) and in the Pajaro Valley subarea (SR 152 Pajaro Valley, SR 25 Pajaro Valley, and US 101 Pajaro Valley sections) in year 2 of the study (October 1, 2019 – September 30, 2020) (Figure 3.1). Data collected in these surveys included geographic coordinates, species, number of individuals, and photographs. Because the roadkill surveys were conducted by car, smaller terrestrial mammals (e.g., squirrel, deer mouse) were likely detected less frequently than relatively larger terrestrial mammals (e.g., raccoons, deer) because of lower persistence time for small-sized carcasses (Henry et al. 2021) and lower search efficiency of car surveys relative to walking surveys, particularly for small-sized animals (Santos et al. 2016).

We used additional roadkill data for the study area from other studies and sources. We included WVC data from surveys conducted by Pathways for Wildlife as part of the Big Sur Land Trust CA Central Coast Study 2012–2013 (Diamond and Snyder 2014), which spanned US 101 from the Tick Creek culvert (US 101 Pajaro Valley Site 3) south to the Habitat Island culverts (US 101 Aromas Hills section, sites 15–17). We also received data from the Santa Cruz Puma Project, which included mountain lion WVC data from 2016–2020. We used all available WVC records for American badger (a California Species of Special Concern) from the California Natural Diversity Database (CNDDB) (CDFW 2022), with the earliest known record of badger WVC in our study area dating to 1995. Badger is the only special-status species of relevance to this study that is tracked in CNDDB. Finally, we included WVC records provided to us by other researchers on an opportunistic basis via personal communication, including badger WVC records from Diamond 2008.

Roadkill data collection coincided with the COVID-19 pandemic, including the shelter-in-place orders of early 2020. One study found a significant decrease in WVC in California in March and April 2020, while the initial shelter-in-place orders were in effect (Nguyen et al. 2020). Another study found a decrease in WVC in the US early in the pandemic, although this was followed by an increase that ultimately exceeded WVC rates for the previous year (Abraham and Mumma 2021). While we did not specifically investigate the relationship between traffic volume, roadkill, and COVID-19 within the study area, it should be noted as a potential influence on the roadkill observed during this study.

Figure 3.1. Routes surveyed 2018–2020 for roadkill along US 101, SR 129, SR 152, SR 25, and SR 156. Year 1 of the study was August 1, 2018 – July 31, 2019; year 2 was October 1, 2019 – September 30, 2020.

ANALYSIS OF ROADKILL DATA

We used all recorded WVC data to detect roadkill clusters, representing areas where wildlife routinely attempted to cross roads but were hit by vehicles during the study period. We visually examined the occurrence of WVCs in relation to existing culverts and bridges as identified through the Wildlife Permeability and Infrastructure Database (WPID) created for this project, which includes the camera monitoring sites. It is important to note that there are known culverts recorded in the WPID that were not monitored for below-grade wildlife passage (see Chapter 2 and Appendix A). We focused our analysis on terrestrial mammals.

We also overlaid WVC data with data on focal species habitat suitability (as described in Chapter 4) and camera data (as described in Chapter 2) to develop the wildlife connectivity enhancement recommendations for the Connectivity Emphasis Sites (see Chapters 5 and 6).

RESULTS AND DISCUSSION

Through roadkill surveys conducted during the 2018–2020 study period, Pathways for Wildlife detected a total of 66 animals killed by WVC (Figures 3.2 and 3.3). Looking at the WVC dataset from this study only, the species with the most recorded WVC were striped skunk (29%), raccoon (26%), deer (18%), and coyote (9%) (Figure 3.4). Pathways for Wildlife also detected two barn owl WVC, but these data are not included in the analysis (see above). We added to these data the previously collected records described above, resulting in a total of 94 records of WVC in the study area (Figures 3.3 and 3.5).

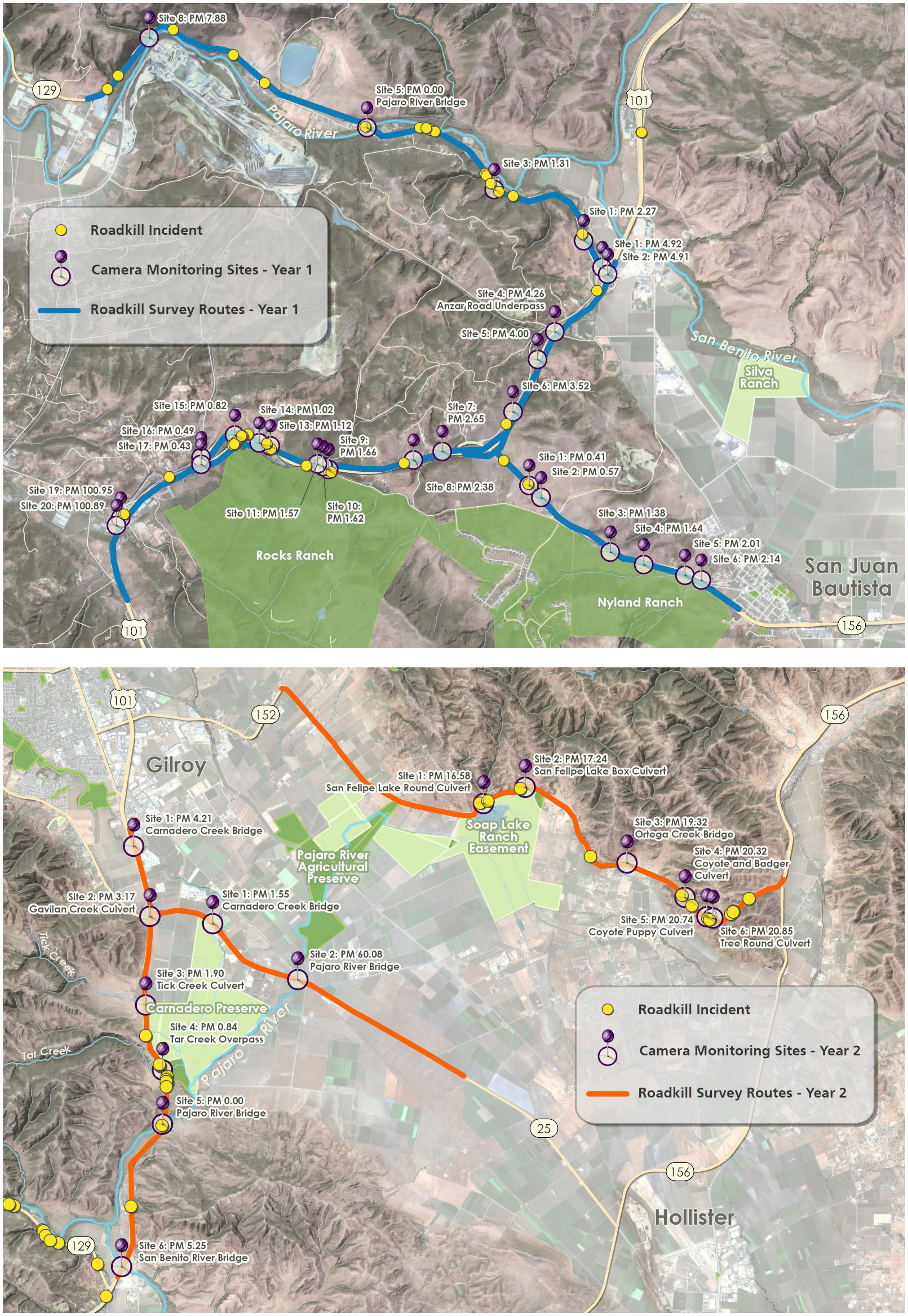


Figure 3.2. Roadkill observations (yellow dots) detected through Pathways for Wildlife roadkill surveys during the two-year survey period in the Aromas subarea (top) and Pajaro Valley subarea (bottom).

Species	Roadkill observations recorded through Pathways for Wildlife surveys, 2018–2020	Additional roadkill observations from other studies and sources*	Total number of roadkill recorded in study area
Badger	0	9	9
Bobcat	2	5	7
Coyote	6	1	7
Deer	12	6	18
Gray fox	1	1	2
Ground squirrel	2	0	2
Jackrabbit	1	0	1
California kingsnake	1	0	1
Mountain lion	0	3	3
Opossum	4	0	4
Raccoon	17	0	17
Skunk	19	2	21
Wild pig	1	1	2
TOTAL	**66**	**28**	**94**

* Includes records from other studies, personal communications from other researchers, and badger records from CNDDB. These records include those detected before, during, and after the study period (2018–2020). Note that previous roadkill surveys were not of equal effort as the roadkill surveys completed during the course of the current study (2018–2020).

Figure 3.3. Roadkill data on focal highways in the study area.

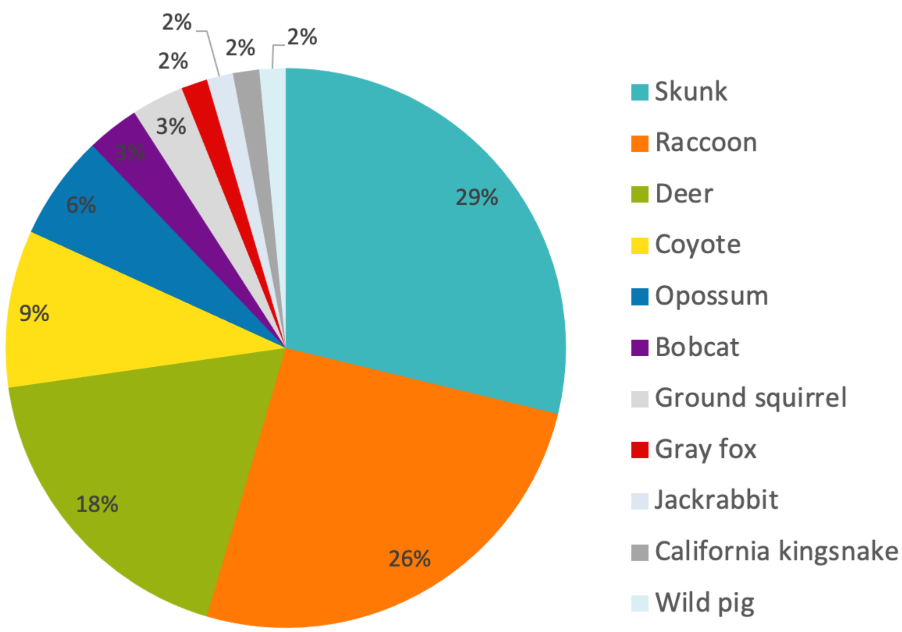


Figure 3.4. Percentage of species recorded as roadkill in the study area by Pathways for Wildlife during the study period (2018–2020).

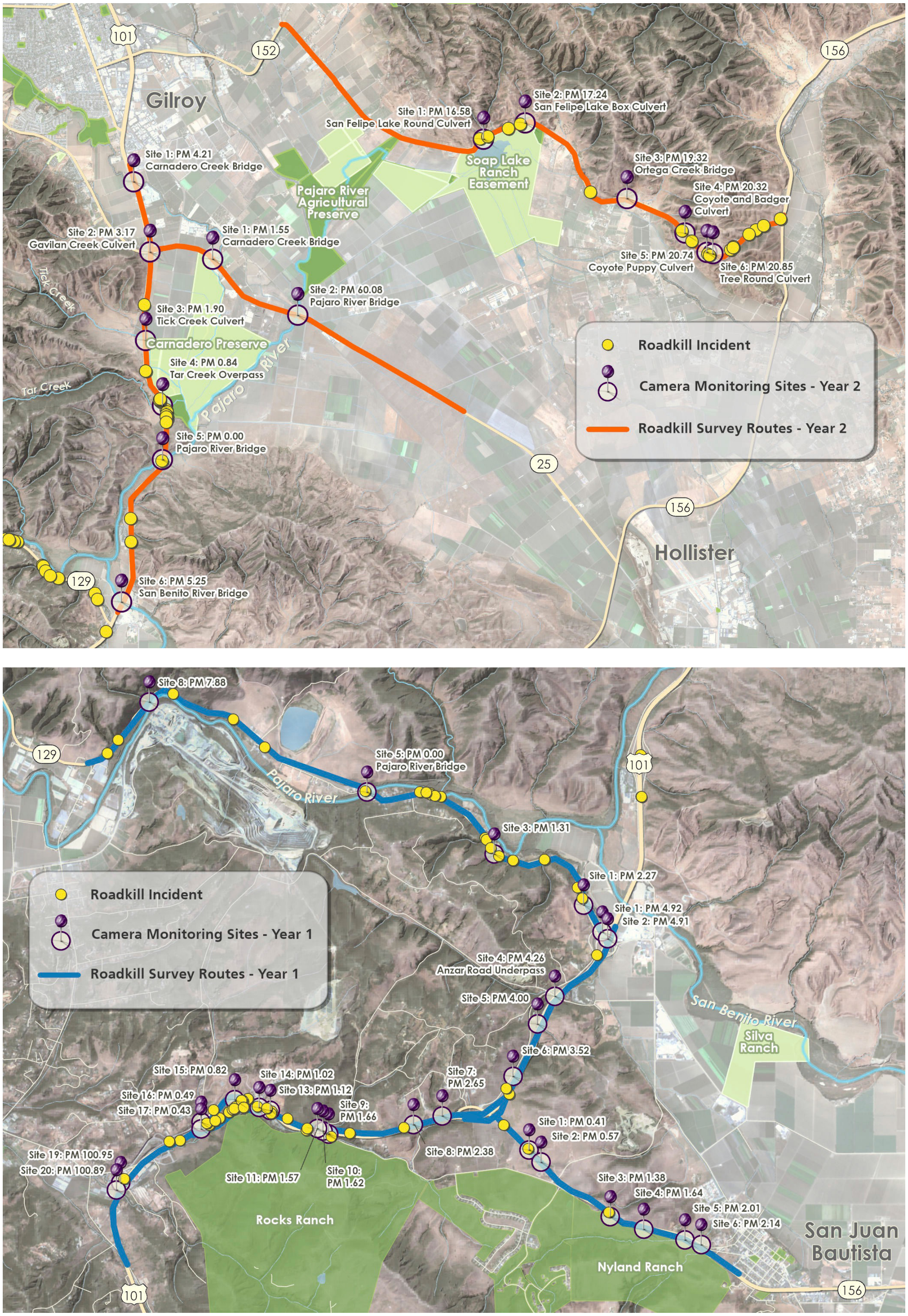


Figure 3.5. Locations of all roadkill records (from this study, additional records from previous studies, personal communications by other researchers, and CNDDB records - available for badger only) in the Pajaro Valley subarea (top) and the Aromas subarea (bottom).

We found several segments of highway with relatively high concentrations of WVC. The main area of concentrated roadkill was the US 101 Aromas Hills section west of the junction of US 101 with SR 156, specifically between the Eucalyptus Grove culverts and the Habitat Island culverts. The lack of large culverts spanning the entire highway in the Eucalyptus Grove region and low rates of native species passages through the existing culverts may have contributed to wildlife attempting to cross US 101 at-grade near this location. Additionally, the Habitat Island culverts were investigated but not used by deer, which again may have contributed to deer attempting to cross US 101 at-grade. Because the Habitat Island median separates the northbound and southbound lanes of US 101, deer may be more likely to attempt to cross at-grade at this location because they have only two lanes to cross.

We also detected an area of concentrated roadkill near US 101 Pajaro Valley Site 4 Tar Creek overpass, near the Carnadero Preserve, including two WVC detections of badger, a California Species of Special Concern. More species may be crossing US 101 at this location because it is adjacent to intact habitat in the Sargent Hills and the northbound and southbound lanes of US 101 are separated at this location by a strip of land featuring some natural vegetation. Additional areas of concern include the eastern end of SR 129 and SR 152 near San Felipe Lake and just west of the junction of SR 152 and SR 156. No WVCs were detected along SR 25, perhaps because of its location in a primarily agricultural landscape where natural habitat limited to narrow riparian corridors that correspond with bridge underpasses.

Below we provide details about WVCs for a subset of species: black-tailed deer (due to relatively high occurrence, locations of concentrated WVCs, and relevance for driver safety), mountain lion (due to locations of concentrated detections, population fragmentation, and candidate status under California Endangered Species Act), and American badger (due to status as California Species of Special Concern).

BLACK-TAILED DEER

Surveys for this study during the study period recorded a total of 12 deer dead on road. When combined with additional records, a total of 18 deer were recorded dead on road. Half of these collisions were in the US 101 Aromas Hills section by the Habitat Island, on the west side of the Eucalyptus Grove (Figure 3.6). Deer were not recorded traveling through the Habitat Island culverts. Factors such as culvert dimensions, visibility, and adjacent land use/habitat quality may have deterred use of these culverts by deer. In addition to factors associated with the culverts, separation of the northbound and southbound lanes of US 101 by the Habitat Island median may have contributed to deer attempting to cross US 101 at-grade at this location.

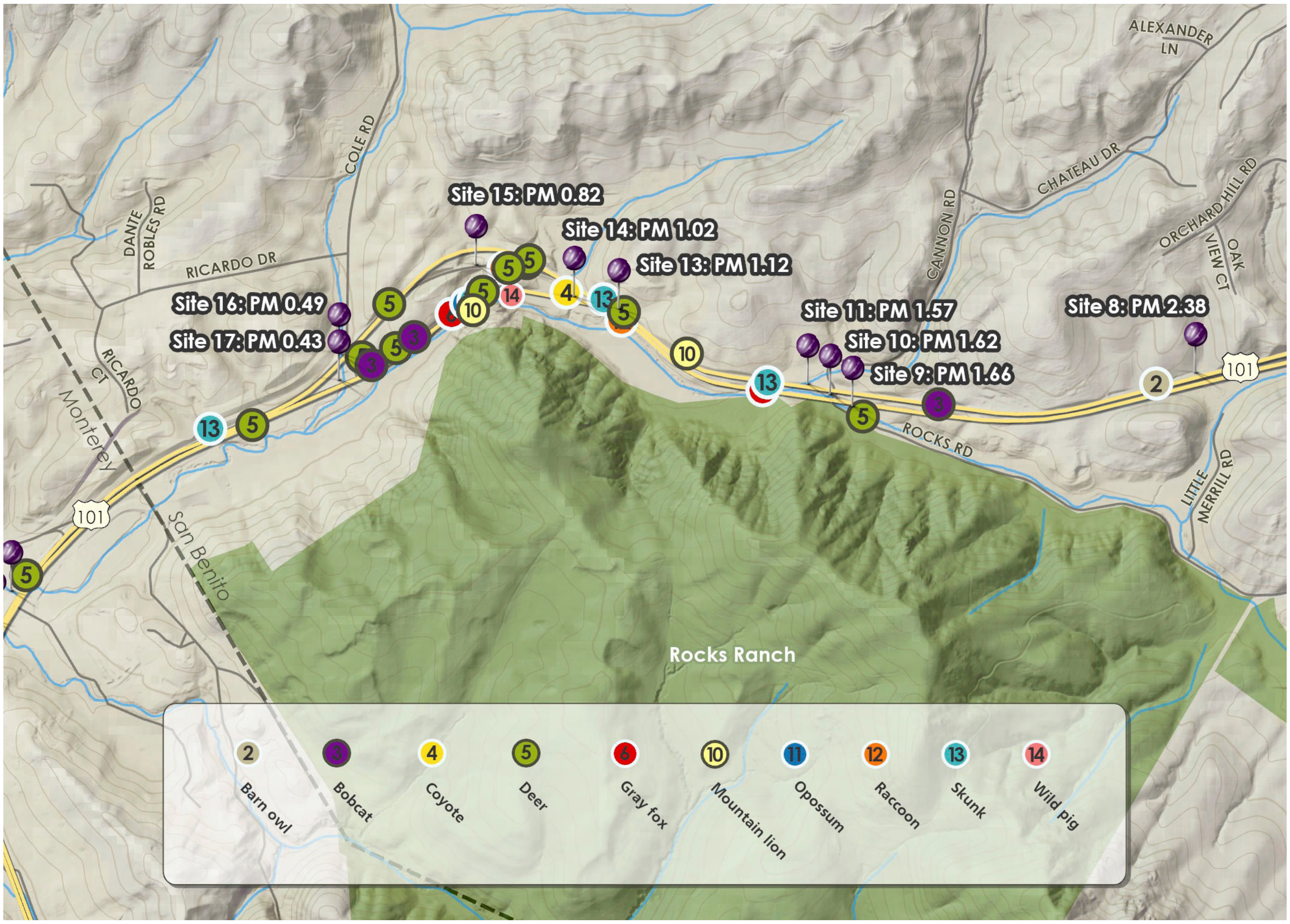


Figure 3.6. Location of deer (and other wildlife) killed by vehicles on US 101 Aromas Hills near the Habitat Island, all records combined. Each icon on the map refers to one recorded WVC for a given species as displayed in the figure legend.

MOUNTAIN LION

Three mountain lions were recorded as killed in vehicle collisions within the study area. These records were provided by the Santa Cruz Puma Project, Santa Clara Valley Habitat Agency, and the California Department of Fish and Wildlife.

All three of the mountain lions killed were in the US 101 Aromas Hills section (Figure 3.7). A radio-collared male mountain lion, 54M, was struck and killed by a vehicle on August 4, 2016 at the Eucalyptus Grove, prior to the 2018–2020 study period. The mountain lion's tracking collar recorded it in this location before the collar stopped sending a signal, and the mountain lion's body was later recovered at its last known GPS location (Chris Wilmers, personal communication 2016; Figure 3.7). A second male mountain lion was recorded during the study period by the Santa Clara Valley Habitat Agency on May 23, 2018 as roadkill in the northbound lanes of US 101 by the Habitat Island (G. Haas, personal communication 2018). A third mountain lion was recorded after the study period as roadkill by CDFW on August 4, 2021, not far from where 54M was suspected of being hit five years earlier (D. Hacker, personal communication 2021; Figure 3.7).

As noted in Chapter 2 of this report, in early October 2018, a young mountain lion was recorded on camera approaching two culverts in the Aromas Hills section, near where 54M's body was recovered: US 101 Site 7 (October 1, 2018) and US 101 Site 11 (October 2, 2018). The individual did not use these culverts to travel beneath US 101. No large mammals were recorded using the Habitat Island or Eucalyptus Grove culverts to travel beneath US 101, suggesting factors such as culvert dimensions and/or land use may be deterring use of these culverts by deer and mountain lion.

These data are particularly relevant to the CDFW status review of the central coast and southern California mountain lion population as a candidate species under CESA, which is described in more detail in Chapter 1. Within this larger population, the Central Coast North (CC-N) subpopulation, which includes the counties of Santa Cruz and Santa Clara, has a very low effective population size of N_e 16.6, and is considered to be at risk (Gustafson et al. 2019).

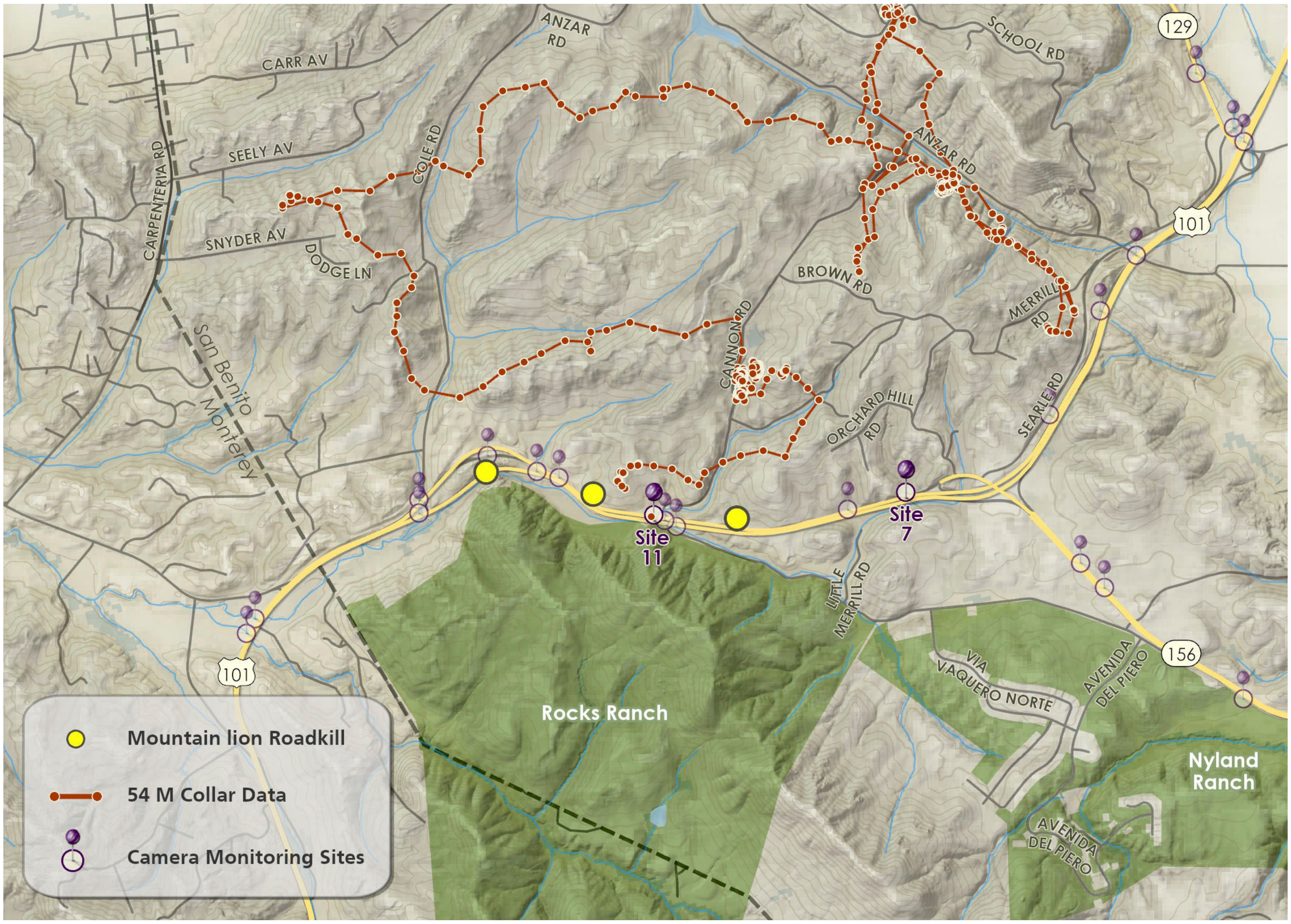


Figure 3.7. Locations where mountain lions were recorded as roadkill in the study area (inclusive of all records), along with radio tracking collar data from 54M, a mountain lion tracked by the Santa Cruz Puma Project.

Male mountain lion killed by vehicle collision on US 101 in the Eucalyptus Grove area on August 4, 2021.

AMERICAN BADGER

Pathways for Wildlife surveys during the study period did not detect any American badger WVC. Our American badger WVC records for the study area include the five records from CNDDB within the study area and four personal observations from other researchers, of which two are included in Diamond 2008, for a total of nine badger WVC detected within the study area.

Three of the detected badger WVC occurred near each other along SR 152, just west of the junction of SR 152 and SR 156 (Figure 3.8). This includes two CNDDB records and one record from 2011 (T. Rahmig, personal communication 2011). One badger WVC was reported on SR 156 near SR 156 Site 3 (CDFW 2022). Two badger WVC were reported near US 101 Site 4 Tar Creek overpass and adjacent to the Carnadero Preserve in 2007 (CDFW 2022) and 2008 (J. Smith, personal communication 2008). This area had a relatively high concentration of WVC for multiple species (Figure 3.9). Another badger WVC reported north of US 101 Site 3 Tick Creek Culvert in 2009 (T. Diamond, personal communication 2021). The final badger WVC was reported on SR 129 (CDFW 2022).

The cluster of three badger WVC records on SR 152 is consistent with results from a comprehensive study of badger in 2019–2022 in Santa Clara, Santa Cruz, San Benito, and San Mateo counties that included roadkill and habitat suitability mapping. That study indicated that SR 152 has the highest known rate of road-based badger mortality on Bay Area highways (Pathways for Wildlife and San Francisco Bay Bird Observatory in prep).

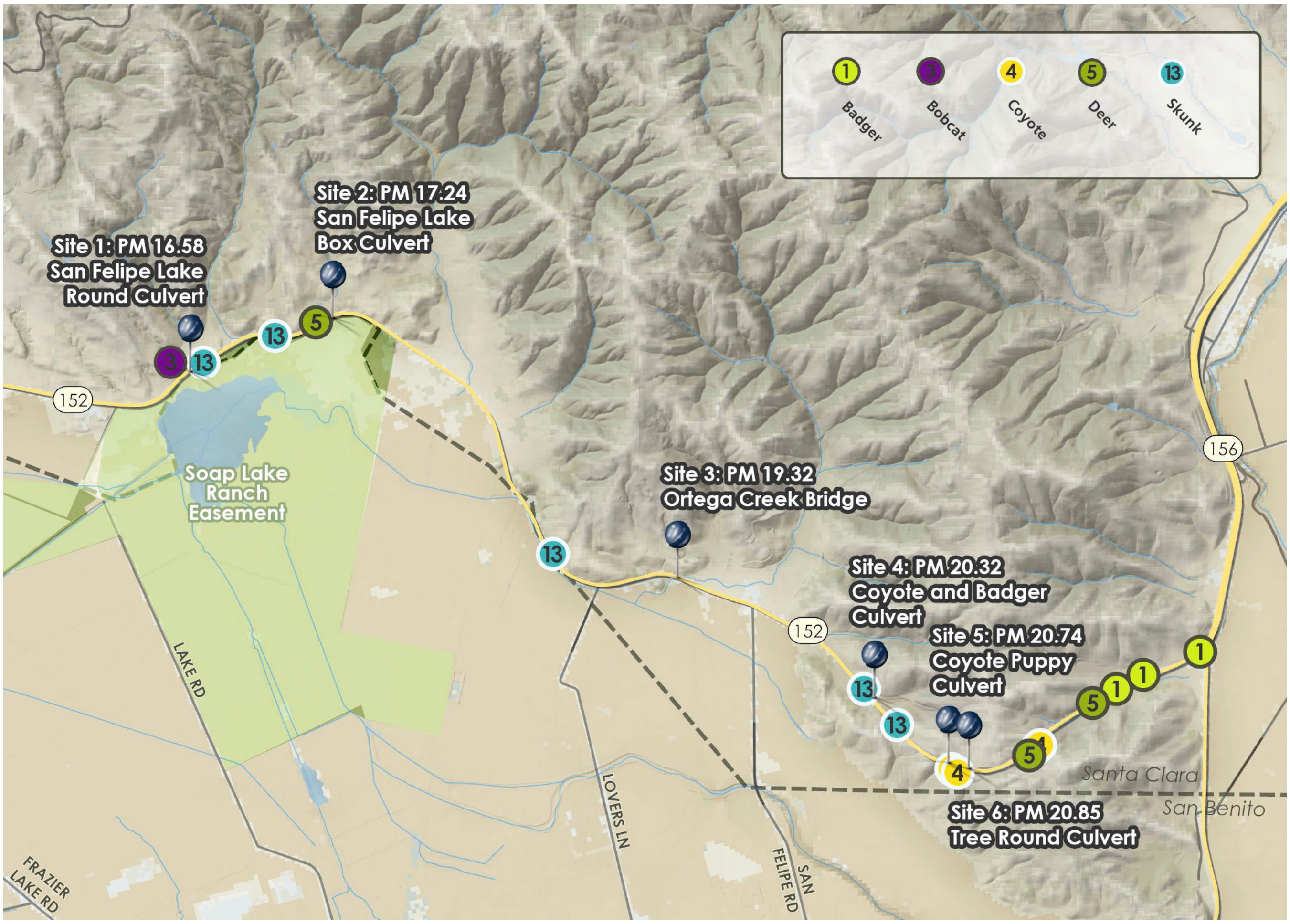


Figure 3.8. Location of badger (and other wildlife) killed by vehicles on SR 152, inclusive of all records. Each icon on the map refers to one recorded WVC for a given species as displayed in the figure legend.

Figure 3.9. Location of badger (and other wildlife) killed by vehicles on US 101 Pajaro Valley, inclusive of all records. Each icon on the map refers to one recorded WVC for a given species as displayed in the figure legend.

4 HABITAT SUITABILITY AND COST SURFACE MODELING

INTRODUCTION

Spatial models can be useful for identifying areas where maintaining or enhancing habitat connectivity would be most beneficial, and thus guide highway improvement projects for wildlife passage. Recent attention has focused on the use of habitat suitability layers and cost surface models that evaluate the suitability of the landscape for movement by different species to guide transportation agencies in improving wildlife passage along highways (Landguth et al. 2012). These types of connectivity models may be particularly well-suited for identifying important wildlife crossing locations as they model large, landscape-scale processes (e.g., dispersal patterns) related to animal movement, rather than more specific models related to the suitability of habitat to fulfill different life history needs of the focal species.

We created habitat suitability layers and cost surface models for four focal species — a set of terrestrial mammal species that collectively use and travel through a large range of habitats in the study area. We used these cost surface models to provide landscape context for consideration in conjunction with camera undercrossing and roadkill data. Together, each dataset provides a different and complementary perspective on wildlife activity, movement, and connectivity in the study area.

In this chapter, we present cost surface models that represent the suitability of the landscape for movement by each focal species. These models were incorporated into the data synthesis and valuation to inform recommendations under the Connectivity Emphasis Sites section of the report (see Chapter 5). Throughout this chapter, the term "habitat suitability" is primarily used to describe the suitability of habitat for movement by a given species, unless stated otherwise.

MODELING METHODS

Our modeling methods involved three steps:

1. Evaluating the suitability of existing habitat models for potential incorporation in this study;
2. Identifying a suite of focal species and their habitat requirements; and
3. Developing habitat suitability layers and cost surface models for the identified focal species in the study area based on analysis of habitat variables.

Each of these steps is described in more detail below.

EVALUATION OF CURRENT MODELS

We evaluated current habitat models for potential incorporation in our habitat suitability modeling, including the Bay Area Critical Linkages project (Penrod et al. 2013) and a model of statewide mountain lion habitat selection (Dellinger et al. 2020b). Our modeling drew on similar methods from both of these previous efforts, but also differed in some key ways, as described below.

In 2013, the Bay Area Critical Linkages (BACL) project completed several spatial analyses to identify the best potential movement routes between areas for a set of focal species. The models were parameterized for each focal species based on expert opinion and the scientific literature (Penrod et al. 2013). The BACL modeling has made a valuable contribution to conservation actions throughout the region by providing an assessment of regional connectivity for focal species across multiple taxa.

We used methods similar to those of the BACL by analyzing habitat suitability for a suite of focal species and developing cost-surface models for focal species movement. However, our approach differed from the BACL in two key ways. First, we supplemented expert opinion and the scientific literature with species occurrence records from our study area to inform habitat suitability rankings for each focal species, which allowed us to create more refined local models with fine-scale rankings within different types of land use. We used species occurrence records from data collected for the current study, the Pajaro Wildlife Connectivity Study (Diamond and Snyder 2013), and the UCSC Puma Project.

Second, our model treated agricultural land, one of the main land uses in our study area, differently. Whereas BACL ranked agricultural lands as poor habitat for wildlife movement, several wildlife connectivity studies in Coyote Valley (Pathways for Wildlife 2016) and the Upper Pajaro Valley (Diamond and Snyder 2013) have found that agricultural lands provide suitable habitat for certain wildlife to both reside in and travel through. Bobcat, coyote, and deer, including with juveniles, have all been recorded traveling across agricultural fields in the Upper Pajaro Valley and along riparian areas within this agricultural landscape (Diamond and Snyder 2013). In Coyote Valley, badger, bobcat, coyote , and deer have been recorded traveling through cropland and agricultural fields (Pathways for Wildlife 2016). These studies show that animals will consistently use and move through riparian habitats and agricultural lands, and that the type of agricultural land use and other landscape characteristics influence wildlife movement (Diamond and Snyder 2013, Pathways for Wildlife 2016). We ranked habitat suitability for wildlife movement in agricultural lands based on documented species occurrence as well as on wildlife movement recorded in this and previous studies.

We also evaluated a recently published model of statewide mountain lion habitat selection (Dellinger et al. 2020b). This work is an important contribution towards a statewide conservation and management strategy for the species. However, we ultimately chose not to use this model because it focused on home-range level habitat selection by mountain lion (e.g., habitat suitable for various life history requirements) rather than generating cost surface models based on habitat suitable for movement and dispersal, as was the focus of our study. Our models instead focused on evaluating the suitability of the landscape for mountain lion movement, rather than for other life history requirements such as denning and hunting. Chris Wilmers at the UCSC Puma Project scored the habitat rankings for mountain lion in this study.

FOCAL SPECIES SELECTION

Similar to the approach used in the BACL (Penrod et al. 2013), we used a set of focal species to create the habitat suitability layers and cost surface models. The focal species approach recognizes that species move through and utilize habitat in a wide variety of ways (Beier and Loe 1992, Penrod et al. 2013). Species used in landscape permeability analysis must be carefully chosen; we included them in this analysis only if:

- Sufficient data were available about the movement of the species to reasonably estimate the cost-weighted distance using the data layers available for our analysis;
- Data layers in the analysis reflect the species' ability to move; and
- The focal species occurred in core habitat areas (or historically did so and could and could be restored) and could potentially move through the landscape between core habitat areas, at least over multiple generations. We defined core habitat areas as each species' preferred habitat, which includes resources such as food and water, breeding habitat, and dispersal habitat (Hilty et al. 2019).

Our goal was to include species that collectively use and travel through a large range of habitats in the study area so we could identify important core locations and habitats that connect these sites. We selected focal species to capture these ecological attributes (after Penrod et al. 2013):

- **Area-sensitive**: Species that need connectivity for dispersal, seasonal migration, and/or home range connectivity
- **Barrier-sensitive**: Species reluctant to traverse roads, canals, urban areas, or other barriers
- **Corridor dwellers**: Species with limited dispersal that may take days or generations to move between core habitat areas
- **Habitat specialists**: Species strongly associated with specific habitat types or topographical elements
- **Ecological indicator**: Species tied to important ecological process and whose presence indicates the health of the system

The focal species selected for this study were American badger, bobcat, mountain lion, and black-tailed deer, all of which were included as focal species in the BACL project (Figure 4.1). The habitat requirements and life history characteristics of these species are described in detail below. These species descriptions are pulled from the BACL report (Penrod et al. 2013).

Focal species	Area-sensitive	Barrier-sensitive	Corridor dweller	Habitat specialist	Ecological indicator
American badger	X	X	X	X	X
Black-tailed deer	X		X		X
Bobcat	X	X	X		
Mountain lion	X	X			X

Figure 4.1. The four focal species for this study and selection criteria.

American badger

American badger is a highly specialized species with naturally low population densities that requires open habitats with soils suitable for excavating large burrows (De Vos 1969, Banfield 1974, Zeiner et al. 1990, Sullivan 1996). Badgers require expansive wildlands to survive, with relatively large home ranges of up to 20 km^2 in California (Quinn 2008). They are highly sensitive to human disturbance and habitat fragmentation, and tend to reside in relatively undisturbed areas, with a low probability of occurrence in small, isolated habitat patches (Crooks 2002, Lay 2008).

The badger is a grassland specialist that tends to reside on gentle slopes. Badgers have been found to travel through chaparral habitat between core grasslands (Pathways for Wildlife and San Francisco Bay Bird Observatory in prep). Badgers tend not to travel through dense forests (Lindzey 1982, Quinn and Diamond 2008), although they will travel through forest occasionally (Pathways for Wildlife and San Francisco Bay Bird Observatory in prep; Neal Sharma, personal communication 2022). Badgers are also capable of dispersing 100 km or more (Quinn 2008), but because they must create burrows to reside in each night, they are considered corridor dwellers as they may spend several days transiting through corridors. Badgers can use agricultural landscapes and have been recorded using agricultural fields in Coyote Valley (Pathways for Wildlife and San Francisco Bay Bird Observatory in prep).

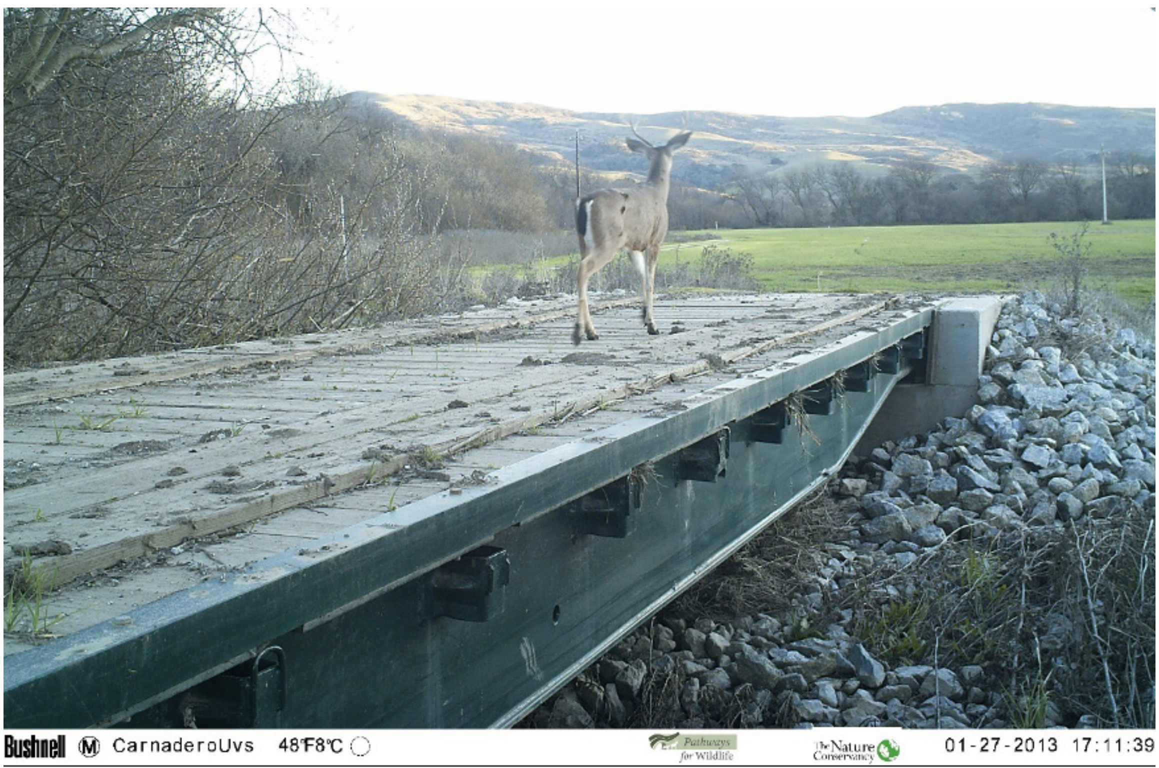
Road-killed badger on Santa Teresa Boulevard in Coyote Valley on September 6, 2008. Photo by Tanya Diamond, Pathways for Wildlife.

Vehicle collisions are the primary cause of badger mortality in the United States (Long 1973, Zeiner et al. 1990, Sullivan 1996, Penrod et al. 2013). Badgers are susceptible to collisions with motor vehicles as they are slow moving, have poor eyesight, are unable to climb over road median barriers, have large home ranges, and are capable of dispersing long distances.

Black-tailed deer

Black-tailed deer was chosen as a focal species in part to help support viable populations of mountain lions, which rely on deer as their primary prey. Areas that support connectivity for deer may be particularly important as mutually supportive for mountain lion. The deer is also an ecological indicator, as this large herbivore can have significant effects on vegetation composition and plays a role in ecosystem processes such as nutrient cycling (Molvar et al. 1993, Hanley 1996, Hobbs 1996, Kie et al. 2002).

Black-tailed deer is also a barrier-sensitive species whose movements are inhibited by impediments including highways (especially with solid median barriers), urban development, and high fences (e.g., around vineyards). Deer are particularly vulnerable to habitat fragmentation by roads; several hundred thousand deer are killed in vehicle collisions each year in the US (Forman et al. 2003, Huijser et al. 2007). Relatively high rates of deer-vehicle collisions and the species' large body size are particularly relevant for public safety. Deer have been found to move through agricultural fields (Diamond and Snyder 2013).



Deer traveling through the Carnadero Preserve. Photo by Pathways for Wildlife, captured as part of The Nature Conservancy's Pajaro Study (Diamond and Snyder 2013).

Bobcat

Bobcat is an area-dependent species that is sensitive to habitat fragmentation (Serieys et al. 2021). This species is more sensitive to disturbance than coyotes and other mesopredators (Crooks and Soulé 1999, Crooks 2002). Bobcat is less likely to be found in smaller and more isolated habitat patches (Crooks 2002). Roads are also a major source of bobcat mortality (Riley et al. 2003). Bobcats may utilize a wide range of habitats, including coastal scrub, chaparral, sagebrush, oak woodlands, and forests (Jameson and Peeters 1988). Within these habitats, they make use of cavities in rocky outcrops, logs, snags, and stumps, and use dense brush for cover and den sites. Bobcats preferentially move through natural habitats with cover and avoid intensely developed areas (Riley et al. 2003).

Bobcats have been found to travel through agricultural lands, though the type of agriculture and presence of natural habitat can influence use of these landscapes. Within the Upper Pajaro Valley, bobcats have been recorded traveling along riparian habitats within this predominantly agricultural landscape (Diamond and Snyder 2013). Narrow (<25m) riparian strips have been found to be critical to connectivity for bobcat within these fragmented agricultural landscapes and allow bobcats of all demographics to move through otherwise barren fields of row crops, likely because of the presence of water and vegetation cover (Serieys et al. 2021). Thus, linear, vegetated riparian corridors within agricultural landscapes like those found in the Upper Pajaro Valley likely provide important functional connectivity.

Bobcats have also been recorded traveling through open agricultural fields, pastures, and irrigated hayfields within the Upper Pajaro Valley (Diamond and Snyder 2013). In Coyote Valley, several collared bobcats extensively used orchards to travel through (Serieys et al. 2021), while previous research has documented bobcats traveling through vineyards (Hilty and Merenlender 2004).

Bobcat traveling through The Nature Conservancy's Pajaro Ranch. Photo by Pathways for Wildlife, captured as part of The Nature Conservancy's Pajaro Study (Diamond and Snyder 2013).

Mountain lion

With large home ranges and naturally low population densities, mountain lion is an area-sensitive species that is highly sensitive to habitat fragmentation (Dellinger et al. 2020a). As a result, mountain lion can help indicate broad-scale landscape connectivity (Riley et al. 2006).

Mountain lion near culvert under US 101 in the Aromas Hills section on October 2, 2018.

A number of dispersal corridors for mountain lions have already been lost in California, making the species susceptible to extirpation from existing protected areas (Beier 1993, Dellinger et al. 2020a). Habitat fragmentation caused by urbanization and an extensive road network has restricted movement, escalated mortality, and increased contact with humans, all with detrimental effects on the species (Penrod et al. 2013).

Mountain lions use brushy stages of a variety of habitat types with good cover (Dellinger et al. 2020b, Suraci et al. 2020). This species is known to utilize habitats at the urban-wildland interface and in parklands used extensively for human recreation (Riley et al. 2006). Their preferred travel routes are along stream courses and gentle terrain, but they use all habitats with cover (Beier and Barrett 1993, Dickson et al. 2005). They generally avoid grasslands, agricultural areas, and human-altered landscapes (Dickson et al. 2005), although mountain lions can and will use these habitats (Riley et al. 2006, C. Wilmers, personal communication). Dirt roads do not impede movement, but highways, residential roads, and two-lane paved roads can (Dellinger et al. 2020b, Hilty et al. 2019, Wilmers et al. 2013).

Studies also show that mountain lions are sensitive to human disturbance, including both human development and human activity, and may adjust their behavior in response. A recent study found that mountain lions avoided human voices and moved more cautiously when hearing humans, suggesting that passive recreation as well as human development may impact mountain lion behavior (Suraci et al. 2019). One study suggested that reproductive behaviors (communications and denning) require a buffer from human development at least four times larger than non-reproductive behaviors (movement and feeding), and mountain lions give a wide berth to types of human development that provide a consistent source of human interference, such as neighborhoods (Wilmers et al. 2013).

HABITAT SUITABILITY LAYERS AND COST SURFACE MODELS

We used species occurrence data and a set of habitat variables to develop habitat suitability layers for each focal species, with a particular focus on habitat suitable for movement. These layers were then combined to generate cost surface models for each focal species, with each model demonstrating the relative "cost" associated with a species' movement across the landscape (Figure 4.2).

Habitat variable GIS inputs

1. Vegetation type layer
2. Land cover layer
3. Hydrology layer
4. Roads layer

Rasterize

Convert each layer into a raster layer (grid)

Create habitat suitability layers

For each focal species, reclassify each layer from a range of highly suitable habitat to unsuitable habitat, using species occurrence data, literature, and expert opinion.

Create cost surface layer

Use the Weighted Overlay GIS tools to create the cost surface layer, which reflects the cost of movement for each focal species across the landscape.

Figure 4.2. Process of creating habitat suitability and cost surface models in GIS.

Our habitat variables included vegetation type, land cover, hydrology, and roads (Figure 4.3). Each habitat variable layer included a set of attributes that were reclassified using ArcMap 10.2 on a discrete scale from 1-4 to reflect the suitability of the given habitat feature for focal species presence and movement. This resulted in a set of habitat suitability layers for each habitat variable that reflect a range of habitat features from highly suitable (low cost for movement) to poor habitat (high movement costs). For example, the vegetation type habitat variable layer included habitat attributes such as pasture and mixed forest that were assigned scores based on the suitability of that habitat feature for movement by the given focal species. Figures 4.3, 4.4, 4.5, and 4.6 include the assigned values for each attribute in each habitat variable layer for the focal species. Chris Wilmers at the UCSC Puma Project scored the habitat rankings for mountain lion and also reviewed the bobcat rankings.

Habitat variable	Example attributes	GIS layer	Source	Format	Raster cell/ min. map unit size	Data source
Vegetation type	Annual grassland Cropland Freshwater emergent wetland Mixed chaparral	FVEG 2014	CalFire	Raster	30m	https://frap.fire.ca.gov/mapping/gis-data/
Land cover	Cultivated crops Developed, high intensity Hay/pasture	National Land Cover Data 2014	Multi-Resolution Land Characteristics (MRLC) Consortium	Raster	30m	https://www.usgs.gov/centers/eros/science/national-land-cover-database?qt-science_center_objects=0#qt-science_center_objects
Hydrology	Creek River	National Hydrography Dataset	US Geological Survey	Polyline	10m	https://www.usgs.gov/core-science-systems/ngp/national-hydrography/national-hydrography-dataset?qt-science_support_page_related_con=0#qt-science_support_page_related_con
Roads	Highway, freeway, expressway Two-lane roads: primary One-lane road: secondary Dirt roads	Tiger/Line shapefiles	US Census Bureau	Polyline	10m	https://www.census.gov/cgi-bin/geo/shapefiles/index.php

Figure 4.3. Habitat variables, example attributes associated with the habitat variable, the GIS layer used for each habitat variable, source, and additional information used in mapping and analyses.

We analyzed the suitability of the landscape for movement by each focal species by developing a cost surface layer (also referred to as a cost surface model). Such cost surface analyses can be developed in ArcGIS to find an optimal route between two points through continuous space that minimizes costs, with cost path algorithms designed to efficiently find the path with the minimum total cost (Figure 4.8). A cost surface layer is a raster grid made up of individual cells. The value in each cell represents the "cost" or effort required for an animal of a given species to travel through a landscape. The cost for a given cell is determined by the cell's characteristics, such as vegetation type or housing density. For example, a cell that has high-use roads and high-density housing will have a higher cost for movement than a cell that contains highly suitable vegetation types for movement and no roads, which would have a lower cost for movement. Any path through the landscape will accumulate costs. Routes with low associated costs (effort) are more favorable than routes with higher costs.

Vegetation type	Badger	Bobcat	Deer	Mountain lion
Annual grassland	1	1	1	3
Barren	2	3	4	4
Blue oak woodland	2	1	1	1
Blue oak-foothill pine	3	1	1	1
Chamise-redshank chaparral	2	1	1	1
Closed-cone pine-cypress	3	1	1	1
Coastal oak woodland	2	1	1	1
Coastal scrub	1	1	1	1
Cropland	2	3	3	4
Deciduous orchard	2	2	2	3
Douglas fir	3	1	1	1
Dryland grain crops	3	3	3	4
Estuarine	4	2	3	3
Eucalyptus	3	3	3	3
Freshwater emergent wetland	3	3	3	2
Irrigated hayfield	2	2	2	4
Irrigated row and field crops	2	3	2	4
Lacustrine	3	3	2	4
Marsh	4	2	3	3
Mixed chaparral	2	1	1	1
Montane hardwood	3	1	1	1
Montane hardwood-conifer	3	1	1	1
Montane riparian	3	1	1	1
Pasture	2*	2*	2*	3
Perennial grassland	1	1	1	3
Ponderosa pine	3	1	1	1
Redwood	3	1	1	1
Rice	3	3	3	4
Riverine	3	1	1	1
Saline emergent wetland	3	3	3	3
Urban	4	4	3	4
Valley foothill riparian	3	1	1	1
Valley oak woodland	2	1	1	1
Vineyard	3	2	2	3
Water	4	4	4	4
Wet meadow	2	1	1	3

* The rankings for pasture for these species were increased by 1 (indicating higher movement cost) to reflect ground-truthing of the vegetation types layer, which misclassified some areas of row crops as pasture. Thus, the pasture ranking has been adjusted as if it were row crops. Actual areas of pasture provide highly suitable movement habitat for these focal species and would be scored as a 1 if the vegetation types layer more accurately reflected on-the-ground conditions.

Figure 4.4. Habitat variables associated with the vegetation type layer and their associated ranking for each focal species. The rankings are as follows: 1 - Highly suitable for movement, 2 -Fairly suitable for movement, 3 - Poor habitat for movement, and 4 - Unsuitable habitat for movement.

Land cover type	Badger	Bobcat	Deer	Mountain lion
Barren land (gravel pits)	3	4	4	4
Cultivated crops	2	2	2	4
Deciduous forest	3	1	1	1
Developed, high intensity	4	4	4	4
Developed, low intensity	3	3	3	3
Developed, medium intensity	3	4	3	4
Developed, open space	3	3	3	3
Emergent herbaceous wetland	3	1	3	3
Evergreen forest	3	1	1	1
Hay/pasture	2*	2*	2*	3
Herbaceous	1	1	1	3
Mixed forest	3	1	1	1
Open water	4	3	4	4
Perennial snow/ice	4	3	3	2
Shrub/scrub	1	1	1	2
Woody wetlands	3	1	1	1

* The rankings for pasture for these species was increased by 1 (indicating higher movement cost) to reflect ground-truthing of the vegetation types layer, which misclassified some areas of row crops as pasture. Thus, the pasture ranking has been adjusted as if it were row crops. Actual areas of pasture provide highly suitable movement habitat for these focal species and would be scored as a 1 if the vegetation types layer more accurately reflected on-the-ground conditions.

Figure 4.5. Habitat variables associated with the land cover layer and their associated ranking for each focal species. The rankings are as follows: 1 - Highly suitable for movement, 2 -Fairly suitable for movement, 3 - Poor habitat for movement, and 4 - Unsuitable habitat for movement.

We created cost surface layers for each focal species by combining the four habitat suitability layers (vegetation type, land cover, hydrology, and roads) into one raster using the Cost Surface tool in ArcGIS. Each habitat suitability layer was weighted equally in the resulting cost surface layer, which produced a model output showing the suitability of the landscape for movement by a given focal species. The vegetation type and land cover habitat suitability layers are rasters that covered the entire study area, and thus each cell contained a value for these two layers based on suitability for movement. Vegetation types included habitat features such as pasture, cultivated crops, valley foothill riparian, and redwood. Land cover types included habitat features such as degree of human development (low, medium, or high intensity) and general habitat types, such as mixed forest and herbaceous.

The hydrology and roads habitat suitability layers are unbuffered polyline features, and thus a cell would have a value associated with these layers only if that cell intersected with the polyline feature. The hydrology habitat suitability layer included attributes such as creeks and streams, referring specifically to areas where water is present for some or all of the year, while the vegetation types layer included habitats that border creeks and streams, such as valley foothill riparian. A cell intersected by a road would be assigned a value for a given focal species, while cells without a road would not be assigned any value. Roads were classified by road type (e.g. highways or dirt roads) and were included because they can act as barriers to wildlife movement (Messick and Hornocker 1981) and are one of the leading causes of wildlife mortality (Hoodicoff 2003, Ruediger and DiGiorgio 2007).

Hydrology	Badger	Bobcat	Deer	Mountain lion
Creek	2	1	1	1
River	2	1	1	1

Figure 4.6. Habitat variables within the hydrology layer and their associated ranking for each focal species. The rankings are as follows: 1 - Highly suitable for movement, 2 -Fairly suitable for movement, 3 - Poor habitat for movement, and 4 - Unsuitable habitat for movement.

Road type	Badger	Bobcat	Deer	Mountain lion
Highway, freeway, expressway	4	4	4	4
Two-lane roads: primary	3	3	3	3
One-lane road: secondary	2	2	2	2
Dirt roads	1	1	1	1

Figure 4.7. Road types within the road layer and their associated ranking for each focal species. The rankings are as follows: 1 - Highly suitable for movement, 2 -Fairly suitable for movement, 3 - Poor habitat for movement, and 4 - Unsuitable habitat for movement.

In developing the cost surface models for each focal species, we clipped the habitat suitability layers to the extent of the study area. We then converted all habitat suitability layers to raster layers to enable reclassification from the original raster value to a movement cost value. We joined hydrology layers for the separate counties and converted them to raster layers.

This resulted in cost surface models for each focal species which reflected a range of habitats from highly suitable (low cost for movement) to poor habitat (high movement costs). The process for creating the models is outlined in Figures 4.2 and 4.8.

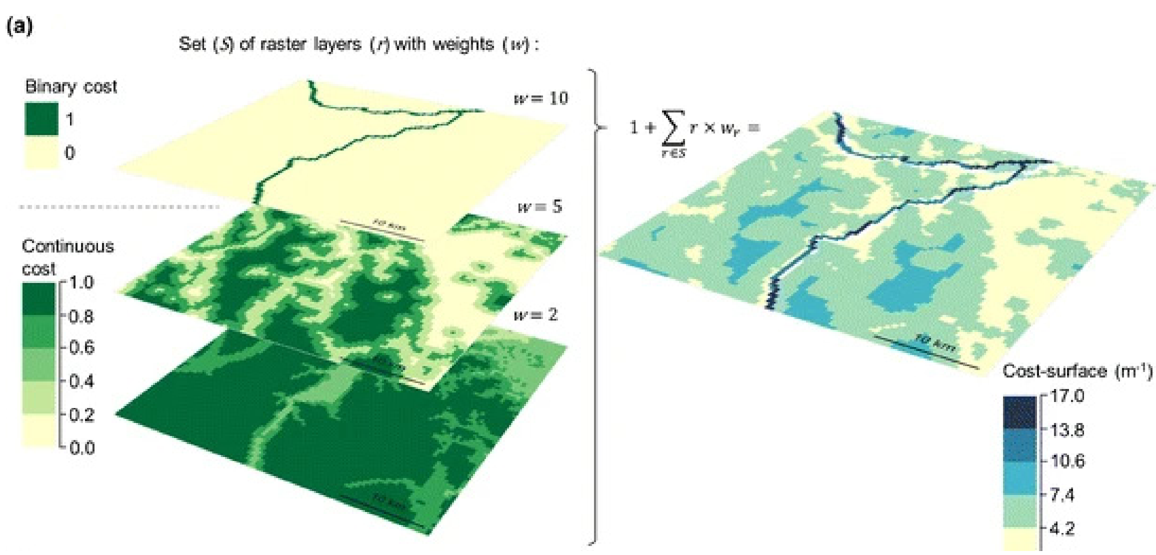


Figure 4.8. Cost surface mapping (from Etherington 2016). Development of a cost surface layer. Each habitat suitability raster layer was used to create a cost surface layer — each cell represents, for a given species, the effort required for an individual to move through the landscape.

AGRICULTURAL LAND USE ATTRIBUTES IN THE UPPER PAJARO VALLEY

The vegetation type GIS layer provides more fine-scale detail of agricultural land use attributes than the land cover layer. For example, the vegetation type layer includes agricultural land use attributes such as deciduous orchard, dryland grain crops, and pasture, while agricultural land use attributes within the land cover layer are limited to cultivated crops and hay/pasture. Thus, the vegetation type layer allowed for more fine-scale rankings of different agricultural land use attributes for each focal species when compared to the land cover layer.

However, there are some limitations and inconsistencies in how the vegetation type layer and the land cover layer classify areas of pasture within the study area. The vegetation type layer appears to classify more of the Upper Pajaro Valley as pasture when compared to the land cover layer. Additionally, a comparison of these layers to aerial imagery in the Upper Pajaro suggests that the vegetation type layer may have misclassified some areas of row crops as pasture. Thus, the vegetation type layer (and possibly the land cover layer) may together overestimate the amount of pasture within this region. This has implications for the habitat suitability analyses and cost surface modeling, as previous studies indicate that pasture is suitable for movement and has lower movement costs for bobcat, badger, and deer when compared to row crop agriculture.

To address potential inconsistencies with pasture and row crop classification in the Upper Pajaro across the vegetation type and land cover layers, we adjusted the pasture ranking for each focal species so that it more closely resembled the scores for row crops (Figures 4.4 and 4.5). This resulted in a higher movement cost for pasture for each focal species relative to our expert opinion of what the actual movement cost for pasture would be on the ground. This adjustment to the pasture scoring was made to reflect potential inconsistencies with on the ground conditions, namely that some areas classified as pasture are likely row crops. Nevertheless, it is important to note that pasture can be suitable movement habitat for badger, bobcat, and deer. Our adjustment to the pasture score should not be interpreted as a literal score of the movement value for that habitat type, but rather an adjustment made to reflect inconsistencies in the layers used in modeling. Earlier versions of these models with different pasture rankings are available upon request.

We recommend fine-scale vegetation mapping of the Upper Pajaro Valley to better determine the distribution of row crop and pasture across the landscape, which would allow for more fine-scale adjustment of movement scores for species between row crops and pasture agriculture. Below, we discuss the cost-surface models generated for each focal species.

RESULTS AND DISCUSSION

AMERICAN BADGER

Figure 4.9 shows the cost surface model for badger. Both the Pajaro Valley and Aromas subareas are relatively fragmented in terms of habitats suitable for badgers movement.

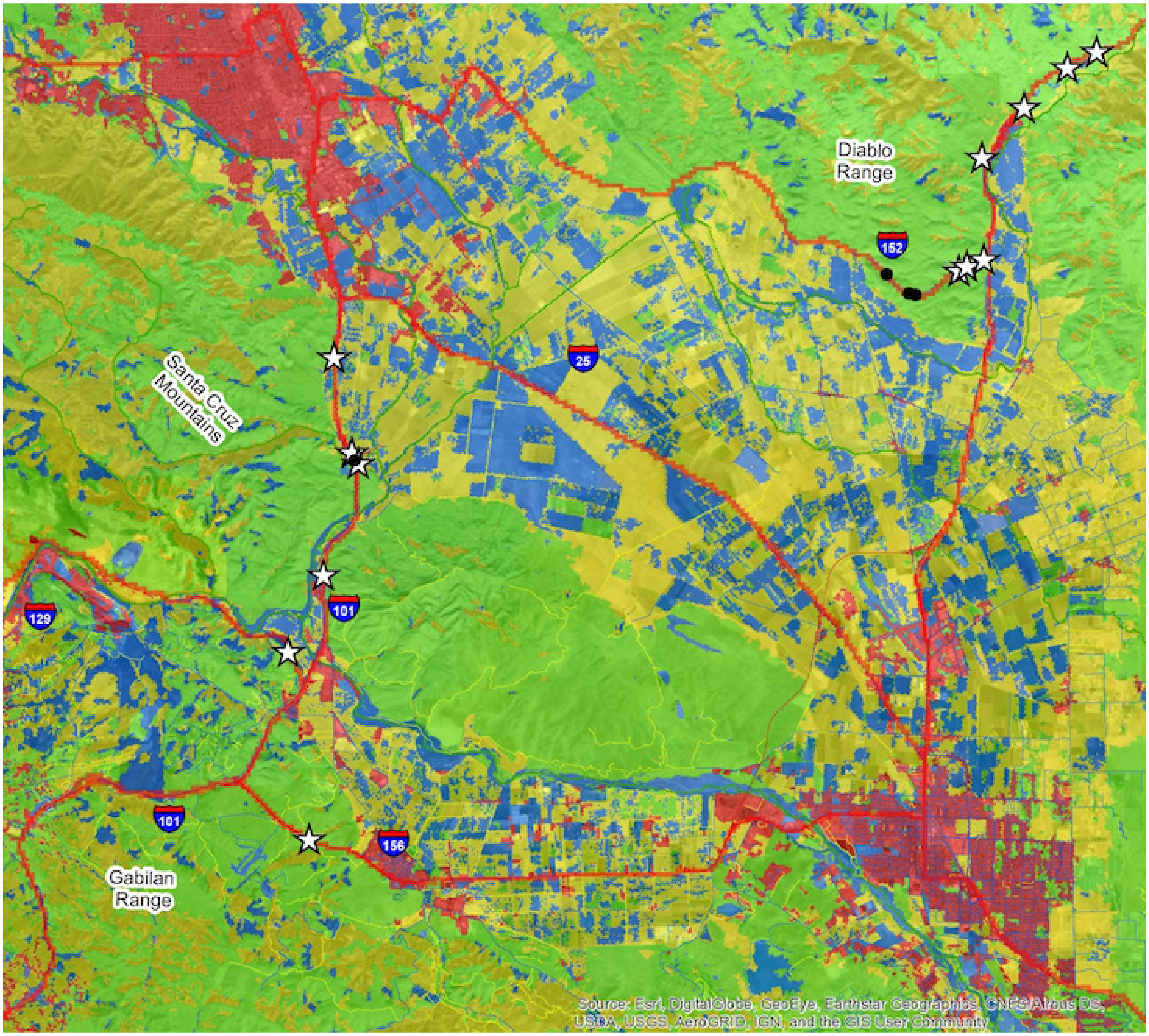


Figure 4.9. American badger cost surface model with wildlife–vehicle collision records and detections at monitoring sites. Habitat highly suitable for movement (green) is separated by fairly suitable habitat with moderate movement costs (yellow), poor habitat with high movement cost (blue), and unsuitable habitat for movement with very high movement cost (red). Recorded badger passages are shown in black circles. White stars indicate records of badger roadkill. Badger roadkill records east of the SR 152/SR 156 interchange were collected as part of the SR 152 Pacheco Pass and Coyote Valley Regional Wildlife Connectivity Study currently being conducted by Pathways for Wildlife and the Santa Clara Valley Habitat Agency.

Modeling suggests that the Pajaro Valley subarea has fair to poor habitat for badger movement within the valley itself, though the valley margins are bordered by grasslands featuring habitat highly suitable for movement. All recorded passages of badger and the majority of badger WVCs occurred in the Pajaro Valley subarea. The highest records of badger passages through the camera monitoring sites occurred along SR 152. There is highly suitable badger habitat on either side of the highway where the culverts are. Multiple badger burrows were found by the culvert where the badger and coyote traveled through the culvert together (SR 152 Site 4 Coyote and Badger culvert). Three badgers were also recorded hit on SR 152 within our study area, with other badger WVCs recorded just east of the SR 152/156 interchange from another study (Figure 4.9). In the US 101 Pajaro Valley section, four badgers were recorded hit and one badger was recorded using the US 101 Site 4 Tar Creek overpass. This undercrossing is surrounded by grassland and oak woodland habitat on the west side and agricultural fields on the east side, providing fair to good habitat for badger movement.

Although the Pajaro Valley largely consists of agricultural fields, badgers will use this type of landscape for denning, travel, and hunting (Pathways for Wildlife and San Francisco Bay Bird Observatory, in prep). Badgers have been widely recorded using agricultural fields in Coyote Valley. Therefore, the Pajaro Valley could be facilitating badger movement as it consists of fairly suitable habitat for badger movement and badgers have been hit along the highway. More research is needed to further investigate the suitability of agricultural lands for badger movement.

Despite the presence of oak woodland and some grassland habitat bordering parts of the SR 129 and the US 101 Aromas Hills sections, we recorded no badger passages along these two highway sections. Grassland and oak woodland are suitable habitat for badger movement. Similarly, the SR 156 section is bordered primarily by grassland and is highly suitable for badger movement, but we did not record any badger passages in this section.

BLACK-TAILED DEER

Figure 4.10 shows the cost surface model for black-tailed deer. There is highly suitable habitat for deer movement in the Aromas subarea and along riparian corridors in the Pajaro Valley subarea, with poor to fair habitat for deer movement on the Pajaro Valley floor.

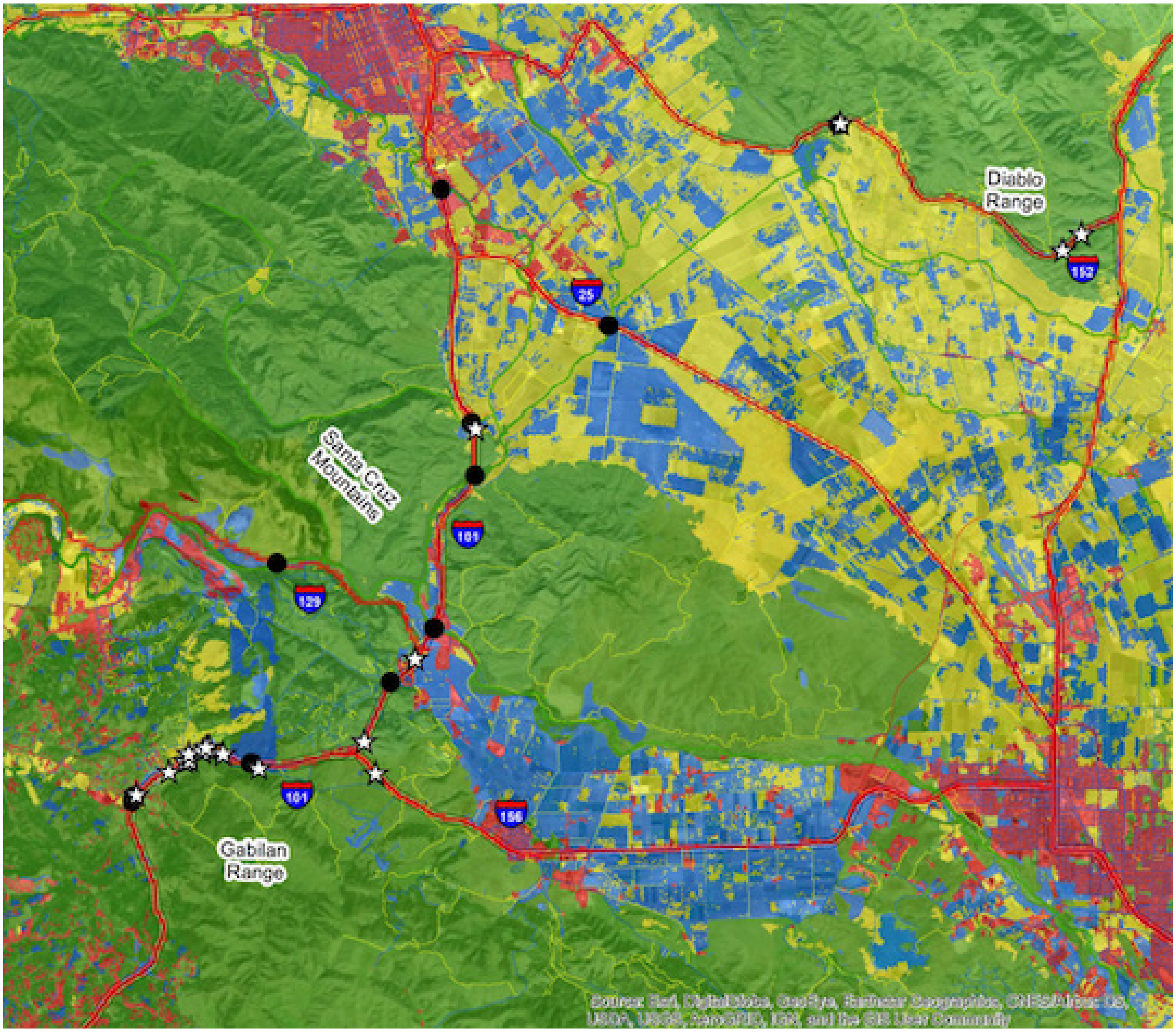


Figure 4.10. Deer cost surface model with wildlife–vehicle collision records and detections at monitoring sites. Habitat highly suitable for movement (green) is separated by fairly suitable habitat with moderate movement costs (yellow), poor habitat with high movement cost (blue), and unsuitable habitat for movement with very high movement cost (red). Recorded deer passages are shown in black circles. White stars indicate records of deer roadkill.

We recorded deer crossing under a bridge or through a culvert at only 11 of the 42 camera monitoring sites. From that total, three sites had only one deer passage, resulting in only eight sites with records of more than one deer passage. Most of the culverts may have been too small for deer passage. For example, a juvenile male deer investigated and entered, but did not pass through, SR 129 Site 3, which is a relatively small box culvert (3′ by 3′). These data indicate that both the Pajaro Valley and Aromas subareas are relatively constrained for deer movement because of the lack of adequate crossings and variation in the availability of habitat suitable for deer movement. This may be resulting in bottlenecks within these two linkages.

Wildlife crossing infrastructure within the Pajaro Valley subarea facilitated higher rates of deer passage than the Aromas subarea. We recorded high rates of deer passage in the US 101 Pajaro Valley section at three sites: US 101 Site 5 Pajaro River Bridge, US 101 Site 6 San Benito River Bridge, and US 101 Site 4 Tar Creek overpass. These are all large structures with highly suitable habitat on the west side of US 101 and fair to poor habitat comprised of predominantly agricultural fields on the east side of US 101. There were also high rates of deer passage at SR 152 Site 2 San Felipe Lake box culvert, which features highly suitable habitat on the north side of SR 152 and fair habitat on the south side of SR 152.

Though the Aromas subarea features habitat highly suitable for deer movement, the subarea is constrained for deer movement due to the lack of crossing structures large enough to accommodate deer passage. There is a deer roadkill cluster at US 101 at the Habitat Island, indicating that deer are attempting to cross at-grade at this location (Figure 4.10). Installation of a wildlife crossing structure along this stretch of US 101 to facilitate movement for large mammals such as deer and mountain lions would be highly beneficial for increasing the safety of the highway for both wildlife and motorists.

BOBCAT

Figure 4.11 shows the cost surface model for bobcat. The Aromas subarea features highly suitable habitat for bobcat movement, especially within the Santa Cruz mountains and Gabilan Range. However, the Eucalyptus Grove features poor habitat and may poses a barrier to bobcat movement between the two mountain ranges. Although there is highly suitable habitat for bobcats on either side of US 101 in the Aromas Hills area, there were considerably fewer passages than in US 101 Pajaro Valley. This could be because of the lack of adequate crossing structures along this stretch of the highway.

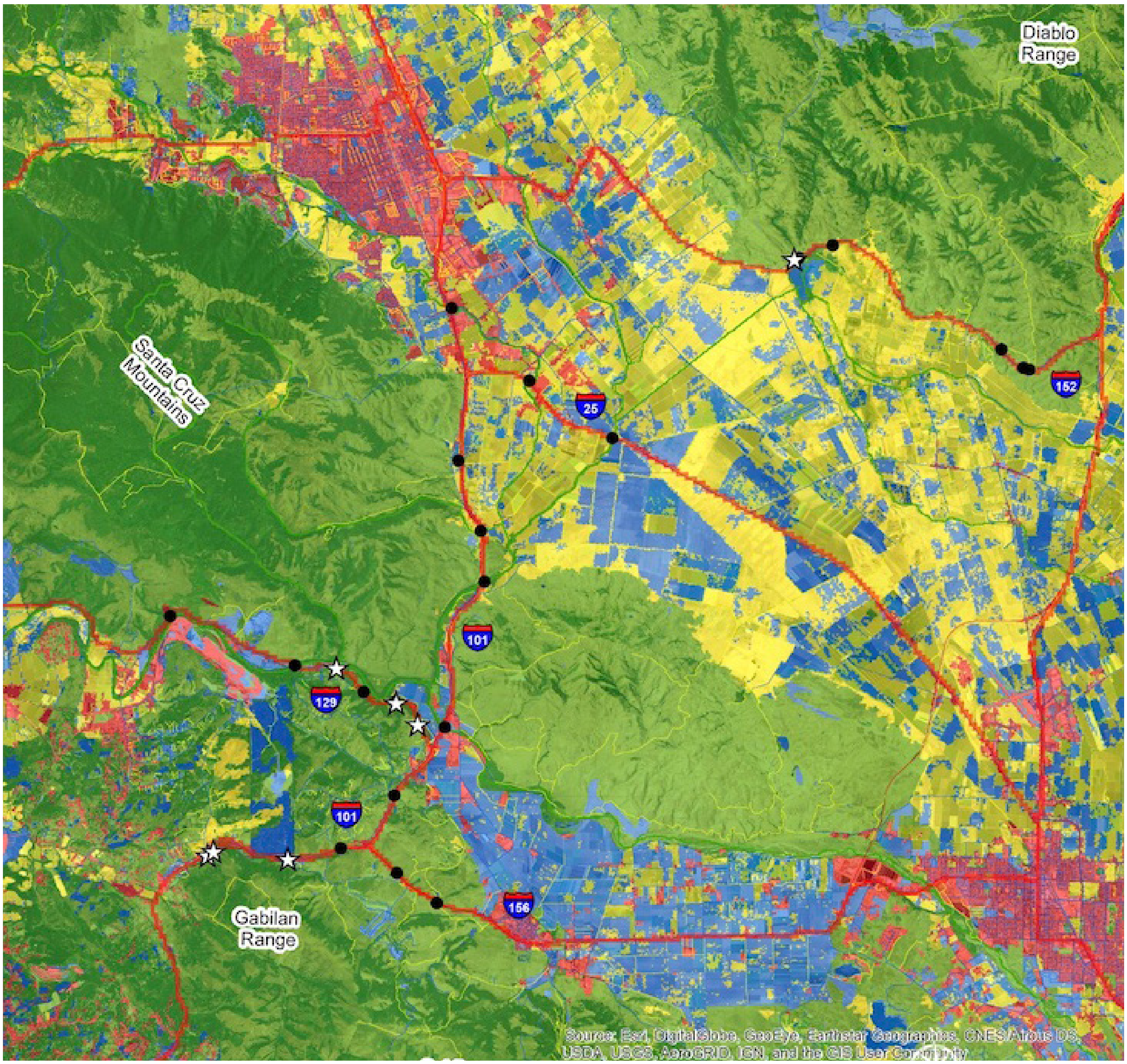


Figure 4.11. Bobcat cost surface model with wildlife–vehicle collision records and detections at monitoring sites. Habitat highly suitable for movement (green) is separated by fairly suitable habitat with moderate movement costs (yellow), poor habitat with high movement cost (blue), and unsuitable habitat for movement with very high movement cost (red). Recorded bobcat passages are shown in black circles. White stars indicate records of bobcat roadkill.

The Pajaro Valley subarea features habitat highly suitable for bobcat in the uplands on the west side of US 101 and the northeast side of SR 152. The Pajaro Valley floor features poor to fair habitat for movement within different agricultural fields. However, it is important to note that riparian corridors feature habitat highly suitable for bobcat movement. Additionally, pasture is highly suitable for bobcat movement within this agricultural landscape.

Four of the culverts along SR 152 had high bobcat passages, with highly suitable habitat on the north side and fairly suitable habitat on the south side. Undercrossings along US 101 Pajaro Valley section and SR 25 also recorded bobcat passages, including in agricultural areas and along riparian corridors. During the TNC Pajaro study, we recorded multiple female bobcats with juveniles throughout the Pajaro Valley floor, indicating this is a potential linkage area that may be facilitating breeding and genetic flow for bobcat (Diamond and Snyder 2013).

MOUNTAIN LION

Figure 4.12 shows the cost surface model for mountain lion. Mountain lion habitat in the study area is heavily fragmented and poorly suited for mountain lion movement. This makes it challenging for mountain lion to move across these landscapes and contributes to ongoing genetic isolation of the Santa Cruz Mountains' mountain lion population (Gustafson et al. 2019). The Aromas subarea, especially in the US 101 Aromas Hills section, appears to offer more opportunities for mountain lion connectivity than the Upper Pajaro Valley.

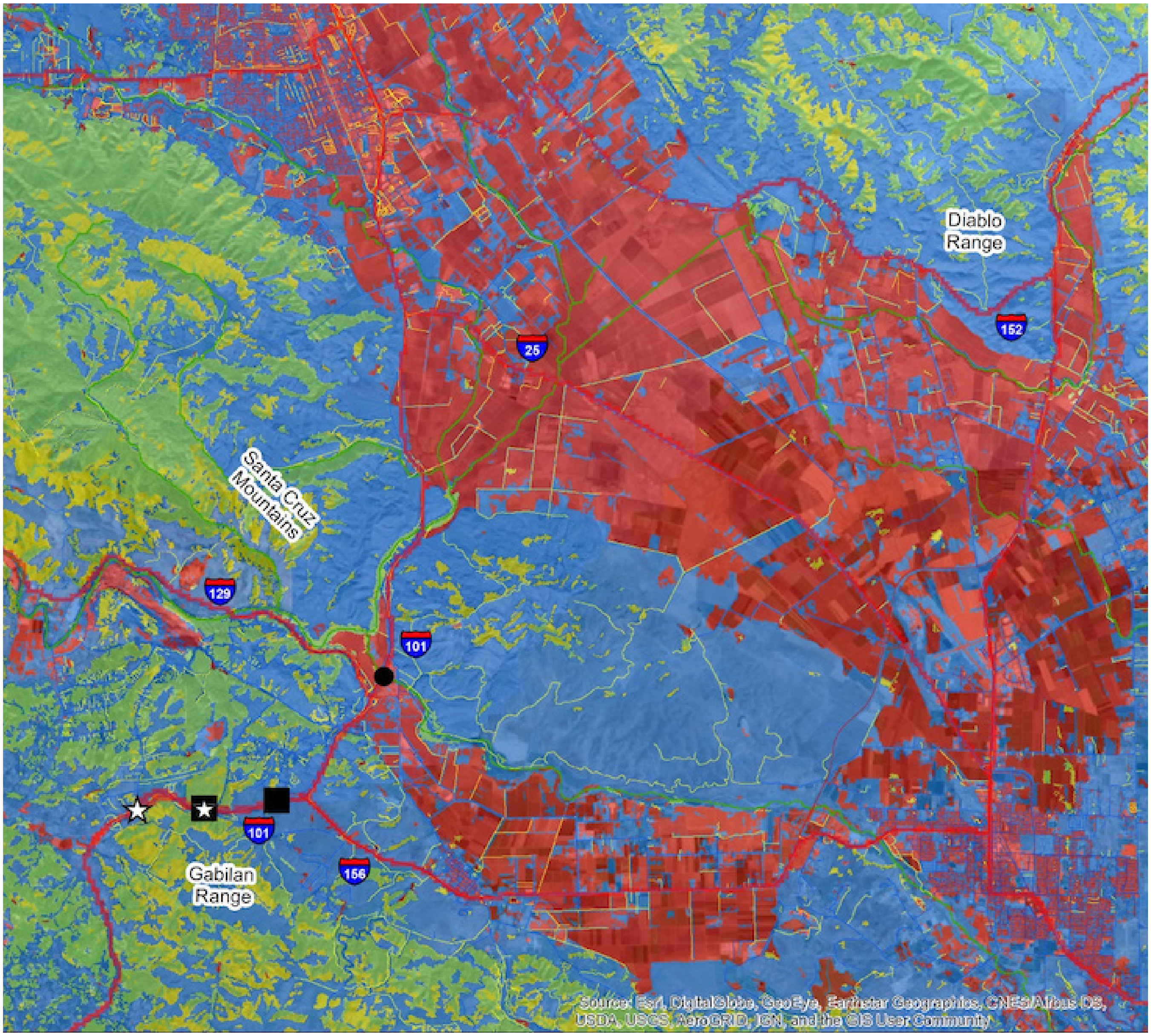


Figure 4.12. Mountain lion cost surface model with wildlife-vehicle collision records and detections at monitoring sites. Habitat highly suitable for movement (green) is separated by fairly suitable habitat with moderate movement costs (yellow), poor habitat with high movement cost (blue), and unsuitable habitat for movement with very high movement cost (red). Recorded mountain lion passages (tracks) are shown in black circles. Recorded detections of mountain lion at culverts without passage are shown in black squares. White stars indicate records of mountain lion roadkill.

As discussed in Chapter 2, we did not record any mountain lion passages on camera at our monitoring sites. However, we did record mountain lion tracks at US 101 Site 6 San Benito River Bridge, suggesting successful mountain lion passage at this site. We also recorded on camera a young mountain lion traveling by two of the culverts along US 101 in the Aromas subarea, though this individual did not pass through the culverts. Notably, all the recorded mountain lion road-related mortality was along the US 101 Aromas Hills section. These data indicate the importance and critical need for new wildlife crossing structure(s) to allow mountain lions to travel between the southern Santa Cruz Mountains and the Gabilan Range.

5 SYNTHESIS, EVALUATION, AND PRIORITIZATION OF SITES FOR IMPROVED CONNECTIVITY

INTRODUCTION

This chapter describes how we combined the data collected in this study to identify and prioritize Connectivity Emphasis Sites (CESs) — locations that appear to be important for one or more focal species and for cross-highway connectivity. Focusing management and enhancement actions at these CESs should reduce wildlife mortalities, improve motorist safety, and improve habitat connectivity and animal movement through transitional habitat between core habitat areas.

We synthesized data from this study and other sources and conducted field assessments to identify CESs. To prioritize the CESs according to their importance, we applied a valuation matrix to score and rank the sites based on regional connectivity significance, local connectivity significance, and land-use security. We determined specific connectivity enhancement measures for each of these locations to improve connectivity for one or more focal species and to reduce wildlife–vehicle collisions. We then categorized the sites into three intervention categories based on our assessment of existing site functionality for wildlife passage and the urgency of needed interventions to improve site functionality. Within each intervention category, the sites are prioritized by their mean score as determined by the valuation matrix.

Site selection and scoring were directly informed by the data synthesis and were complemented by detailed movement data, researcher opinion, other reports, and opportunities and constraints with respect to adjacent land ownership and use. These data are necessary to inform highway planning and interventions. Each of these steps is described in more detail below.

IDENTIFICATION OF CONNECTIVITY EMPHASIS SITES

We used the data from this study and other sources to identify locations that appear important for connectivity for one or more focal species and could benefit from intervention to ameliorate direct impacts of highways and associated traffic on wildlife movement. Data sources included camera trap monitoring of existing undercrossings, roadkill surveys, habitat suitability models, and anecdotal information (e.g., tracking surveys, den surveys) about wildlife use and habitat/land use characteristics. The synthesized data encompassed a range of species and habitat conditions along the highway corridors in this fragmented and highly developed landscape. The identified sites represent generally delineated locations with one or more focal species occurrences/suitability with the greatest potential for maintaining and restoring wildlife connectivity across study area highways.

Stakeholders and subject matter experts visited these locations for site visits on October 25–26, 2021 (see box, Site visit participants). The visits were used to assess site conditions, discuss potential conceptual recommendations, and to share knowledge about factors that could further inform recommendations and site prioritization. This included factors such as habitat conditions, protected lands, potential land use changes, wildlife activity/occurrence (including roadkill), and highway/road infrastructure.

Out of the 42 sites monitored in this study, we identified 19 Connectivity Emphasis Sites as those with the most opportunities for reducing wildlife–vehicle collisions (WVC) and improving connectivity for all wildlife, including species such as mountain lion that are sensitive to habitat fragmentation (Figure 5.2). These sites are generally defined by the locations of existing wildlife crossing infrastructure, though some CESs refer to particular highway segments where additional crossing infrastructure is needed. The CESs include sites that generally support connectivity and should be maintained, sites that are somewhat functional and should be improved, and sites where new infrastructure is needed to support connectivity. Together, these CESs collectively support large landscape connectivity, local-scale movements, motorist safety, and/or specialist species with localized habitat connectivity requirements under current conditions.

SITE VISIT PARTICIPANTS

October 25, 2021
Year 1 — Aromas Hills subarea (Santa Cruz Mountains-Gabilan Range)

Noelle Chambers (POST)
Tony Clevenger
Tanya Diamond (Pathways for Wildlife)
Julie King (Santa Clara Valley Habitat Agency)
Bryan Largay (Land Trust of Santa Cruz County)
Jodi McGraw (Jodi McGraw Consulting)
Dan Medeiros (Land Trust of Santa Cruz County)
Morgan Robertson (Caltrans)
Lauren Ross (Caltrans)
Ahíga Sandoval (Pathways for Wildlife)
Neal Sharma (POST)
Nancy Siepel (Caltrans – retired)
Marian Vernon (POST)

October 26, 2021
Year 2 — Pajaro Valley subarea (Santa Cruz Mountains-Diablo Range)

Noelle Chambers (POST)
Tony Clevenger
Tanya Diamond (Pathways for Wildlife)
Julie King (Santa Clara Valley Habitat Agency)
Lauren Ross (Caltrans)
Ahíga Sandoval (Pathways for Wildlife)
Neal Sharma (POST)
Nancy Siepel (Caltrans – retired)
Edmund Sullivan (Santa Clara Valley Habitat Agency)
Marian Vernon (POST)

VALUATION MATRIX AND SITE SCORING

After identifying the 19 CESs, we developed and applied a valuation matrix to score the conservation value and potential of each CES based on current conditions, and then prioritized the sites according to their importance.

The valuation matrix included three criteria derived from those used in past assessments with similar ecological and transportation objectives (Clevenger 2012, Lee et al. 2012, Clevenger et al. 2017), and based on wildlife conservation and motorist safety issues in the study area.

The valuation matrix criteria were:

1. **Regional connectivity significance** is the importance of the site in maintaining connectivity at a regional scale, especially for the focal species included in this study. This relates especially to special-status mammals that have a low population density and are sensitive to fragmentation effects of roads, such as mountain lion. It also relates to the importance of linkages/corridors based on habitat characteristics within the broader mosaic, including connectivity suitability for non-special status species. Success for some species with low population sizes may be measured by very low rates of safe highway crossings. Field data, spatial modeling, and habitat/land use characteristics were considered in scoring this criterion.
2. **Local connectivity value** is the value of highway interventions for local wildlife conservation regardless of regional significance. This captures the importance of maintaining connectivity for the seasonal movement of mammals, or other related fine-scale opportunities for wildlife, such as daily movements within an animal's home range. Field data, spatial modeling, and habitat/land use characteristics were considered in scoring this criterion.
3. **Land-use security** is the degree to which lands adjacent to the site are protected from development or protected from land uses not conducive to wildlife movement either legally (e.g., conservation easements, other land protection efforts, and/or local regulations limiting development) or de facto (such as site conditions like steep slopes that aren't conducive to development). Investing in highway infrastructure that provides safe passage for wildlife is often an expensive undertaking. Land-use security around the structure and is important for the long-term success of such an investment (Clevenger and Huijser 2011). Scores for land-use security were developed based on land ownership, existing conservation ownership/easements, and land development attributes on both sides of the highway at each CES (Figure 5.1).

We assigned each site a subjective score of importance for each of these three scoring criteria, ranging from 1 (low) to 5 (high), as shown in Figure 5.1.

Score	Regional connectivity significance	Local connectivity value	Land-use security
1 (low)	Low focal species use/suitability, particularly mountain lion	Very little use by native wildlife	No protected land on either side of the highway; development and/or relatively intensive human activity on both sides of the highway
2	Some value as habitat patch/corridor within landscape context; does not appear important for mountain lion	Important for daily movements, low species richness	Some protection through zoning/ordinance
3	Use by mesocarnivores; potentially important for dispersal and/or metapopulation connectivity	Frequent use by mesocarnivores	Protected land with natural habitat on one side of the highway
4	Some focal species overlay, especially mountain lion; relatively high quality habitat at or adjacent to site	Focal species presence	Low likelihood of development on either side of highway due to site conditions
5 (high)	Multiple focal species overlay, especially mountain lion; habitat bottleneck	Use by a variety of taxa; presence of breeding females with young; juvenile/subadult animals; focal species	Land on both sides of the highway is protected

Figure 5.1. Valuation matrix for scoring sites.

It is important to note that the CESs were scored for these criteria based on existing conditions at the time of the study. However, these criteria are not static and unchanging; rather, local and regional connectivity as well as land-use security are likely to change in the future. For example, human land use changes such as rural residential development, mining, and other forms of habitat conversion may impact all three of the criteria scores for a given site. As a result, the scores and/or relative priority level for a given site may require adjustments in the future; additional data collection will also likely be required.

The scores and categorizations described in this report are a starting point to help decision-makers prioritize sites for different actions, but changing conditions will necessitate adjustments. CESs with higher land-use security scores might be prioritized for implementation of enhancements at transportation infrastructure, whereas sites with lower land-use security scores might be prioritized for land conservation actions to facilitate subsequent enhancements at or along the highway.

Connectivity Emphasis Site name	Caltrans postmile*	Regional connectivity score	Local connectivity score	Land security score	Mean score
SR 129 section					
SR 129 Site 1	SBT, SR 129, PM 2.27	1	2	1	**1.3**
SR 129 Site 3	SBT, SR 129, PM 1.31	3	3	1	**2.3**
SR 129 Site 5 Pajaro River Bridge	SBT, SR 129, PM 0.00	4	4	2	**3.3**
SR 129 Site 8	SCR, SR 129, PM 7.88	2	2	4	**2.7**
SR 156 section					
SR 156 Site 3	SBT, SR 156, PM 1.38	1	3	3	**2.3**
US 101 Aromas Hills section					
US 101 Site 7	SBT, US 101, PM 2.65	5	4	1	**3.3**
US 101 Site 11	SBT, US 101, PM 1.57	5	4	3	**4.0**
US 101 Site 16	SBT, US 101, PM 0.49	5	4	3	**4.0**
US 101 Site 20B	MON, US 101, PM 100.89	2	4	2	**2.7**
SR 152 Pajaro Valley section					
SR 152 Site 1 San Felipe Lake dual round culverts	SCL, SR 152, PM 16.58	4	3	3	**3.3**
SR 152 Site 2 San Felipe Lake box culvert	SCL, SR 152, PM 17.24	5	5	3	**4.3**
SR 152 Badger hotspot (includes SR 152 sites 4, 5, and 6)	SCL, SR 152, PM 20.3–21.85	N/A	N/A	N/A	**N/A**
SR 25 Pajaro Valley section					
SR 25 Site 1 Carnadero Creek Bridge	SCL, SR 25, PM 1.55	2	3	1	**2.0**
SR 25 Site 2 Pajaro River Bridge	SBT, SR 25, PM 60.08	5	5	2	**4.0**
US 101 Pajaro Valley section					
US 101 Site 2 Gavilan Creek culvert	SCL, US 101, PM 3.17	1	1	1	**1.0**
US 101 Site 3 Tick Creek culvert	SCL, US 101, PM 1.90	3	3	2	**2.7**
US 101 Site 4 Tar Creek overpass	SCL, US 101, PM 0.84	5	5	3	**4.3**
US 101 Site 5 Pajaro River Bridge	SCL, US 101, PM 0.00	5	5	2	**4.0**
US 101 Site 6 San Benito River Bridge	SBT, US 101, PM 5.25	5	5	2	**4.0**

* Postmiles are listed as reference points rather than highly precise locations. In the case of the Badger hotspot on Highway 152, we list a range of postmiles, as this is a broader stretch of highway than the other sites.

Figure 5.2. The 19 Connectivity Emphasis Sites, organized by highway, with scores from the valuation matrix.

CONNECTIVITY ENHANCEMENT MEASURES

After identifying the CESs and ranking them based on the three scoring criteria described above, we developed recommendations for intervention at each CES based on four different proven connectivity enhancement measures. These measures are described in a comprehensive evaluation of WVC reduction measures prepared in a report to the US Congress, commissioned by the Federal Highway Administration (FHWA) (Huijser et al. 2008; Figure 5.3). A recent literature review concluded that there were no significant differences in the measures' performance in the last decade (Huijser et al. 2021).

Transportation agencies are now accustomed to devising measures that mitigate the impacts of roads in order to increase safety for motorists and wildlife (Kociolek et al. 2015). Figure 5.3 is describes recommended interventions that transportation agencies can use to improve wildlife connectivity and motorist safety in the study area, with a description of each intervention and its effectiveness in reducing WVCs (after Huijser et al. 2008).

Intervention	Type of intervention	Effectiveness at reducing WVCs
Fencing (without crossing structures; fencing can reduce WVC but increase barrier effect of road)	Physically separate animals from roadway	80–100%
Undercrossing with waterflow	Influence animal behavior	80–100%
Undercrossing – wildlife (with associated fencing)	Influence animal behavior	80–100%
Overpass – wildlife (with associated fencing)	Influence animal behavior	80–100%

Figure 5.3. Proven connectivity enhancement measures, their focus and effectiveness. Adapted from Huijser et al. 2008 and Huijser et al. 2021.

The most effective measures for reducing WVCs are fencing and wildlife crossing structures, which have been found to lead to an 83% reduction in WVCs (Rytwinski et al. 2016). In comparison, animal detection systems have been found to reduce WVCs by 57%, while reflectors are virtually ineffective in reducing WVC, with only a 1% reduction (Rytwinski et al. 2016).

The design of wildlife crossings is critical, and structure designs are typically categorized as primary, secondary, or tertiary class, based primarily on dimensions and design (Figure 5.4; Clevenger et al. 2010, Lee et al. 2012). Site conditions will also determine what type(s) of structure(s) are possible at a given location. Further information on this topic can be found in Appendix C, which includes wildlife crossing infrastructure information sheets (after Clevenger and Huijser 2011) that provide further details on each of the main methods to support wildlife road crossings and reduce wildlife–vehicle collisions.

Class	Crossing design type	Recommended dimensions Length is based on constructed width of highway at location	Considerations for use
Primary	Wildlife overpass	Width: 50–70m	▪ Sites that occupy high-quality or critical habitats for wildlife and/or are identified as key habitat linkages to facilitate movement of wildlife at a local or regional scale. ▪ Focal species mountain lion and deer, but suitable for other taxa as well.
	Wildlife undercrossing (open span)	Height: 3.5m Width: 21m	
Secondary	Wildlife undercrossing (open span bridge or open bottom arched culvert)	Height: 3m Width: 11m	▪ Sites with relatively intact or undisturbed habitats, but not considered critical wildlife habitat, such as: (a) habitats that lack special conservation value or designation but are suitable for moving wildlife, and (b) habitats that may not be suitable at present but future restoration is planned. ▪ Secondary class structures contribute to broader permeability in concert with other crossing structures. ▪ Depending on site conditions, should be designed to meet the needs of the widest range of possible species
Tertiary	Elliptical culvert	Height: 3m Width: 7m	▪ Sites with habitats subject to human disturbance or regular human activity. ▪ Sites where primary or secondary class crossing structures are not feasible to construct. ▪ Sites where construction could provide complementarity with other planned or existing structures ▪ Focal species small and mid-sized carnivores and other small mammals
	Concrete pre-fab box culvert	Height: 2.6m Width: 2.8m	

Figure 5.4. Design type and dimensions for three classes of wildlife crossing structures, adapted from Clevenger and Huijser 2011. Though this figure includes examples of focal species associated with each crossing structure type, each crossing structure should be designed to meet the needs of the widest range of possible species.

OTHER CONNECTIVITY ENHANCEMENT MEASURES

In addition to the structural connectivity enhancement measures described above, other complementary measures or interventions can help mitigate road impacts on wildlife. These include:

Fencing. Fencing is critical to the effectiveness of new and retrofitted crossing structures (Rytwinski et al. 2016, Huijser et al. 2016). Fence length will vary with location; care is required to avoid creating a worse situation by allowing "end runs" of wildlife and potentially boxing in animals between fences.

Maintenance. Debris (silt, gravel, garbage), brush, and other blockage can render culverts ineffective and under-utilized for wildlife passage. Simple maintenance can create a larger, more suitable passage. If buildup of material is significant, the entire structure may need to be cleared (Clevenger and Huijser 2011).

Land use and management. If lands are not managed to ensure wildlife use and connectivity of the area adjacent to a crossing structure, regardless of the size or investment, the performance and function of the structure will be severely compromised. Land use and management recommendations can include managing vegetation to increase the likelihood that focal species will find and use crossing structures, reducing or eliminating land use practices that are harmful to wildlife (e.g., rodenticide use), and maintaining and/or restoring habitat.

Coordinated land use and management, including securing land and otherwise preventing land conversion and development, is critical to the success of an investment to restore connectivity and provide safe passage across highways in a highly developed landscape, and will be required for successful interventions at CESs.

SITE CATEGORIZATION AND PRIORITIZATION

After identifying and scoring the CESs based on the valuation matrix and developing specific recommendations for each site, we organized the CESs into three intervention categories. We then prioritized the sites within each intervention category based on the mean valuation matrix score. It is important to note that site categorization was not informed by the site scoring, with the site scoring instead used to prioritize sites within categories. This step also considered the importance and value of each CES and the recommended intervention within the network of sites and in the context of regional connectivity.

We developed and organized the CESs into three intervention categories based on our subjective assessment of site functionality and urgency. The functionality of the site refers to how permeable the landscape is to wildlife movement under current conditions. Sites that are currently functional are those that consistently facilitate passages by native wildlife and have relatively low levels of WVCs adjacent to the site. However, some sites may be functional but still record wildlife–vehicle collisions nearby, which suggest they may be important areas for wildlife movement and require additional interventions to reduce WVCs.

The criticality and urgency of interventions at a location refers to the importance of the site to restore connectivity in a rapidly developing landscape as well as the relative urgency of the needed intervention (Tucker et al. 2018, Gustafson et al. 2019, Suraci et al. 2020). For example, specific landscape "fracture zones" or genetic bottlenecks where the conservation value of maintaining or restoring animal dispersal, metapopulation dynamics, and genetic connectivity is paramount and should be prioritized for near-term action (Crooks and Sanjayan 2006, Hilty et al. 2020).

The other criterion used to inform site categorization was the urgency of the proposed intervention. For example, sites actively threatened by development should be addressed before sites that are currently functional and are not threatened by development. Urgency was also considered in terms of the need for near-term and long-term interventions. Some sites can benefit from low-cost, near-term maintenance actions to increase functionality, while requiring longer-term and bigger interventions as funds, capacity, and opportunities present themselves.

The three intervention categories are:

High priority, critically urgent

These are sites that are not functioning under current conditions and are a key barrier to address, especially for mountain lion connectivity, or sites that are currently functional but face an active development threat.

Functional sites to maintain and enhance

These sites are currently functional and should be maintained because there are no known active development threats. These should be enhanced over time if/when possible. The priority level for these sites could be increased if the land protection status changes or if a development threat emerges.

Near-term maintenance sites with additional enhancement opportunities

These sites are somewhat functional and can be improved through near-term interim maintenance actions. In the long-term, these sites can be enhanced through bigger interventions such as a culvert retrofit or replacement as resources are available and/or opportunities present themselves (e.g., when a culvert needs to be replaced).

It is important to note that the scores generated by the valuation matrix did not inform how sites were organized into intervention categories. Each intervention category refers to the relative importance and urgency of implementing interventions at a given site to aid in decision-making. The categorizations were informed by existing site functionality based on wildlife data, conservation need, and the nature of the recommended intervention. These categories do not necessarily indicate the relative priority level of the site in terms of its importance for local and regional connectivity, which was captured in the valuation matrix.

After categorizing the sites, we used the mean scores generated through the valuation matrix as described above to determine and rank the relative priority of sites within each category (Figure 5.5) (Clevenger et al. 2010, Lee et al. 2012). Prioritization helps identify the relative importance of each site to aid planning and implementation, given limited funding, capacity, partner resources and priorities, etc.

This overall site prioritization and categorization identifies needs and opportunities that Caltrans and regional transportation authorities can incorporate into their planning infrastructure projects and integrate with the agency's Wildlife Connectivity Assessment Tool (WildCAT). While these interventions are interrelated measures intended to restore and protect connectivity and reduce WVCs in this fragmented landscape, it is important to note that intervening land use (including stewardship and management practices) will ultimately influence the success of conservation in the study area. Implementing these recommendations will be most effective when considered and integrated in the context of comprehensive, landscape-scale conservation actions. For example, land use changes or a change in land protection status adjacent to a CES or in the broader surrounding area may reduce or enhance the conservation value of a CES. Similarly, it is important to consider whether there may be opportunities to leverage other planned transportation projects (highway widening, passing lanes, bridge rebuilds, etc.) to facilitate implementation of interventions at a given CES. The emergence of such opportunities might change the relative priority level of a given CES.

Connectivity Emphasis Site name	Caltrans postmile*	Regional connectivity score	Local connectivity score	Land security score	Mean score
High priority, critically urgent					
US 101 Site 4 Tar Creek overpass	SCL, US 101, PM 0.84	5	5	3	**4.3**
US 101 Site 11	SBT, US 101, PM 1.57	5	4	3	**4**
US 101 Site 16	SBT, US 101, PM 0.49	5	4	3	**4**
US 101 Site 6 San Benito River Bridge	SBT, US 101, PM 5.25	5	5	2	**4**
Functional sites to maintain and enhance					
SR 25 Site 2 Pajaro River Bridge	SBT, SR 25, PM 60.08	5	5	2	**4**
US 101 Site 5 Pajaro River Bridge	SCL, US 101, PM 0.00	5	5	2	**4**
SR 129 Site 5 Pajaro River Bridge	SBT, SR 129, PM 0.00	4	4	2	**3.3**
SR 129 Site 8	SCR, SR 129, PM 7.88	2	2	4	**2.7**
US 101 Site 20B	MON, US 101, PM 100.89	2	4	2	**2.7**
SR 129 Site 3	SBT, SR 129, PM 1.31	3	3	1	**2.3**
SR 25 Site 1 Carnadero Creek Bridge	SCL, SR 25, PM 1.55	2	3	1	**2**
SR 129 Site 1	SBT, SR 129, PM 2.27	1	2	1	**1.3**
Near-term maintenance sites with additional enhancement opportunities					
SR 152 Site 2 San Felipe Lake box culvert	SCL, SR 152, PM 17.24	5	5	3	**4.3**
SR 152 Badger hotspot (includes SR 152 sites 4, 5, and 6)	SCL, SR 152, PM 20.3–21.85	N/A	N/A	N/A	**N/A**
US 101 Site 7	SBT, US 101, PM 2.65	5	4	1	**3.3**
SR 152 Site 1 San Felipe Lake dual round culverts	SCL, SR 152, PM 16.58	4	3	3	**3.3**
US 101 Site 3 Tick Creek culvert	SCL, US 101, PM 1.90	3	3	2	**2.7**
SR 156 Site 3	SBT, SR 156, PM 1.38	1	3	3	**2.3**
US 101 Site 2 Gavilan Creek culvert	SCL, US 101, PM 3.17	1	1	1	**1**

* Postmiles are listed as reference points rather than highly precise locations. In the case of the Badger hotspot on Highway 152, we list a range of postmiles, as this is a broader stretch of highway than the other sites.

Figure 5.5. Scores for the 19 CESs, organized within intervention categories by order of priority.

6 RECOMMENDATIONS

Based on the valuation matrix and site conditions, we developed recommendations for each of the 19 Connectivity Emphasis Sites (CESs) to improve connectivity and motorist safety in the study area. As described in Chapter 5, these recommendations are based on local and regional connectivity values (indicated by camera trap data, roadkill data, and habitat suitability modeling) and land-use security at each site. Recommendations for each site (shown in Figure 6.1) include:

- Maintaining existing structures;
- Constructing new wildlife crossing structures;
- Maintaining or increasing land-use security; and/or
- Implementing land and infrastructure management actions to enhance connectivity, such as adding or modifying fencing, managing vegetation, and clearing blockages.

Wildlife-friendly land-use management in areas adjacent to a CES, including permanent protections and habitat restoration or enhancement, is important for the long-term success of any infrastructure enhancements (Clevenger and Huijser 2011) and is described in more detail in the next chapter. Though not an official requirement for projects, Caltrans views permanent land protection on both sides of the highway as a very important consideration before investing significant public funds into wildlife crossing infrastructure (M. Robertson, personal communication May 2, 2022).

In this discussion of recommendations, sites are organized into three intervention categories: (a) high priority, critically urgent, (b) functional sites to maintain and enhance, and (c) near-term maintenance sites with additional enhancement opportunities. Within each category, sites are organized in order of their overall mean score as generated by the valuation matrix. Thus, sites are grouped by intervention category and then prioritized by their overall mean score within each intervention category.

Sites within each intervention category may have different recommendations, as the wildlife enhancement needs may vary. For example, the US 101 Site 4 Tar Creek overpass and US 101 Site 11 (Eucalyptus Grove) sites are both categorized as "high priority, critically urgent," but have different recommended interventions. The primary recommendation for the Tar Creek overpass is to increase land-use security in order to maintain existing connectivity values, while the primary recommendation for the Eucalyptus Grove is to construct a new wildlife crossing structure.

More detail on the sites and specific recommendations can be found in two of the appendices to this report. Appendix C includes information sheets on each type of crossing infrastructure, including general descriptions and technical guidelines. Appendix D contains hot sheets for each site summarizing site characteristics and recommendations; these are designed for use in the field.

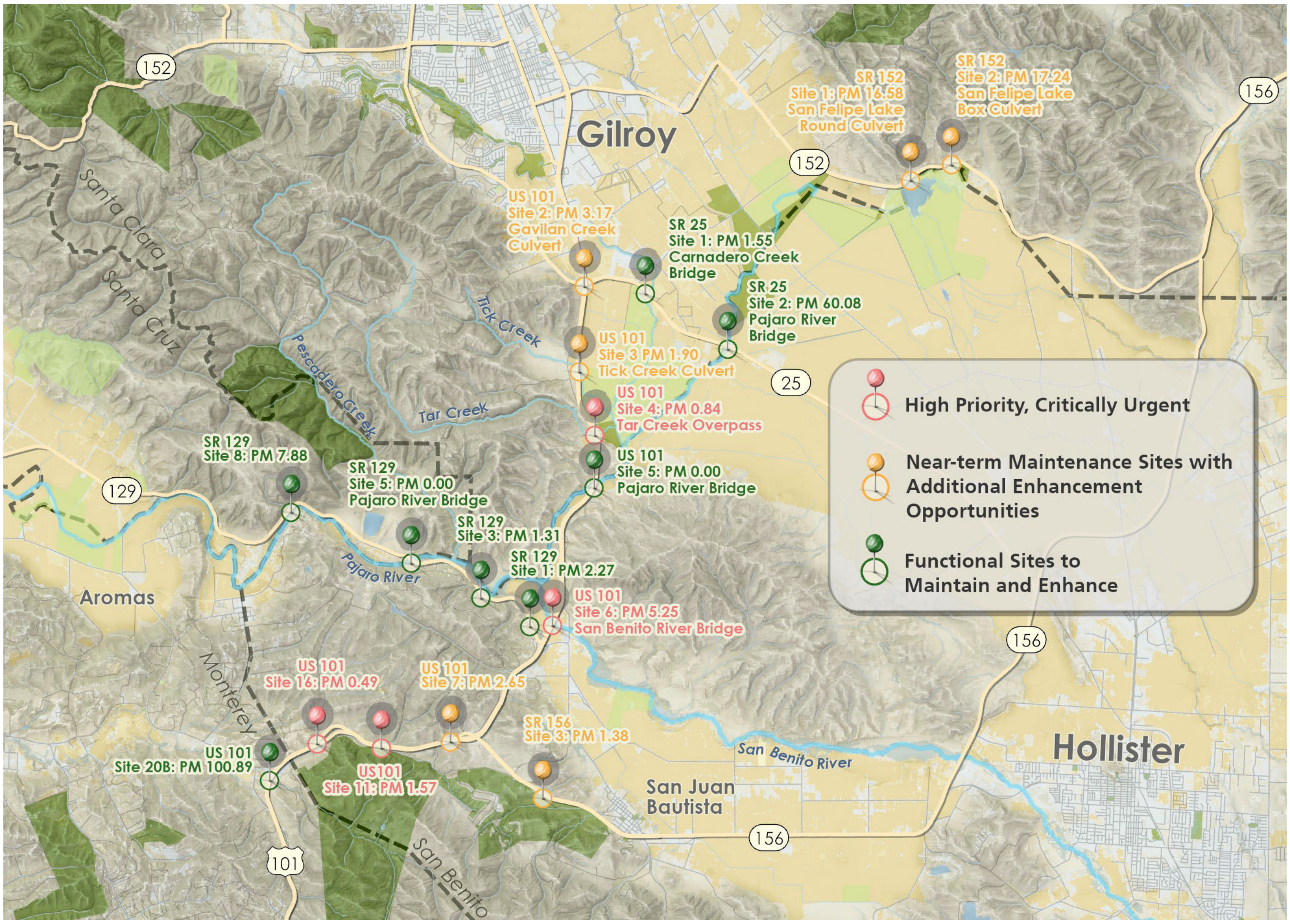


Figure 6.1. Location of CESs within the study area by category.

GUIDANCE FOR DECISION-MAKING

The intervention categories and site prioritization within each category should be viewed as one suggested approach to decision-making. We encourage stakeholders to use these categories and relative priorities as a starting point, and consider other factors as needed to help further refine site prioritization. It is important to implement interventions at each CES, given that these are a subset of sites within an already highly fragmented landscape.

Working on projects sequentially according to site categorization and relative priority level might not be possible or desirable based on stakeholder goals and other factors. For example, stakeholders might choose sites for intervention based on geographic location, relevance in implementing conservation plan(s), and/or importance for focal species. Stakeholders might also choose to prioritize sites with lower land-use security scores as a means to catalyze land protection and infrastructure improvement efforts. A flexible approach to decision-making will be necessary to accommodate changing conditions on the landscape and reflect different stakeholder priorities.

Regardless of the ultimate approach to site prioritization, we recommend that stakeholders "show their work" and record how they made decisions about which sites to prioritize for intervention. Given that wildlife crossing infrastructure projects can take years or decades to complete, it is important to provide a written record of decision-making and rationale in case of staff turnover or changing site conditions and relative conservation priorities. Additionally, the information and rationale used to guide action today may be very different from information used to guide actions in the future as the landscape is affected by climate change, development pressure, or other threats (Stein et al. 2014). Showing our work can also support adaptive management as new information becomes available.

CONNECTIVITY EMPHASIS SITE RECOMMENDATIONS

HIGH PRIORITY, CRITICALLY URGENT

These are sites that are not functioning under current conditions and that present a key barrier, especially for mountain lion connectivity, or sites that are currently functional but face an active development threat.

US 101 Site 4 Tar Creek overpass

SCL, US 101, PM 0.84

Lat/Long: 36.9289, 121.54797

Hot sheet 1

Summary

This site is categorized as high priority, critically urgent because it is facing active potential for conversion of habitat in the adjacent Sargent Ranch, located to the west of the site in the southern Santa Cruz Mountains.

Existing infrastructure

This is a large bridge where Tar Creek, the railroad, and a private road run under US 101. The bridge is 20'+ tall directly over the creek. The bridge consists of two separate spans — one for the southbound lanes and another for the northbound lanes.

Mean score 4.3

This site is tied for highest mean score in the study area.

Regional connectivity score 5

Tar Creek is an important location for regional connectivity because it interfaces the Santa Cruz Mountains and the intervening valley bottom lands (predominantly human-developed) that ultimately connect with the Diablo Range. Though the Upper Pajaro Valley to the east of this site is largely agricultural, the valley includes riparian corridors that are important for focal species movement, specifically deer and bobcat, both of which were recorded using this site for passage. Restoration projects are planned for protected land within the valley that may increase connectivity and the ecological value of the landscape.

Local connectivity score 5

Tar Creek is an important location for local connectivity; it was used by a variety of taxa and had the highest species richness of any in the study area (including badger, long-tailed weasel, gray fox, coyote, bobcat, and deer). The large open undercrossing structure accommodated passage for many different species. Focal species that used this site for passage included badger, bobcat, and deer. Habitat adjacent to the site supports reproduction, as evidenced by recorded passages of subadult deer, coyote, and bobcat.

Land-use security score 3

This site is flanked by protected habitat on the east side of the highway (Carnadero Preserve). Development is proposed in Sargent Ranch, adjacent to Tar Creek (Sargent Quarry, currently undergoing environmental review).

WVC considerations

Because US 101 is elevated here, WVC is of relatively low concern at this site. However, two badger roadkill records were reported in the vicinity of this site and there is a roadkill hotspot just to the south of this site.

Target species for connectivity enhancements

American badger, long-tailed weasel, gray fox, coyote, bobcat, and deer.

Wildlife objectives

- Provide safe movement for wildlife traveling between Sargent Hills and Upper Pajaro Valley.
- Maintain connectivity as currently facilitated at this site.

Recommendations

- Improve land-use security on the west side of US 101 and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity across US 101.
- Add fencing (with gate, as needed) at the access road (located on the west side of northbound 101) to reduce roadkill. Modify and/or improve fencing on the east side of northbound 101 as needed. Monitor this site after implementation to assess effectiveness of the intervention.

Relevant conservation plans

- California Department of Fish and Wildlife (CDFW) Wildlife Barriers 2020
- California Essential Habitat Connectivity Project
- California State Wildlife Action Plan and SWAP 2015 Transportation Planning Companion Plan
- Critical Linkages: Bay Area and Beyond
- Santa Clara County Regional Conservation Investment Strategy
- Santa Clara Valley Greenprint
- Santa Clara Valley Habitat Plan

US 101 Site 11 (Eucalyptus Grove)

SBT, US 101, PM 1.57

Lat/Long: 36.86008, -121.60507

Hot sheet 2

Summary

This site is categorized as high priority, critically urgent because it is crucial to restore mountain lion population connectivity and is not currently functional as evidenced by low native species passages and adjacency to an area of concern for wildlife–vehicle collisions. This site is meant to be inclusive of the stretch of US 101 that borders the Eucalyptus Grove and is not necessarily tied to the existing system of culverts at this location (US 101 Sites 9, 10, and 11), though we include the site number and postmile for the culvert spanning the southbound lanes for ease of reference.

Existing infrastructure

A concrete square box culvert 4′ wide and 4′ high crosses under the southbound lanes of US 101 towards the median habitat to the south. An animal emerging from this culvert must travel along the highway median to reach US 101 Site 10 culvert, which spans the median. An animal must then travel further east to reach another large culvert, US 101 Site 9, to cross under the northbound lanes. This meandering design poses a challenge for wildlife to navigate successfully.

Mean score 4

Regional connectivity score 5

This site is crucial for regional connectivity primarily due to mountain lion occurrence in this area, especially given the genetic fragmentation in neighboring populations.

Local connectivity score 4

Despite the site's importance for mountain lion, habitat suitability modeling and relatively low use by native species resulted in a slightly lower score for local connectivity.

Land-use security score 3

There is high-quality protected habitat on the south side of highway (Rocks Ranch).

WVC considerations

This is an area of concern for collisions, as shown by the number of mountain lion roadkills at this site.

Target species for connectivity enhancements

Mountain lion and other species.

Wildlife objectives

- Restore mountain lion population (genetic) connectivity.

Recommendations

- Add a new primary class wildlife crossing structure (overpass or open-span underpass that spans the northbound and southbound lanes of US 101 and the vegetated median), along with appropriate landscape-scale habitat restoration or enhancement.
- Add fencing to guide animal movement to new structure and keep animals off road; incorporate escape ramps/jump-outs near ends of fence as appropriate.
- Improve the land-use security on the north side of US 101 and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.
- Modify fences along the protected habitat at Rocks Ranch to increase permeability.
- In the eucalyptus grove itself, creation of unpaved roads or trails with native vegetation on the periphery may increase use of existing new structure(s).
- Determine landscape-scale habitat restoration/enhancement as part of subsequent detailed planning for a new wildlife crossing structure.

Relevant conservation plans

- California State Wildlife Action Plan and SWAP 2015 Transportation Planning Companion Plan
- CDFW Wildlife Barriers 2020
- Critical Linkages: Bay Area and Beyond
- San Benito County Conservation Plan (in progress; this will be a Habitat Conservation Plan and Natural Community Conservation Plan, or HCP/NCCP)

US 101 Site 16 (Habitat Island)

SBT, US 101, PM 0.49

Lat/Long: 36.86084, -121.62256

Hot sheet 3

Summary

This site is categorized as high priority, critically urgent because it is crucial to restore mountain lion population connectivity and is an area of concern for wildlife–vehicle collisions, which indicates the need to enhance site functionality. This site is meant to be inclusive of the stretch of US 101 that features the Habitat Island and is not necessarily tied to the existing system of culverts spanning this location (US 101 Sites 15, 16, and 17), though we include the site number and postmile for the culvert spanning the southbound lanes for ease of reference.

Existing infrastructure

A large concrete box culvert, 6′ wide and 6′ high, crosses under the southbound lanes of US 101. This is part of an existing system of culverts spanning this location, as described above.

Mean score 4

Regional connectivity score 5

This area features high-quality habitat on both sides of the highway (and in the median) and modeled habitat suitability across the four focal species. It is located in a habitat bottleneck from the Aromas Hills across US 101 into the Gabilan Range.

Local connectivity score 4

This area had some use of the existing culvert by medium-sized mammals, and a variety of wildlife sign was found in the immediate vicinity. Though deer were not recorded using the existing culvert, there was a cluster of deer mortality near this location, suggesting the area is important for deer movement.

Land-use security score 3

This site has protected land to the south (Rocks Ranch), but to the north and immediately southwest of this site are US 101 development nodes, as identified by San Benito County.

WVC considerations

There was a high concentration of roadkill at this area, including a deer mortality cluster and mountain lion roadkill.

Target species for connectivity enhancements

Deer, mountain lion, and other species.

Wildlife objectives

- Provide safe passage for wildlife between high-quality habitat on both sides of the highway.
- Reduce WVCs/road mortality.

Recommendations

- Add a new primary class wildlife crossing structure (overpass or open-span underpass that spans the northbound and southbound lanes of US 101 and the vegetated habitat island median) with associated fencing.
- In the near-term, perform selective vegetation clearing and install directional fencing to increase wildlife access to the existing culvert system while maintaining cover and structure.
- Improve land-use security on the north and southwest sides of US 101 and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.

Relevant conservation plans

- California State Wildlife Action Plan and SWAP 2015 Transportation Planning Companion Plan
- CDFW Wildlife Barriers 2020
- Critical Linkages: Bay Area and Beyond
- San Benito County Conservation Plan (in progress)

US 101 Site 6 San Benito River Bridge

SBT, US 101, PM 5.25

Lat/Long: 36.88724, -121.55888

Hot sheet 4

Summary

This site is categorized as high priority, critically urgent because it is facing active conversion of habitat from the Betabel Road Project, a commercial proposal along US 101 north of the site. This site may be an important regional connection for mountain lion between the Gabilan Range and southern Santa Cruz Mountains.

Existing infrastructure

This is a large bridge where the San Benito River runs under US 101. The bridge is 20'+ tall directly over the river. The bridge consists of two separate spans, one for the southbound lanes and one for the northbound lanes.

Mean score 4

Regional connectivity score 5

Multiple focal species were detected at this location, including deer and bobcat. Mountain lion tracks were also found in this location. This may be a highly important regional connection between the Santa Cruz Mountains and Gabilan Range because the San Benito River flows from the Gabilan Range to the Pajaro River, which borders the southern Santa Cruz Mountains. Though the San Benito River runs adjacent to agricultural lands and the urban centers of San Juan Bautista and Hollister, the river and its floodplain are relatively wide, which could allow for movement of animals along this riparian corridor.

Local connectivity score 5

A variety of wildlife, including focal species, were recorded using the large, open underpass: deer (including adult male), bobcat, gray fox, raccoon, skunk, and opossum. The undercrossing is adjacent to habitat at the Flint Hills. The undercrossing held water during the driest part of the monitoring period.

Land-use security score 2

While this site has some level of protection through the existing Riparian Protection Ordinance (San Benito County), development activities continue to take place near the riparian corridor. The site also faces regional development threats. A commercial development node is located south of the site, and the proposed Betabel Road Project, a commercial proposal along US 101, is located north of the site.

WVC considerations

Data indicate that collisions are of relatively low concern at this site.

Target species for connectivity enhancements

Multiple species, including mountain lion and deer.

Wildlife objectives

- Maintain and enhance safe passage for wildlife living in and moving through the San Benito River corridor.

Recommendations

- Improve land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.
- Maintain existing structure, ensuring that wildlife is able to travel along the river bank (i.e., dry ground).
- Incorporate fencing between highway lanes (at median) to prevent wildlife from accessing the middle of the highway from the riparian area.

Relevant conservation plans

- California State Wildlife Action Plan and SWAP 2015 Transportation Planning Companion Plan
- California Essential Habitat Connectivity Project
- CDFW Wildlife Barriers 2020
- Critical Linkages: Bay Area and Beyond
- San Benito County Conservation Plan (in progress)

FUNCTIONAL SITES TO MAINTAIN AND ENHANCE

These are sites that are currently functional, have no known active development threats, and should be maintained. When possible, these sites should be enhanced over time. The priority level for these sites could increase if the land protection status changes or if a development threat emerges.

SR 25 Site 2 Pajaro River Bridge

SBT, SR 25, PM 60.08

Lat/Long: 36.94805, -121.51211

Hot sheet 5

Summary

This site is currently functional as evidenced by passages by multiple native species and relatively low levels of WVCs. Actions to improve conditions by improving land-use security and land management will be valuable as capacity and resources allow.

Existing infrastructure

This is a moderate-sized bridge where Pajaro River runs under SR 25. Bridge is 20′+ tall directly over the river.

Mean score 4

Regional connectivity score 5

The focal species models indicate strong overlap in suitability along the Pajaro River corridor for badger, bobcat, and deer, indicating the site's importance for cross-valley connectivity. This connectivity is also suggested by detection of deer in the Pajaro River corridor using this site along with sites at Highways 101 and 152. Though the Upper Pajaro Valley is largely agricultural, the valley includes riparian corridors that are important for focal species movement, specifically deer and bobcat. Restoration projects that are planned for protected land in the valley may increase connectivity and the ecological value of the landscape. The site appears to be a crucial point of highway permeability within the valley floor and element within the habitat network.

Local connectivity score 5

This site was used by a wide variety of taxa. We documented bobcat, raccoon, opossum, a pack of coyotes, and multiple individual deer using the large, open underpass at this site.

Land-use security score 2

This site has some level of protection through the San Benito County Riparian Protection Ordinance, but is vulnerable to conversion and other intensification of human activity in proximity to the corridor.

WVC considerations

Data indicate that collisions are of relatively low concern at this site.

Target species for connectivity enhancements

Multiple species, including deer.

Wildlife objectives

- Maintain and enhance function as safe passage for wildlife under the highway.
- Maintain value relative to cross-valley connectivity.

Recommendations

- Improve land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.
- Maintain existing structure.

Relevant conservation plans

- California Essential Habitat Connectivity Project
- California State Wildlife Action Plan and SWAP 2015 Transportation Planning Companion Plan
- Critical Linkages: Bay Area and Beyond
- San Benito County Conservation Plan (in progress)
- Santa Clara Valley Greenprint
- Santa Clara Valley Habitat Plan

US 101 Site 5 Pajaro River Bridge

SCL, US 101, PM 0.00

Lat/Long: 36.91745, -121.54797

Hot sheet 6

Summary

This site is currently functional as evidenced by high richness in native species passages, including by deer, and relatively low WVCs. It requires increased land-use security and land management to maintain and enhance functionality.

Existing infrastructure

This is a large bridge where the Pajaro River runs beneath US 101. The bridge is 20′+ tall directly over the river.

Mean score 4

Regional connectivity score 5

Multiple focal species were recorded using this site for passage, including deer and bobcat. Habitat suitability modeling shows multiple focal species overlay along the Pajaro River corridor across the Upper Pajaro Valley. Deer were detected here, as well as in the Pajaro River corridor under Highways 25 and 152, suggesting potential cross-valley connectivity. Though the Upper Pajaro Valley is largely agricultural, the valley includes riparian corridors that are important for focal species movement, specifically deer and bobcat. Restoration projects that are planned for protected land in the valley may increase connectivity and the ecological value of the landscape.

Local connectivity score 5

This site had the second-highest number of native species passage in the study area. A variety of species used the large, open underpass structure at this site. Successful passages included male and female deer, coyote, bobcat, opossum, skunk, and raccoon. This site had the highest rate of deer passages in the study area.

Land-use security score 2

This site has some level of protection through the San Benito County Riparian Protection Ordinance, but is vulnerable to conversion and other intensification of human activity in proximity to the riparian corridor.

WVC considerations

Data indicate that collisions are a relatively low concern at this site.

Target species for connectivity enhancements

Multiple species, including deer.

Wildlife objectives

- Maintain safe passage for wildlife under the highway.
- Maintain value relative to cross-valley connectivity.

Recommendations

- Improve land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.
- Maintain existing structure, ensuring that wildlife can travel on dry ground along the river bank.

Relevant conservation plans

- California Essential Habitat Connectivity Project
- California State Wildlife Action Plan and SWAP 2015 Transportation Planning Companion Plan
- CDFW Wildlife Barriers 2020
- Critical Linkages: Bay Area and Beyond
- San Benito County Conservation Plan (in progress)
- Santa Clara Valley Greenprint
- Santa Clara Valley Habitat Plan

SR 129 Site 5 Pajaro River Bridge

SBT, SR 129, PM 0.00

Lat/Long: 36.90051, -121.5976

Hot sheet 7

Summary

This site is currently functional as evidenced by high levels of native species passages by numerous species and relatively low WVCs. It requires increased land-use security and land management to maintain and enhance functionality.

Existing infrastructure

This is a bridge overpass with two sections separated by a concrete wall. The western section is 82′ 6″ wide and approximately 20′+ high; the eastern section is wider and higher. The Pajaro River flows through the eastern section.

Mean score 3.33

Regional connectivity score 4

Habitat suitability modeling suggests that this area may be an important connection between the southern Santa Cruz Mountains and the habitats to the south. Focal species recorded using this site include deer and bobcat.

Local connectivity score 4

A variety of species were observed at this site using the large, open underpass structure, including focal species. Successful passages included male and female deer, bobcat, gray fox, raccoon, dusky-footed woodrat, opossum, and skunk.

Land-use security score 2

There is a protected property on the northwestern side of the structure (Land Trust of Santa Cruz County).

WVC considerations

Data indicate that collisions are of relatively low concern at this site.

Target species for connectivity enhancements

Multiple species, including deer.

Wildlife objectives

- Maintain function as safe passage for wildlife under the highway.

Recommendations

- Improve land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.
- Maintain existing structure.

Relevant conservation plans

- California Essential Habitat Connectivity Project
- California State Wildlife Action Plan and SWAP 2015 Transportation Planning Companion Plan
- Conservation Blueprint for Santa Cruz County
- Critical Linkages: Bay Area and Beyond
- Santa Cruz County Regional Conservation Investment Strategy (in progress)

SR 129 Site 8

SCR, SR 129, PM 7.88

Lat/Long: 36.91135, -121.63035

Hot sheet 8

Summary

This site is currently functional as evidenced by high numbers of native species passages by mesocarnivores and relatively low levels of WVCs. Near- and long-term actions can be taken at this site to further improve passage for wildlife. Actions to improve conditions by improving land-use security and land management as well as infrastructure improvements will be valuable as capacity and resources allow.

Existing infrastructure

This is a cement box/arch culvert. The northwest opening is shaped as a square 4′ 4″ wide and 3′ 7″ high. The southeast opening is shaped as an arch measuring 4′ wide at the center (midway vertically), and 4′ high at the top middle of arch (down the center).

Mean score 2.7

Regional connectivity score 2

Focal species models show strong overlap at this location with suitable habitat on the north side of the highway. The south side of this site borders the Pajaro River corridor, but is also near an open mine. This site had the highest rates of bobcat passage within the entire study area. No other focal species were detected at this location.

Local connectivity score 2

The site showed frequent use by resident bobcat, with additional passage by a subadult. Opossum and raccoon also used this site regularly. Data suggest that this site may be important for daily movements by resident individuals.

Land-use security score 4

With the river to the south and very steep topography to the north, this site has a low likelihood of being converted to non-habitat uses.

WVC considerations

Data indicate that collisions are of relatively low concern at this site.

Target species for connectivity enhancements

Multiple species, especially mesocarnivores.

Wildlife objectives

- Maintain and enhance function as safe passage for wildlife under the highway.

Recommendations

- Maintain the structure until it can be replaced with a tertiary class undercrossing structure (elliptical culvert or concrete pre-fab box culvert).
- If and when a new crossing structure is installed, consider modifying the topography on the south side outlet to promote wildlife access from river to culvert.
- Improve land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.

Relevant conservation plans

- California Essential Habitat Connectivity Project
- California State Wildlife Action Plan and SWAP 2015 Transportation Planning Companion Plan
- Conservation Blueprint for Santa Cruz County
- Critical Linkages: Bay Area and Beyond
- Santa Cruz County Regional Conservation Investment Strategy (in progress)

US 101 Site 20B

MON, US 101, PM 100.89

Lat/Long: 36.85271, -121.63529

Hot sheet 9

Summary

This site is currently functional as evidenced by passages by multiple native species and relatively low levels of WVCs. Actions to improve conditions, including by improving land-use security and land management as well as adding directional fencing, will be valuable as capacity and resources allow.

Existing infrastructure

Large cement box culvert, 9′ 10″ wide and 6′ high.

Mean score 2.7

Regional connectivity score 2

Habitat suitability modeling indicates this site has unsuitable habitat for mountain lion with high movement costs.

Local connectivity score 4

This is a large existing culvert with native substrate. It is functional for deer, with deer passages recorded. Opossum, raccoon, and skunk were also documented using the site for passage.

Land-use security score 2

Land adjacent to the highway is in rural residential, commercial, and agricultural use; none of the lands are protected. There is some level of protection from riparian protection ordinance.

WVC considerations

Collisions are of relatively low concern based on roadkill data, with one deer WVC detected.

Target species for connectivity enhancements

Multiple species, including deer.

Wildlife objectives

- Maintain and enhance function as safe passage for wildlife under the highway.

Recommendations

- Maintain existing structure.
- Focus on improving the land-use security in the area and manage adjacent lands in a way that protects permeability for wildlife.
- Consider adding and integrating directional fencing with existing structures at Sites 20A and 20B.

Relevant conservation plans

- California State Wildlife Action Plan and SWAP 2015 Transportation Planning Companion Plan
- CDFW Wildlife Barriers 2020
- Critical Linkages: Bay Area and Beyond

SR 129 Site 3

SBT, SR 129, PM 1.31

Lat/Long: 36.89307, -121.57847

Hot sheet 10

Summary

This site is currently functional with recorded passages by several native species. Actions to improve conditions by improving land-use security and land management as well as infrastructure improvements will be valuable as capacity and resources allow.

Existing infrastructure

This is a square box concrete culvert, 3′ wide and 3′ 1″ high.

Mean score 2.3

Regional connectivity score 3

There is strong overlap of focal species habitat suitability models at this area, though habitat is somewhat constrained because of rural residential development.

Local connectivity score 3

We recorded frequent bobcat and coyote passages through this culvert. One juvenile deer investigated and entered this culvert, but likely did not use it for passage. Some passages by opossum, raccoon, and skunk were also detected at this site.

Land-use security score 1

Adjacent lands are unprotected rural residential.

WVC considerations

Collisions are of moderate concern based on roadkill data (bobcat, skunk)

Target species for connectivity enhancements

Multiple species, especially mesocarnivores.

Wildlife objectives

- Maintain and enhance function as safe passage for wildlife under the highway.
- Reduce WVC/road mortality.

Recommendations

- Improve land-use security in the area and manage adjacent lands in a way that protects permeability for local wildlife.
- Consider replacing existing structure with tertiary class undercrossing structure (elliptical culvert or concrete pre-fab box culvert) and associated directional fencing.

Relevant conservation plans

- California Essential Habitat Connectivity Project
- Critical Linkages: Bay Area and Beyond
- California State Wildlife Action Plan and SWAP 2015 Transportation Planning Companion Plan
- San Benito County Conservation Plan (in progress)

SR 25 Site 1 Carnadero Creek Bridge

SCL, SR 25, PM 1.55

Lat/Long: 36.95997, -121.53468

Hot sheet 11

Summary

This site is currently functional as evidenced by recorded passages by mesocarnivores and relatively low levels of WVCs. Actions to improve conditions by improving land-use security and land management will be valuable as capacity and resources allow.

Existing infrastructure

This is a moderate-sized bridge where Carnadero Creek (also known as Uvas-Carnadero Creek) runs under SR 25. The bridge is 20′+ tall directly over the creek.

Mean score 2

Regional connectivity score 2

There is low overlap in habitat suitability for focal species. It may be important for bobcats that are resident on the valley floor.

Local connectivity score 3

We recorded passages in this large structure by bobcat (adults and kittens), coyote, gray fox, opossum, raccoon, and skunk.

Land-use security score 1

None of the nearby lands are protected, and adjacent lands show relatively intensive human use.

WVC considerations

Data indicate that collisions are of relatively low concern at this site.

Target species for connectivity enhancements

Multiple species, especially mesocarnivores.

Wildlife objectives

- Maintain and enhance function as safe passage for wildlife under the highway.

Recommendations

- Improve land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.
- Maintain existing structure.

Relevant conservation plans

- California State Wildlife Action Plan and SWAP 2015 Transportation Planning Companion Plan
- Santa Clara County Regional Conservation Investment Strategy
- Santa Clara Valley Greenprint
- Santa Clara Valley Habitat Plan

SR 129 Site 1

SBT, SR 129, PM 2.27

Lat/Long: 36.88695, -121.56503

Hot sheet 12

Summary

This site is currently functional, with frequent passages by mesocarnivores. Actions to improve conditions by improving land-use security and land management as well as infrastructure improvements will be valuable as capacity and resources allow.

Existing infrastructure

This is a round corrugated culvert 2′ in diameter.

Mean score 1.33

Regional connectivity score 1

Adjacent habitat to the south of the highway is suitable for focal species, but habitat is unsuitable on immediately north of the highway.

Local connectivity score 2

We recorded frequent passages in this small culvert by bobcat, raccoon, and opossum, and one passage by gray fox. The area southwest of the culvert leads to riparian habitat and open grassland. The northeastern opening leads to the Pajaro River.

Land-use security score 1

This area has no protected lands.

WVC considerations

Collisions are of moderate concern based on roadkill data (bobcat, badger).

Target species for connectivity enhancements

Multiple species, especially mesocarnivores (including badger).

Wildlife objectives

- Maintain and enhance function as safe passage for wildlife under the highway.
- Reduce WVC/road mortality.

Recommendations

- Maintain existing structure.
- Improve land-use security in the area and manage adjacent lands in a way that protects permeability for local wildlife.
- Consider replacing existing structure with tertiary class undercrossing structure (elliptical culvert or concrete pre-fab box culvert) and associated directional fencing.

Relevant conservation plans

- California Essential Habitat Connectivity Project
- Critical Linkages: Bay Area and Beyond
- California State Wildlife Action Plan and SWAP 2015 Transportation Planning Companion Plan
- San Benito County Conservation Plan (in progress)

NEAR-TERM MAINTENANCE SITES WITH ADDITIONAL ENHANCEMENT OPPORTUNITIES

These sites are somewhat functional and can be improved through near-term interim maintenance. In the long term, these sites can be enhanced through interventions such as a culvert retrofit or replacement as resources are available and/or opportunities present themselves (e.g., when a culvert needs to be replaced).

SR 152 Site 2 San Felipe Lake box culvert

SCL, SR 152, PM 17.24

Lat/Long: 36.98883, -121.45172

Hot sheet 13

Summary

This site is somewhat functional as evidenced by high rates of native species passages, but is also an area of concern for wildlife–vehicle collisions. Near- and long-term actions can be taken at this site to improve passage for wildlife.

Existing infrastructure

This is a single box culvert approximately 6′ wide and 4′ tall.

Mean score 4.3

This site is tied for highest mean score in the study area.

Regional connectivity score 5

There is a strong overlap of focal species habitat suitability models at this area for bobcat, deer, and badger. Deer were detected at this site as well as in the Pajaro River corridor under Highways 25 and 101.

Local connectivity score 5

This site had the highest rate of native species passages in the entire study area. There was a high rate of passages by deer (including males), bobcat, coyote (including subadult), gray fox, raccoon, and skunk. Nearby San Felipe Lake provides important habitat, especially due to wetlands and water resources. The high rates of passage and presence of nearby water resources suggests it may be an important site for species' daily movements.

Land-use security score 3

There is protected land on south side of the highway (San Felipe Lake Ranch Easement).

WVC considerations

There was road mortality by multiple species along this stretch of SR 152 in the vicinity of San Felipe Lake.

Target species for connectivity enhancements

Multiple species, especially mesocarnivores and deer. This site also overlaps critical habitat for California tiger salamander.

Wildlife objectives

- Maintain and enhance function as safe passage for wildlife under the highway.
- Reduce WVC/road mortality.

Recommendations

- In the near term, modify the existing fence on the south side for wildlife permeability, and perform vegetation management on the north side.
- In the long-term, add a new tertiary class undercrossing structure (elliptical culvert, concrete pre-fab box culvert) and install wing-fencing to guide animals to the structure and keep them off the road; install escape ramps/jump-outs near ends of fence.
- Improve land-use security on the north side of SR 152 and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.

Relevant conservation plans

- California Essential Habitat Connectivity Project
- California State Wildlife Action Plan and SWAP 2015 Transportation Planning Companion Plan
- Critical Linkages: Bay Area and Beyond
- Santa Clara County Regional Conservation Investment Strategy
- Santa Clara Valley Greenprint
- Santa Clara Valley Habitat Plan

SR 152 Badger hotspot

SCL, SR 152, PM 20.3-21.85

This hotspot does not have scores; it includes SR 152 sites 4, 5, and 6

Hot sheet 14

Summary

Existing structures (small round culverts) in this location are somewhat functional as evidenced by passages by small and medium-sized mammals, but structures are not functional for large mammals such as deer. It is also an area of concern for wildlife–vehicle collisions, especially badger. This site represents a stretch of SR 152 that includes existing undercrossings used by badger and nearby badger burrows, and is a diffuse roadkill hotspot, with several badger WVCs to the east of SR 152 Site 6. Near- and long-term actions can be taken at this site to improve passage for wildlife.

Existing infrastructure

This hotspot includes three culverts: a cement round culvert 4′ in diameter at SR 152 Site 4 Coyote and badger culvert, and cement round culverts approximately 30″ in diameter at SR 152 Site 5 Coyote puppy culvert and SR 152 Site 6 Tree round culvert.

Connectivity and land-use security

This stretch of highway has unprotected open grassland habitat on both sides of the road, with three culverts that are used by badger and several other species.

WVC considerations

This stretch of highway had three records of badger WVCs. Deer, coyote, and skunk WVCs have also been recorded here. This is an area of concern for WVCs.

Target species for connectivity enhancements

Primarily badger, mesocarnivores, and deer. This stretch of highway also overlaps critical habitat for California tiger salamander and California red-legged frog.

Wildlife objectives

- Reduce WVC/road mortality, especially for American badger (California Species of Special Concern).
- Maintain and enhance function as safe passage for wildlife under the highway.

Recommendations

- Add wildlife fencing between existing undercrossings. It may be appropriate to extend fencing to the east of the study area; spatial extent of fencing should be refined as part of pre-implementation planning.
- Add additional undercrossing structures between existing culverts and to the east of SR 152 Site 6, with at least one secondary class (open-span bridge or open bottom arched culvert) or tertiary class (elliptical culvert or concrete pre-fab box culvert) undercrossing structure large enough to provide passage for deer.
- Improve land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.

Relevant conservation plans

- California State Wildlife Action Plan and SWAP 2015 Transportation Planning Companion Plan
- Santa Clara County Regional Conservation Investment Strategy
- Santa Clara Valley Greenprint
- Santa Clara Valley Habitat Plan

US 101 Site 7

SBT, US 101, PM 2.65

Lat/Long: 36.86161, -121.58629

Hot sheet 15

Summary

This site is categorized as lower priority and less urgent because the site has the potential to contribute to the habitat system and offer some redundancy/complementarity to connectivity enhancement measures at the Eucalyptus Grove and Habitat Island CESs. Actions to improve conditions by improving land-use security and land management, as well as retrofitting the structure with a secondary class undercrossing structure, will be valuable as capacity and resources allow.

Existing infrastructure

The northern opening features a round corrugated pipe culvert 4′ in diameter. Midway through the culvert, it changes from a round corrugated culvert to a square box culvert, with dimensions 4′ x 4′ through to the southern opening.

Mean score 3.3

Regional connectivity score 5

Habitat suitability modeling indicates strong overlap in suitability for deer, badger, bobcat, and mountain lion at this location. Mountain lion, deer, and bobcat were detected on the north side of US 101 at this site, but were not documented passing through the culvert.

Local connectivity score 4

This site is east of Eucalyptus Grove. This site had the highest richness of native species in detections without passage. Focal species observed at this site included mountain lion, deer, and bobcat. Opossum, raccoon, and skunk were recorded using the structure. There is native habitat, including a pond, adjacent to the site and along the margins of a nearby housing development.

Land-use security score 1

This site connects rural residential development on both sides of the highway.

WVC considerations

Data indicate that collisions are of relatively low concern at this site.

Target species for connectivity enhancements

Multiple species, including mountain lion and deer.

Wildlife objectives

- Create/enhance function as safe passage for wildlife under the highway, especially for mountain lion and deer.

Recommendations

- In the near-term, manage vegetation immediately adjacent to the site to encourage species' use.
- In the long-term, retrofit structure with secondary class undercrossing structure (open-span bridge or open bottom arched culvert).
- Improve land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.

Relevant conservation plans

- California State Wildlife Action Plan and SWAP 2015 Transportation Planning Companion Plan
- CDFW Wildlife Barriers 2020
- Critical Linkages: Bay Area and Beyond
- San Benito County Conservation Plan (in progress)

SR 152 Site 1 San Felipe Lake dual round culverts

SCL, SR 152, PM 16.58

Lat/Long: 36.98539, -121.46276

Hot sheet 16

Summary

This site is somewhat functional as evidenced by some native species passages, but is also an area of concern for wildlife–vehicle collisions. Near- and long-term actions can be taken at this site to improve passage for wildlife.

Existing infrastructure

This is a double round culvert with each culvert approximately 4′ in diameter.

Mean score 3.3

Regional connectivity score 4

There is some overlap of focal species habitat suitability models at this area for bobcat, deer, and badger, though the existing structure is not suitable for deer passage.

Local connectivity score 3

The culverts had frequent use by mesocarnivores, including bobcat, coyote, raccoon, and skunk. There is important habitat (especially due to wetlands/water resources) at San Felipe Lake, which is immediately to the south of the highway. These water resources may be important for animals' daily movements.

Land-use security score 3

There is protected land on the south side of the highway (San Felipe Lake Ranch Easement).

WVC considerations

There was road mortality by multiple species along this stretch of SR 152 in the vicinity of San Felipe Lake.

Target species for connectivity enhancements

Multiple species, especially mesocarnivores.

Wildlife objectives

Maintain and enhance function as safe passage for wildlife under the highway.

Recommendations

- In the near term, clear sediment from the culverts.
- In the long term, add a new tertiary class undercrossing structure (elliptical culvert or concrete pre-fab box culvert) and install wing-fencing to guide animals to the structure and keep them off the road; install escape ramps/jump-outs near ends of fence.
- Improve land-use security on the north side of SR 152 and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.

Relevant conservation plans

- California Essential Habitat Connectivity Project
- California State Wildlife Action Plan and SWAP 2015 Transportation Planning Companion Plan
- Critical Linkages: Bay Area and Beyond
- Santa Clara County Regional Conservation Investment Strategy
- Santa Clara Valley Greenprint
- Santa Clara Valley Habitat Plan

US 101 Site 3 Tick Creek culvert

SCL, US 101, PM 1.90

Lat/Long: 36.94274, -121.55243

Hot sheet 17

Summary

This site is somewhat functional as evidenced by frequent passages by mesocarnivores. Near- and long-term actions can be taken at this site to improve passage for wildlife.

Existing infrastructure

This is a double box culvert, with each box approximately 11′ wide and 3′ 4″ tall.

Mean score 2.7

Regional connectivity score 3

Local connectivity score 3

This site scored the same for regional and local connectivity because it appeared to be well-used by mesocarnivores (several individual bobcats, a group of four coyotes) and provides access between high-quality habitat to the east and west.

Land-use security score 2

This site connects protected land on east side of the highway (Carnadero Preserve) to intact, but unprotected, land on the west side of the highway. The Carnadero Preserve at this location is primarily cropland with little natural habitat, thus this site scored slightly lower for land-use security.

WVC considerations

Data indicate that collisions are of relatively low concern at this site.

Target species for connectivity enhancements

Mesocarnivores.

Wildlife objectives

- Maintain and enhance function as safe passage for wildlife under the highway.

Recommendations

- Near-term, manage vegetation to improve access to the culvert while maintaining some cover.
- Long-term (e.g., when culvert needs to be replaced), replace the existing culvert with a tertiary class undercrossing structure (elliptical culvert or concrete pre-fab box culvert) and wing-fencing to guide animals to the structure and keep them off the road.
- Improve land-use security on the west side of US 101 and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.

Relevant conservation plans

- California State Wildlife Action Plan and SWAP 2015 Transportation Planning Companion Plan
- Santa Clara County Regional Conservation Investment Strategy
- Santa Clara Valley Greenprint
- Santa Clara Valley Habitat Plan

SR 156 Site 3

SBT, SR 156, PM 1.38

Lat/Long: 36.84949, -121.56099

Hot sheet 18

Summary

This site is somewhat functional as evidenced by passages by some mesocarnivores and relatively low levels of WVCs. Actions to improve conditions by improving land-use security and land management as well as infrastructure modifications will be valuable as capacity and resources allow.

Existing infrastructure

This is a large box culvert 12′ wide and 12′ 5″ high.

Mean score 2.3

Regional connectivity score 1

This site had low focal species use, with only bobcat detected using the structure. It also has low habitat suitability for mountain lion but connects highly suitable habitat for badger, bobcat, and deer.

Local connectivity score 3

We documented passage by bobcat (one with mange), coyote, opossum, raccoon, and skunk. The most passages at this site were by coyote.

Land-use security score 3

The site has protected land on the south side of SR 156 (Nyland property).

WVC considerations

Data indicate that collisions are of relatively low concern at this site.

Target species for connectivity enhancements

Mesocarnivores.

Wildlife objectives

- Maintain and enhance function as safe passage for wildlife under the highway.

Recommendations

- Modify gate at culvert opening to promote wildlife passage.
- Longer-term, incorporate a mix of vegetated cover and open conditions near the culvert and the surrounding landscape to promote increased use by a variety of species such as mountain lion and badger.
- Improve land-use security on the north side of SR 156 and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.

Relevant conservation plans

- California State Wildlife Action Plan and SWAP 2015 Transportation Planning Companion Plan
- San Benito County Conservation Plan (in progress)

US 101 Site 2 Gavilan Creek culvert

SCL, US 101, PM 3.17

Lat/Long: 36.96145, -121.55131

Hot sheet 19

Summary

This site is not functional under current conditions, as evidenced by almost no native species use, though WVCs are of relatively low concern at this location. Near- and long-term actions may help improve the value of this site for native species passages.

Existing infrastructure

This is a large single box culvert approximately 12′ wide and 6′ tall.

Mean score 1

Regional connectivity score 1

No focal species use and low habitat suitability for focal species.

Local connectivity score 1

Almost no native species use was recorded at this large culvert. It is regularly used by domestic dogs and cats, with some passages by coyote and raccoon. This site was inundated with water for part of the study period, which — along with the presence of domestic animals — may have contributed to low native species passage at this site.

Land-use security score 1

Lands on both sides of the highway are developed; on the east side, lands are in intensive agricultural use with little habitat value.

WVC considerations

Data indicate that collisions are of relatively low concern at this site.

Target species for connectivity enhancements

Multiple species.

Wildlife objectives

- Enhance function as safe passage for wildlife under the highway.

Recommendations

- In the near-term, add critter shelves to allow species passage during periods when the culvert experiences ponded water.
- Incorporate a mix of vegetated cover and open conditions along Gavilan Creek to encourage use by wildlife.
- Work with adjacent landowners to reduce the use of the culvert by domestic animals.
- Absent of comprehensive habitat restoration actions in the vicinity of this culvert, interventions would likely be more effective at sites further south on US 101 (e.g., US 101 Pajaro Valley Site 3 Tick Creek culvert).

Relevant conservation plans

- California State Wildlife Action Plan and SWAP 2015 Transportation Planning Companion Plan
- Santa Clara County Regional Conservation Investment Strategy
- Santa Clara Valley Greenprint
- Santa Clara Valley Habitat Plan

7 CONCLUSIONS AND NEXT STEPS

This study assessed ecological connectivity between the southern end of the Santa Cruz Mountains and both the Gabilan Range and the Diablo Range. We assessed the need for improved permeability of highways in this region by synthesizing data from wildlife camera trapping of existing undercrossings, data from roadkill surveys along highways, and habitat suitability and cost surface modeling for a suite of focal species.

Based on our findings, we identified 19 Connectivity Emphasis Sites (CESs) with the most opportunities for reducing wildlife–vehicle collisions and improving connectivity for wildlife, and made specific recommendations for each site (Chapter 6). Focusing management and enhancement actions in these areas should reduce wildlife mortality and improve habitat connectivity and animal movement through transitional habitat along these highway segments; as a result, these actions will also improve motorist safety.

Our recommendations for each CES generally include: (a) maintaining or retrofitting existing crossing structures, (b) constructing new wildlife crossing structures, (c) ensuring wildlife-friendly land management practices in surrounding lands, (d) maintaining or increasing land-use security, and/or (e) implementing land and infrastructure management and habitat restoration to enhance connectivity, such as adding or modifying fencing, managing vegetation, and clearing blockages.

NEXT STEPS

We recommend designing new and maintaining or retrofitting existing structures to maximize use across taxonomic groups, incorporating considerations of the life history and ecology of organisms that were not the focus of this study (e.g. amphibians and reptiles). Pre-project field-based surveys, including for special-status species, would help inform project-level planning such as by identifying focal species that could benefit from improved wildlife crossing infrastructure and designing crossing structures to meet their preferences and needs. Such considerations will enhance the ability of these interventions to reach goals both near-term (e.g., mountain lion population connectivity) and longer-term (e.g., climate adaptation), particularly in the case of large structures.

At several CESs, we recommend maintaining existing structures. This could include actions such as clearing blocked culverts, removing vegetation that is blocking culvert access, enhancing surrounding habitat, and/or repairing fencing. Monitoring these structures over time will be essential to identify any emerging issues requiring maintenance or management actions.

At several CESs, we propose construction of new wildlife crossing structures, which requires a number of steps. Site visits with a registered civil engineer will be necessary to ascertain the feasibility of construction at each site. This may involve adjusting locations relative to those identified in this report. Collection of supplementary information (e.g., ground and aerial survey data) would also help refine the recommendations. These types of finer-scale site inspections with engineers are part of the highway enhancement design process prior to starting preliminary design work and have been a part of numerous highway projects in North America. Such projects include US 93 in Montana (Evaro to Polson); Interstate 90 Snoqualmie Pass East, Washington; SR 260 near Payson, Arizona; US 101 Liberty Canyon in southern California; and SR 17 Laurel Curve in Santa Cruz County, California.

Engagement with rural residential landowners and agricultural operators regarding wildlife-friendly landscaping, animal husbandry, and other management practices will support the success of landscape-scale connectivity. Compiling information on best practices (e.g., wildlife-friendly fencing, enclosures for goats and sheep, avoidance of anticoagulant rodenticides, native plants appropriate for revegetation, nighttime lighting, etc.) would support this effort. Partners for coordination and outreach to landowners may include Resource Conservation Districts, Natural Resources Conservation Service, non-governmental organizations, and agricultural operators.

Maintaining and/or increasing land-use security on both sides of the highway at each CES is an essential part of maintaining and enhancing the permeability of the landscape. The study area faces development threats, including but not limited to rural residential development and resource extraction. Increased development in this region would lead to greater traffic volume on highways, thus increasing the barrier effect of roads. Land protection through acquisition of fee title or conservation easements and/or land use policy (e.g., zoning) is necessary to protect existing habitat, provide opportunities for habitat enhancement and restoration, and safeguard any investments in new or existing wildlife crossing infrastructure. Land protection efforts should focus on areas of core habitat as well as habitat linkages where specific crossing structures are or may be located in the future. Growth projections and development nodes should be considered in future phases of planning and feasibility analyses for any proposed wildlife crossing structure retrofits or construction.

Finally, habitat restoration and enhancement actions can help increase wildlife habitat and increase the likelihood that animals will find and use crossing structures. The frequency of mountain lion passage through wildlife crossing structures has been found to be highly correlated with the presence of nearby high-quality habitat (Gloyne and Clevenger 2001). Strategic restoration can substantially reduce landscape resistance to mountain lion movement, even in an otherwise high-resistance landscape (Suraci et al. 2020), as is the case in the majority of the study area. Another study found that the main factor determining the use of culverts by different vertebrate species was the location of the structure relative to habitat (Rodriguez et al. 1996). The presence and quality of habitat adjacent to the undercrossings evaluated in our study likely contributed to the use of structures by different species, underlying the importance of maintaining and enhancing habitat quality throughout the study area through targeted restoration and management actions.

FUTURE RESEARCH NEEDS

This study highlighted the need for future research to improve our understanding of wildlife movement across the landscape as well as to evaluate the success of any wildlife crossing infrastructure and/or restoration projects designed to increase landscape permeability.

Our overarching recommendation is to develop a research, monitoring, and adaptive management plan to evaluate the effectiveness of implementing the recommendations in this report and to advance our knowledge of wildlife in the study area and broader region. The plan should include objectives for short- and long-term monitoring as well as metrics to measure whether objectives are met. The data collected through this study can serve as a baseline reference to document changes in factors such as wildlife occurrences, movements, and wildlife–vehicle collisions. This research, monitoring, and adaptive management plan could complement the forthcoming San Benito County Conservation Plan and the forthcoming amendment to the Santa Clara Valley Habitat Plan. It could also help drive creation and implementation of actions, objectives, and goals for the Natural Community Conservation Plan (NCCP) portion of the Conservation Strategy of the San Benito County Conservation Plan.

The following proposed research areas represent opportunities to advance our understanding of wildlife movement in the broader region:

1. **Continue and expand monitoring of below-ground passage at critical locations.** This should include existing and new sites within the study area in key bottleneck areas that may function as connections between the three ranges, including the northern part of the Gabilan Range, San Benito River, north of San Felipe Lake, and interior valley floor/agricultural lands and canals/riparian corridors of the Upper Pajaro Valley. We also recommend using the Hobbs Active Light Trigger (HALT) camera technique to monitor existing culverts along SR 152 that are adjacent to or overlap critical habitat for the federally threatened California red-legged frog and federally endangered California tiger salamander. This monitoring can help assess whether these amphibians are utilizing these culverts and help identify any improvements to these culverts that would increase their suitability for amphibians.
2. **Collect more information about wildlife use of core habitat and the intervening linkages between and within the northern Gabilan Range** (e.g., Rocks Ranch and Hollister Hills areas) **and western Diablo Range** (e.g., lands within and surrounding Henry W. Coe State Park). These core areas were not sampled in this study. Future studies should include a rigorous camera trap sampling scheme in the northern part of the Gabilan Range. This should include the Rocks Ranch area and any areas potentially important for mountain lion movement, given that the only mountain lions detected on camera or as roadkill occurred just north of the Gabilan Range in the US 101 Aromas Hills section. Ideally, radio telemetry would be employed to provide fine-scale data on mountain lion movement and activity in this critical bottleneck area. Similarly, additional camera and/or telemetry work in the western Diablo Range would yield valuable information about the regional habitat network.
3. **Conduct camera monitoring along the fence line at the northern boundary of Rocks Ranch** to inform fence modifications and other stewardship actions. A camera array in this location would also be useful in assessing the effectiveness of any future fence modifications by comparing wildlife use before and after fence modifications occur.

4. **Continue and expand roadkill data collection in the study area**, including systematic surveys (and potentially community scientist efforts) as feasible. Specific locations where additional roadkill surveys may be most useful include the portion of US 101 in Aromas Hills where mountain lion WVC have been detected, and on SR 152 where badger WVC have been detected. Since the conclusion of the monitoring period for this study, Pathways for Wildlife has conducted weekly roadkill surveys along SR 152 in partnership with the Santa Clara Valley Habitat Agency; the monitoring period for that project concluded in May 2022.
5. **Build on the modeling from this and previous studies by conducting a Linkage Mapper analysis**. This set of tools is used to analyze and identify potential habitat linkages. We recommend further development and refining of habitat linkages for this study area as a next step. Such modeling efforts would benefit from fine-scale vegetation mapping of the study area, particularly the Upper Pajaro Valley, to aid understanding of the distribution and types of current agriculture, which in turn affects wildlife movement. For example, more information is needed about the location of row crop versus pasture agriculture, as these two agricultural uses differ in their suitability for wildlife movement across the focal species.

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APPENDIX A

WILDLIFE PERMEABILITY AND INFRASTRUCTURE DATABASE (SSCMWCS-WPID)

OVERVIEW

As part of this project, SCL Ecological created the Southern Santa Cruz Mountains Wildlife Connectivity Study Wildlife Permeability and Infrastructure Database (SSCMWCS-WPID), with some assistance from Pathways for Wildlife on behalf of Peninsula Open Space Trust (POST).

The SSCMWCS-WPID was created:

1. To contribute to and support the following study funded by POST: *Enhancing ecological connectivity and safe passage for wildlife on highways between the southern Santa Cruz Mountains, Gabilan Range, and Diablo Range in California*, informally referred to as the Southern Santa Cruz Mountains Wildlife Connectivity Study (SSCMWCS);
2. To serve as a reference for transportation, regulatory, and conservation agencies/organizations and inform future conservation actions in the SSCMWCS study area; and
3. To share any data missing from the Caltrans Culvert GIS.

The SSCMWCS-WPID includes information on all potential crossings (culverts 3′ diameter and greater; bridges and other underpasses) and all potential barriers (fencing and medians) for medium- to large-sized mammal movement through the SSCMWCS-WPID study area (Figure C1), which is slightly different from the SSCMWCS study area.

Highway	Area covered	Total length (miles)
US 101	MON PM 98.40 to SCL PM 3.30	13.77
SR 156	SBT PM 0.00 to SBT PM 2.40	2.40
SR 129	SBT PM 2.60 to SCR PM 1.40	11.20
SR 25	SCL PM 2.50 to SBT PM 60.00	2.51
SR 152	SCL PM 16.10 to SCL PM 21.90	5.80

Figure C1. The area covered by the SSCMWCS-WPID.

The SSCMWCS-WPID consists of the following:

1. A GIS geodatabase (.gdb) made up of two feature datasets (groups of data; potential crossing structures and potential barriers). Each dataset consists of two feature classes (data types related to the feature dataset; bridge undercrossing, culvert, fencing, and median). The geodatabase also includes a single feature class, WPID-termini, which identifies the limits of the SSCMWCS-WPID study area. The geodatabase can be used with any GIS software, including QGIS and ArcGIS. For ArcGIS users, Relative Pathways and Relative Hyperlinks were used to increase sharing capability and consistency among end users. As long as all of the files are kept within the main folder, the ArcMap document (.mxd) and linked photo documents will work across computers and drives. This main folder can be stored on any drive at any location.
2. A Google Earth version of the database (.kmz) was created for non-GIS users. Due to the large file size, photo hyperlinks were omitted from this version.
3. A folder with photos documenting bridges (including underpasses and overpasses).

Those interested in use of the database should contact POST: openspacetrust.org/contact.

METHODS

1. We requested and received GIS data for the SSCMWCS-WPID study area (culvert, bridge undercrossing, and median) from Caltrans.
2. Through field visits, we ground-truthed all bridges.
3. Through field visits, we ground-truthed all accessible culverts greater than or equal to 3′ wide or high.
4. We inspected satellite imagery and hydrology data to identify locations of potential culverts not in the Caltrans GIS data and transferred these data to tables for field reconnaissance.
5. To prepare for field visits, we created hard copy maps, tables with attribute data per structure, and survey forms.
6. We visited each identified location in the field that was accessible. During these field visits, we verified and/or corrected existing spatial and attribute data, collected additional data, and photo-documented the structure and site. We collected this for all structures located in the field that were absent in the Caltrans GIS data.
7. We mapped all medians and fencing along the highways within the SSCMWCS-WPID study area (see notes under Limitations, below). We collected all attribute and spatial data on 1:400 scale hard copy maps, using a tablet for georeferencing.
8. We digitized all spatial data from the hard copy maps in ArcGIS. We created attribute tables for each spatial feature class, and transcribed data from the hard copy.
9. We used relative pathways and relative hyperlinks to support the ability to share symbology and hyperlinks in ArcGIS between different end users on different computers and drives using the provided ArcMap .mxd file.
10. The ArcGIS .mxd file was converted to a Google Earth .kmz file for non-GIS end users.

LIMITATIONS

1. This inventory included only culverts greater than or equal to 3′ in diameter or height. This size is an appropriate minimum for the target species for this inventory (medium- to large-sized mammals). Including culverts less than 3′ would have drastically increased the level of effort and budget. However, because we monitored with camera traps some culverts that were less than 3′, these sites were included in the SSCMWCS-WPID.
2. We only mapped fencing that was considered a potential significant barrier to medium- to large-sized mammals. This included cyclone fencing, goat fencing, and goat fencing with barbed wire top strands. Certain species such as mountain lion, bobcat, gray fox, and deer are known to jump or climb over these fence types; however, such fences pose a more significant barrier to species such as American badger and coyote. On the other hand, stranded barbed wire fencing is not considered to pose a significant barrier to any of the mammals listed above (though it can injure animals) and thus was not mapped within the scope of the SSCMWCS-WPID.
3. Fencing was mapped regardless of status, and includes both intact and non-intact fencing. We recorded the type of fencing, locations, and alignments; fence status and any maintenance needs were not recorded. There are likely several locations where the mapped fencing needs repair and thus poses little to no barrier for medium- to large-sized mammals.

APPENDIX B

CAMERA MONITORING SITE ASSESSMENTS

1. SR 129 section
2. SR 156 section
3. US 101 Aromas Hills section
4. SR 152 Pajaro Valley section
5. SR 25 Pajaro Valley section
6. US 101 Pajaro Valley section

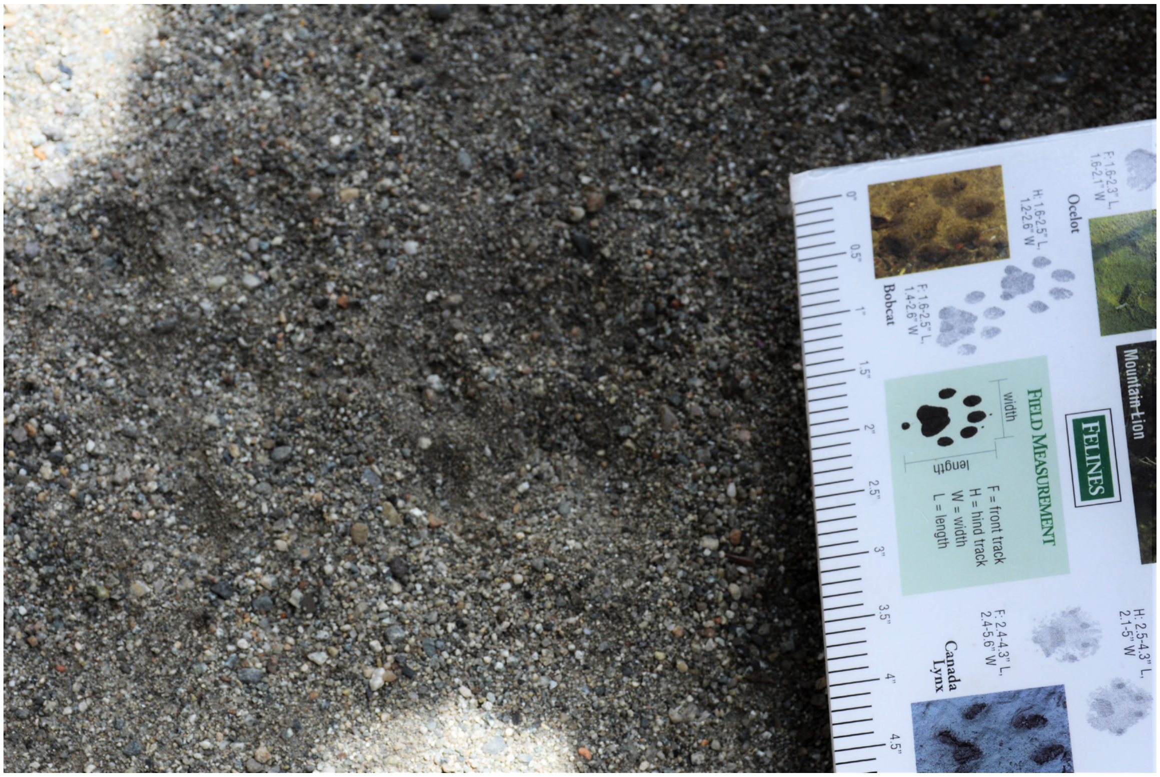
1. SR 129 SECTION

SR 129 SITE 1	
Postmile	SBT, SR 129, PM 2.27
GPS location	Latitude: 36.88695 Longitude: -121.56503
Dimensions	Round corrugated culvert 2′ in diameter
Direction	Southwest – northeast. Direction is toward the decline.
Visibility	Yes
Substrate	Corrugated steel (bare bottom). No buildup at southwestern opening.
Habitat/land use	Southwestern area leads to riparian habitat, and open grassland. Northeastern opening leads to Pajaro River.
Wildlife track and sign	Medium-sized mammal bones were found approximately 25′ north of the southwestern opening. Raccoon (*Procyon lotor*) tracks identified on westbound shoulder, above northeastern opening of culvert.
Track and sign transects	Both the westbound and eastbound shoulders have suitable substrate for tracking transects. The substrate consists of fine dirt mixed with gravel.

SR 129 Site 1. Southwest opening. Photo faces northwest.

SR 129 Site 1. Close-up of southwest opening. Photo faces northeast.

SR 129 Site 1. Medium-sized mammal bones located approximately 25′ from southwestern opening of culvert.



SR 129 Site 1. Right hind track of raccoon (*Procyon lotor*) heading east on the westbound shoulder of SR 129. Track was recorded above the northeastern opening of culvert.

SR 129 Site 1. Detailed look at right hind track showing five toes of raccoon.

SR 129 SITE 3	
Postmile	SBT, SR 129, PM 1.31
GPS location	Latitude: 36.89307 Longitude: -121.57847
Dimensions	Square/box concrete culvert 3′ wide and 3′ 1″ high
Direction	Southwest – northeast
Visibility	No visibility. Unable to see through the culvert.
Substrate	Concrete (bare bottom). No buildup at southwestern opening.
Habitat/land use	Southwestern opening leads to open habitat via a ravine. Eucalyptus and oak providing cover. Northeastern opening is oak woodland and open habitat, although there is a house nearby to the north.
Wildlife track and sign	Bobcat scat found within the southwestern opening of the culvert. Two wildlife trails lead to/from the ravine at the southwestern opening of the culvert.
Track and sign transects	The two wildlife trails and ravine leading to the southwestern opening of the culvert are suitable areas for track and sign identification.

SR 129 Site 3. Southwest opening. Photo faces north.

SR 129 Site 3. Close-up of southwest opening. Bobcat scat *(Lynx rufus)* visible in entrance of culvert (circled in yellow).

SR 129 Site 3. Within southwest opening of culvert. Photo faces northeast. The northeast end of the culvert is not visible.

SR 129 Site 3. Bobcat scat within southwest opening of culvert.

SR 129 SITE 5 PAJARO RIVER BRIDGE	
Postmile	SBT, SR 129, PM 0.00
GPS location	Latitude: 36.90051 Longitude: -121.5976
Dimensions	Pajaro River Bridge with the western section 82′ 6″ wide and approximately 20′+ high. The Pajaro River flows through another section to the east, which is separated by a structural wall. This section is wider and higher than the western section. The current water level is low enough so that a 2′-wide area of bank is exposed for wildlife to travel along at that section.
Direction	Northeast – southwest. Direction is based on the flow of the Pajaro River.
Visibility	Yes, this bridge is well lit and has high visibility throughout.
Substrate	The western section is made up of fine dirt mixed with sand. The middle section (to the east) has mud banks. Both are typical substrates of riparian habitat.
Habitat/land use	This is the largest underpass structure and only bridge on SR 129 in the study area. The Pajaro River is a major natural thoroughfare providing water and cover for wildlife connectivity.
Wildlife track and sign	Numerous tracks from several species present, such as opossum, bobcat, striped skunk, California ground squirrel, brush rabbit (*Sylvilagus bachmani)*, and raccoon. Numerous wildlife trails lead up (north) and down (south) from the underpass.
Track and sign transects	The entire western section and the bank of the Pajaro River are highly suitable candidates for tracking transects.

SR 129 Site 5 Pajaro River Bridge. Postmile marker of Pajaro River Bridge and SR 129. Photo faces east.

SR Site 5 Pajaro River Bridge. Western section. Photo faces east.

SR 129 Site 5 Pajaro River Bridge. Western section. Photo faces west.

SR 129 Site 5 Pajaro River Bridge. Photo of wildlife trail at western section, facing north. Trail with tracks indicated by yellow arrow.

SR 129 SITE 8	
Postmile	SCR, SR 129, PM 7.88
GPS location	Latitude: 36.91135 Longitude: -121.63035
Dimensions	Cement box/arch culvert. Northwest opening is a box 4′ 4″ wide and 3′ 7″ high. Southeast opening is an arch 4′ wide at the center (midway vertically), and 4′ high at top middle of arch (down the center).
Direction	Northwest – southeast (toward decline).
Visibility	Yes. Opposite opening can be seen through the culvert, and the culvert is well lit throughout.
Substrate	Concrete (bare bottom) at both openings. No build-up at either opening. There is a dip in the middle of the culvert.
Habitat/land use	The northeastern opening leads to one of the only ravines that break up the sheer steep cliffs along SR 129 at this section. The southeastern opening has cover along the ravine leading to the Pajaro River.
Wildlife track and sign	None
Track and sign transects	Due to the concrete and rocky ravine this site would not benefit from a wildlife track and sign transect.

SR 129 Site 8. Northwest square/box opening. Photo faces southeast.

SR 129 Site 8. Southeast arch opening. Photo faces northwest.

SR 129 Site 8. Photo shows drop in midway through the culvert. Photo faces northwest.

2. SR 156 SECTION

SR 156 SITE 1	
Postmile	SBT, SR 156, PM 0.41
GPS location	Latitude: 36.85751 Longitude: -121.57321
Dimensions	Large cement box culvert 6′ wide and 7′ high. Measurements were taken from the northeastern opening only as there were swallows actively flying from and returning to their nests at the southwestern opening. From our vantage point (without disturbing the swallows) we were able to estimate that the southwestern opening was similar to the northeastern opening.
Direction	Northeast – southwest. Unable to determine direction of decline.
Visibility	Yes. The openings of this culvert are large enough to see through and keep this culvert well lit throughout. In addition to the large openings, a circular cutout in the ceiling of the culvert allows more light to pass through. This opening leads up to the highway and is covered by a grate, concrete median, and then another grate from left to right.
Substrate	Fine dirt mixed with gravel. This substrate is consistent throughout the culvert.
Habitat/land use	This culvert is large enough to facilitate large mammal passage and has open habitat at both sides. A small eucalyptus grove at the northeastern opening provides cover before the open habitat to the north. There is a barbed wire fence approximately 50′ from northeastern opening. The fence is not well maintained and has various large openings that allow wildlife passage.
Wildlife track and sign	There is a wildlife trail from the northeastern opening to the west. Also, unidentified large mammal bones were found located west of the northeastern opening just off the wildlife trail.
Track and sign transects	The substrate throughout the culvert is highly suitable for tracking transects.

SR 156 Site 1. Northeastern opening. Photo faces southwest.

SR 156 Site 1. Photo from within the culvert faces outward from the northeast opening.

SR 156 Site 1. Circular opening in ceiling within middle of culvert with grate, median, then grate visible.

SR 156 Site 1. View of the habitat outside of northeastern opening.

SR 156 Site 1. Another view of the adjacent habitat outside northeastern opening Photo faces east; the culvert opening is indicated by yellow arrow.

SR 156 Site 1. Example of barbed wire fence and open habitat beyond northeastern opening. Photo faces north.

SR 156 Site 1. Unidentified large mammal bones near wildlife trail west of the northeastern opening. Bones are indicated by yellow arrows.

SR 156 SITE 2	
Postmile	SBT, SR 156, PM 0.57
GPS location	Latitude: 36.85603 Longitude: -121.57142
Dimensions	Round corrugated and half cement lined culvert 3′ 5″ wide and 3′ 2″ high. The upper portion of this culvert is corrugated steel and the bottom half is cement.
Direction	Northeast – southwest. Unable to determine direction of decline.
Visibility	Yes
Substrate	Cement (bare bottom) without any buildup.
Habitat/land use	Culvert is large enough for medium-sized mammals. There is visibility through the culvert, and open habitat on both sides. The northeastern opening has a small eucalyptus grove and culvert is not obstructed.
Wildlife track and sign	A wildlife trail leads north from the northeastern opening.
Track and sign transects	The wildlife trail leading north is suitable for a tracking transect as it would show if it is actively being used.

SR 156 Site 2. Northern opening.

SR 156 Site 2. Close-up of northern opening showing cement bottom.

SR 156 Site 2. Example of vegetation/cover alongside the highway and in front of the northeastern opening (shown by yellow arrow).

SR 156 SITE 3	
Postmile	SBT, SR 156, PM 1.38
GPS location	Latitude: 36.84949 Longitude: -121.56099
Dimensions	Large box culvert 12′ wide and 12′ 5″ high. This is the largest box culvert under SR 156. It is large enough to drive a vehicle through and appears that it was once a former access road.
Direction	Northeast – southwest. Unable to determine direction of decline as the foundation appears to be level.
Visibility	Yes. This culvert is very well lit with high visibility throughout.
Substrate	Dirt mixed with gravel creating a soft substrate.
Habitat/land use	This culvert is large enough to facilitate large mammal movement. The culvert is well lit, and both openings lead to open habitat without any nearby development. There is a gate in front of the southern opening, however it does seem to be permeable for some species of wildlife.
Wildlife track and sign	Numerous tracks show throughout the culvert.
Track and sign transects	The substrate throughout the culvert is highly suitable for a wildlife tracking transect.

SR 156 Site 3. Southwestern opening with gate in front of entrance.

SR 156 Site 3. Photo of southwestern opening (facing east) showing fence and adjacent habitat.

SR 156 Site 3. View of habitat beyond southwestern opening.

SR 156 Site 3. View from within northeastern opening showing open habitat.

SR 156 SITE 4	
Postmile	SBT, SR 156, PM 1.64
GPS location	Latitude: 36.84798 Longitude: -121.55598
Dimensions	Round corrugated culvert 2′ 5″ in diameter
Direction	North – south. This culvert is 2′ 6″ above ground level and it appears that water pools in front of the southern opening. However, looking through the culvert to the other side reveals that the northern entrance of the culvert curves down. The direction cannot be accurately stated.
Visibility	Yes
Substrate	Corrugated steel (bare bottom).
Habitat/land use	This culvert is large enough to facilitate movement of medium-sized mammals. There is visibility through the culvert and the raised southern opening has a concrete ledge making access more feasible for small to medium-sized mammals. 10′ south of the southern opening, a fence has a small section with loose barbed wire strands that may allow medium-sized mammals to pass through.
Wildlife track and sign	None
Track and sign transects	None

SR 156 Site 4. Southern opening showing raised entrance and concrete ledge. Photo faces northwest.

SR 156 Site 4. Close-up of southern opening.

SR 156 Site 4. Photo from within southern opening showing curve. Photo faces north.

SR 156 Site 4. View of fence and section of loose barbed wire strands. Loose barbed wire strands are indicated by yellow arrow. Photo faces southwest.

SR 156 SITE 5	
Postmile	SBT, SR 156, PM 2.01
GPS location	Latitude: 36.84675 Longitude: -121.54977
Dimensions	Dual box culverts. Western culvert is 11′ wide and 3′ 11″ high. An open section of the ceiling in the western culvert allows light. The eastern culvert is 12′ 7″ wide and 4′ high.
Direction	Northeast – southwest. Unable to determine direction of decline.
Visibility	Yes. There is visibility through both culverts. However, vegetation growing at the western portion of the southwestern opening of the western culvert may affect visibility.
Substrate	The western culvert has dirt substrate from the southern opening to the opposite opening. The eastern culvert has dirt substrate at the southern opening to approximately 12′ within the culvert where the cement (bare bottom) is revealed.
Habitat/land use	This culvert connects open grassland with rolling hills on both sides. A riparian strip offers cover leading to the southwestern opening. There is a barbed wire fence approximately 17′ from the southwestern opening, and an old barn to the south. An access road is visible to the south leading to the barn.
Wildlife track and sign	Within the western culvert there are numerous tracks including raccoon and striped skunk.
Track and sign transects	The western culvert is a highly suitable candidate for tracking transects.

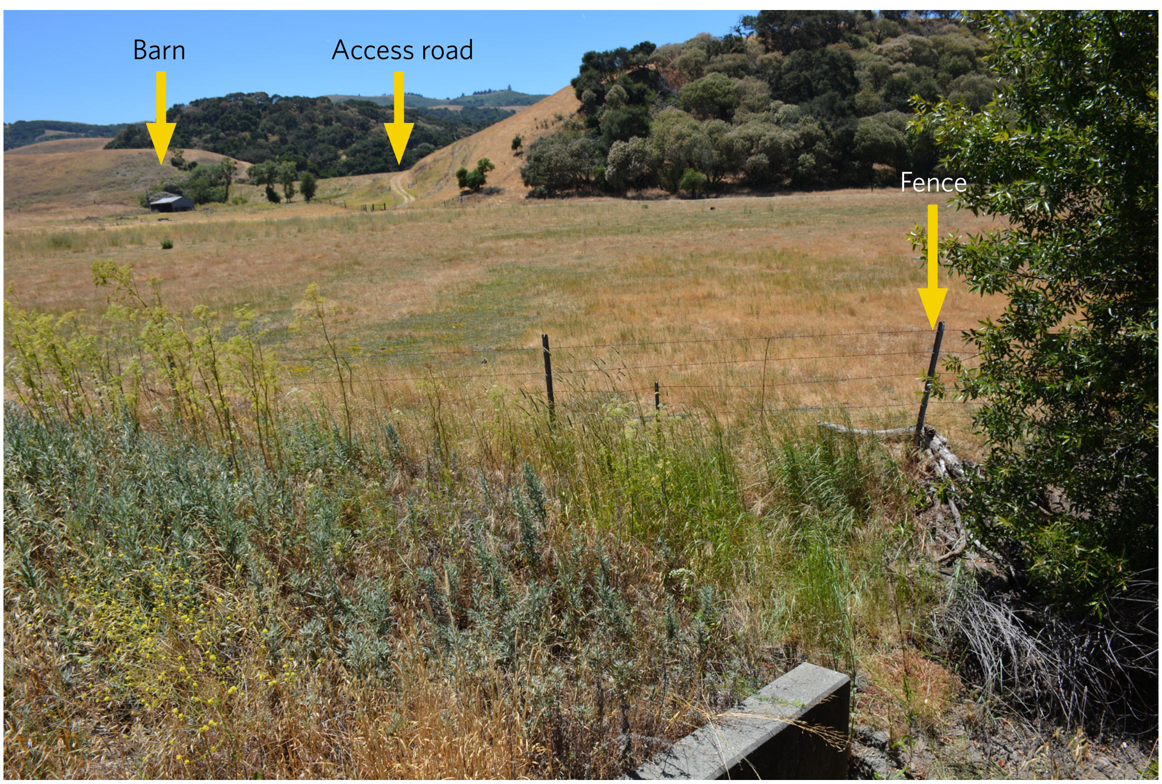
SR 156 Site 5. Southwestern opening. Photo faces north.

SR 156 Site 5. Inside western culvert, facing northeast to the southwestern opening.

SR 156 Site 5. Inside eastern culvert, facing northeast to the southwestern opening.

SR 156 Site 5. Vegetation in front of southwestern opening. Photo faces east.

SR 156 Site 5. Example of vegetation at the southwestern opening of western culvert. Photo faces southwest.



SR 156 Site 5. Example of open habitat beyond the southwestern opening. Barbed wire fence, barn, and access road are indicated by yellow arrows. Photo faces south.

SR 156 SITE 6	
Postmile	SBT, SR 156, PM 2.14
GPS location	Latitude: 36.84612 Longitude: -121.54734
Dimensions	Dual box cement culvert. Western culvert 7′ 6″ wide, and 3′ high. The eastern culvert is 7′ 4″ wide and 3′ 2″ high.
Direction	North – south based on direction of decline.
Visibility	Yes. There is visibility from one opening to the other, however the culvert does bend to the east.
Substrate	There is dirt throughout both culverts.
Habitat/land use	Culvert connects open habitat on the south side to riparian habitat on the north side. A nearby levee runs west to east (adjacent to SR 156) connecting to another culvert that is almost constructed as a small bridge to the north. There is housing to the northwest and northeast from the northern opening. A private road leads to the houses. North of the northern opening is another structure resembling a bridge.
Wildlife track and sign	Bobcat, raccoon, and opossum tracks found within the eastern culvert and in the levee.
Track and sign transects	The levee adjacent to the culvert as well as both dual box culverts are highly suitable candidates for tracking transects.

SR 156 Site 6. Northern opening. Photo faces south.

SR 156 Site 6. View from within northern opening of western culvert. The eastern bend toward the southern opening is visible. Photo faces south

SR 156 Site 6. View from within northern opening of eastern culvert. Eastern bend in culvert identical to western culvert. Photo faces south.

SR 156 Site 6. View of bridge to the north. The levee (indicated by yellow arrow) runs through the western section below the bridge.

SR 156 Site 6. Example of habitat and housing beyond the northern opening. Photo faces north.

3. US 101 AROMAS HILLS SECTION

US 101 SITE 1	
Postmile	SBT, US 101, PM 4.92
GPS location	Latitude: 36.8837 Longitude: -121.56221
Dimensions	Medium size triple box culvert with three sections (southern section, center section, and northern section) each approximately 8′ wide and 5′ high. Due to active swallows flying to and from their nests, we avoided the three culverts and instead approximated the dimensions.
Direction	Northwest – southeast.
Visibility	Yes. There is visibility through all three sections.
Substrate	There is approximately 2″ of water throughout all three sections. At the northwestern opening of the northern section sediment appears to be building up. Other than the water and sediment, the substrate is concrete (bare bottom).
Habitat/land use	San Juan Creek flows through this culvert and very thick and dense riparian vegetation leads from the northwestern and southeastern openings. This structure is one of a series of four that allows San Juan Creek to flow south through the interchange. The habitat to the northwest is open agricultural fields, and to the southeast is the interchange between US 101 and SR 129.
Wildlife track and sign	A wildlife trail heads northeast from the southeastern side of the culvert.
Track and sign transects	The banks of the creek and the wildlife trail are suitable candidates for tracking transects.

US 101 Site 1. Southeastern opening showing the three sections of the culvert—from left to right, southern, center, and northern sections. Photo faces west.

US 101 Site 1. Center section facing northeast.

US 101 Site 1. View of northern section showing sediment build-up at the northwestern opening.

US 101 SITE 2	
Postmile	SBT, US 101, PM 4.91
GPS location	Latitude: 36.88288 Longitude: -121.5614
Dimensions	Large dual box culvert with both sections 6′ wide and 8′ high.
Direction	North – south.
Visibility	Yes. There is high visibility through both sections.
Substrate	Both sections have approximately 3″ of water throughout. A bank of mud (1′ wide and 4′ long) extends from the southeastern corner of the eastern section's southern opening. The bank extends north before stopping 4′ within the culvert.
Habitat/land use	This structure is in the middle of the US 101–SR 129 interchange and is the second of four structures that allow San Juan Creek to flow south. There is thick and dense riparian habitat to the north and south of this structure. This is an interesting location with wildlife trails and deer scat adjacent on both sides of the creek.
Wildlife track and sign	Three wildlife trails lead to the riparian habitat at the southern opening from the west. Deer (*Odocoileus hemionus*) scat was found to the west of the riparian habitat near one of the wildlife trails. A coyote (*Canis latrans*) track was found on the 1′-wide, 4′-long bank within the southern opening of the eastern section of the culvert.
Track and sign transects	The banks of the San Juan Creek, the mud bank within the structure, and the three wildlife trails are suitable candidates for tracking transects.

US 101 Site 2. Northern section showing sediment build-up at the northwestern opening.

US 101 Site 2. Northern section showing sediment build-up at the northwestern opening.

US 101 SITE 4 ANZAR ROAD UNDERPASS	
Postmile	SBT, US 101, PM 4.26
GPS location	Latitude: 36.87599 Longitude: -121.56935
Dimensions	Large underpass (well over 20′ high) where Anzar Road runs under US 101.
Direction	West – east
Visibility	Yes. There is high visibility throughout the underpass.
Substrate	There is soft dirt along the northern and southern shoulders and the slopes that lead up to the overpass.
Habitat/land use	Searle Road is to the west, and McAlpine Lake is to the northeast producing a lot of human activity.
Wildlife track and sign	Deer (*O. hemionus*) tracks were found along a pathway at the southern shoulder. Two trails lead north and south through the underpass at both the northern and southern shoulders.
Track and sign transects	The soft soil at both the northern and southern shoulders is highly suitable for tracking transects.

US 101 Site 4 Anzar Road underpass. Photo faces south.

US 101 Site 4 Anzar Road underpass. Southern slope of shoulder leading up to US 101 overpass.

US 101 Site 4 Anzar Road underpass. Deer track located at the southern shoulder heading east. The yellow arrow points in the direction of travel.

US 101 Site 4 Anzar Road underpass. Example of trails west of the southern shoulder. The yellow arrows highlight the trails and point to where the trails meet.

US 101 SITE 5	
Postmile	SBT, US 101, PM 4.00
GPS location	Latitude: 36.87264 Longitude: -121.57197
Dimensions	Round corrugated pipe culvert 4′ in diameter. There is a concrete levee at the northwestern opening.
Direction	Northwest – southeast.
Visibility	Yes. There is visibility through this culvert. A grate in the middle of the culvert allows light in.
Substrate	The steel is corroded at the northwestern opening exposing the earth underneath. Other than the corroded and exposed area, it is corrugated steel (bare bottom) throughout the culvert.
Habitat/land use	This culvert connects a large ravine and opens to the west and east. There is a fence at the end of the levee to the west of the northwestern opening, which is raised.
Wildlife track and sign	A wildlife trail connects the northwestern end of the levee to a lift at the base of the fence to the west.
Track and sign transects	The wildlife trail leading to and from the fence and the muddy substrate in the levee are suitable candidates for tracking transects.

US 101 Site 5. Northwestern opening and concrete levee.


US 101 Site 5. Within northwestern opening, showing the corroded bottom of the culvert.

US 101 Site 5. Raised fence and wildlife trail indicated by yellow arrow.

US 101 SITE 6	
Postmile	SBT, US 101, PM 3.52
GPS location	Latitude: 36.86636 Longitude: -121.57565
Dimensions	Round corrugated culvert 2′ 6″ in diameter.
Direction	West – east
Visibility	Yes. There is visibility to the other side.
Substrate	Corrugated steel (bare bottom).
Habitat/land use	Culvert connects open habitat on both the west and east sides. There is an additional culvert to the west going under Searle Road, however it is buried and filled in with sediment.
Wildlife track and sign	A deceased long-tailed weasel was found in the western opening of the culvert.
Track and sign transects	None

US 101 Site 6. Northern opening.

US 101 Site 6. Western opening close-up. Photo faces east.

US 101 Site 6. Long-tailed weasel carcass within western opening.

US 101 Site 6. Long-tailed weasel carcass close-up.

US 101 Site 6. Culvert to the west under Searle Road.

US 101 SITE 7	
Postmile	SBT, US 101, PM 2.65
GPS location	Latitude: 36.86161 Longitude: -121.58629
Dimensions	Round corrugated pipe culvert 4′ in diameter at the northern opening. Midway through the culvert, it changes from a round corrugated culvert to a square box culvert, with dimensions 4′ x 4′ through to the southern opening. A concrete levee in front of the northern opening extends to the east.
Direction	North – south
Visibility	Yes. There is visibility through the culvert. The square box southern opening can be seen from the northern opening.
Substrate	Concrete (bare bottom)
Habitat/land use	There is open habitat to the north and south with riparian habitat to the north leading to the culvert.
Wildlife track and sign	A wildlife trail can be seen connecting the northern opening with the hole in the fence to the north
Track and sign transects	The wildlife trail is a suitable area for a tracking transect.

US 101 Site 7. Northern opening.


US 101 Site 7. Photo faces the southern opening.


US 101 Site 7. Hole in the fence to the north indicated by yellow arrow.

US 101 SITE 8	
Postmile	SBT, US 101, PM 2.38
GPS location	Latitude: 36.86055 Longitude: -121.59062
Dimensions	Concrete box culvert 4'wide and 4' high. A median grate in the middle of the culvert allows light to shine through. There is also a levee leading east beyond the southern opening.
Direction	Northwest – southeast
Visibility	Yes. There is visibility through the culvert.
Substrate	Concrete (bare bottom)
Habitat/land use	This culvert is large enough to facilitate medium-sized mammal movement, however there are two houses immediately to the southeast of the southern opening. To the north, the nearest homes are between .14 and .25 miles away. There is a ravine to the north for cover.
Wildlife track and sign	None
Track and sign transects	None

US 101 Site 8. Southern opening.

US 101 Site 8. Southern opening close-up. Photo faces north.

US 101 Site 8. Example of the levee leading to the east.

US 101 SITE 9 (Eucalyptus Grove)	
Postmile	SBT, US 101, PM 1.66
GPS location	Latitude: 36.85943 Longitude: -121.60339
Dimensions	Large cement box culvert 8′ wide and 10′ high
Direction	North – south
Visibility	Yes. There is high visibility throughout the culvert.
Substrate	Concrete (bare bottom)
Habitat/land use	This culvert is large enough to facilitate large mammal movement. This culvert only allows safe passage under the northbound lanes of US 101 to the median habitat; however it is one in a series of three culverts that together cross under both lanes and a ravine with cover connects the three culverts.
Wildlife track and sign	None
Track and sign transects	None

US 101 Site 9. Southern opening (in highway median).

US 101 Site 9. Example of ravine and median habitat to the northeast.

US 101 SITE 10 (Eucalyptus Grove)	
Postmile	SBT, US 101, PM 1.62
GPS location	Latitude: 36.85977 Longitude: -121.60423
Dimensions	Large cement box culvert 8′ wide and 10′ high.
Direction	Northwest – southeast
Visibility	Yes. There is high visibility throughout the culvert.
Substrate	Concrete (bare bottom)
Habitat/land use	This culvert is large enough to facilitate large mammal movement. This culvert is only under the northbound lanes of US 101, however it is one in a series of three culverts that together cross under both lanes, and a ravine with cover connects the three culverts.
Wildlife track and sign	Deer (*O. hemionus*) tracks embedded in the cement of the southeastern opening.
Track and sign transects	None

US 101 Site 10. Northern opening with 5′ 7″ tall person standing near southern opening for scale.

US 101 SITE 11 (Eucalyptus Grove)	
Postmile	SBT, US 101, PM 1.57
GPS location	Latitude: 36.86008 Longitude: - 121.605065
Dimensions	Concrete square/box culvert 4′ wide and 4′ high. Built in 1947.
Direction	North – south
Visibility	Yes. There is visibility through the culvert.
Substrate	Soft substrate throughout the culvert made up of fine dirt.
Habitat/land use	This culvert is large enough to facilitate medium-sized mammals. It is the third in a series of three culverts that together cross under US 101. This culvert crosses only under the southbound lanes of US 101 toward the median habitat to the south. The habitat to the north is eucalyptus groves mixed with oak woodland.
Wildlife track and sign	This culvert was previously monitored for the Big Sur Land Trust's Central Coast Wildlife Connectivity study from 2013 to 2014. Species recorded traveling through the culvert include: bobcat, raccoon, skunk, and opossum.
Track and sign transects	None

US 101 Site 11. Northern opening.

US 101 Site 11. Close-up view facing southern opening.

US 101 SITE 13	
Postmile	SBT, US 101, PM 1.12
GPS location	Latitude: 36.86226 Longitude: -121.61215
Dimensions	Round corrugated pipe culvert 3′ in diameter.
Direction	North – south
Visibility	Yes. The opposite opening of the culvert is visible when looking through, however the culvert does have a slight dip in the middle. This dip creates a slight incline toward each opening. A grate near the northern opening allows light to enter.
Substrate	The substrate at the northern opening is a smooth slick black coating over the corrugated steel. The southern opening is corrugated steel (bare bottom).
Habitat/land use	Adjacent business to the north with perimeter barbed wire fence and an RV community to the southeast. A large eucalyptus grove to the south provides cover and other than the business, there is oak woodland to the northeast.
Wildlife track and sign	Site assessors encountered a gopher snake stuck in the middle of the culvert and unable to exit because it could not grip onto the slick coating in the culvert.
Track and sign transects	None

US 101 Site 13. Northern opening with Pacific gopher snake (*Pituophis catenifer catenifer*).

US 101 Site 13. Southern opening.

US 101 SITE 14	
Postmile	SBT, US 101, PM 1.02
GPS location	Latitude: 36.86262 Longitude: -121.61382
Dimensions	Tall concrete rectangular culvert 3′ wide and 7′ high.
Direction	North – south
Visibility	Yes
Substrate	Muddy bottom.
Habitat/land use	This culvert runs only under the northbound lane of US 101 and connects the median habitat to the north to the eucalyptus grove to the south. The southern opening leads into a creek and riparian strip that flows through the RV community parking lot.
Wildlife track and sign	None
Track and sign transects	None

US 101 Site 14. Southern opening.

US 101 SITE 15 (Habitat Island)	
Postmile	SBT, US 101, PM 0.82
GPS location	Latitude: 36.86353 Longitude: -121.61749
Dimensions	Round corrugated pipe culvert 3′ 10″ wide and 4′ high
Direction	North – south
Visibility	Yes. The other opening is visible when looking through.
Substrate	Corrugated steel (bare bottom).
Habitat/land use	Culvert connects open habitat on the north side and opens up into the median habitat island which spans the north and southbound lanes. This culvert runs only under the southbound lane.
Wildlife track and sign	Previously monitored from 2013 to 2014 for the Big Sur Land Trust Central Coast Connectivity Study. Species recorded traveling through the culvert include bobcat, raccoon, and skunk. Bobcat and deer scat recorded on wildlife trail leading to the culvert. Deer carcass recorded just off the southbound shoulder on the northern side.
Track and sign transects	Wildlife trails to the culvert from the highway are suitable candidates for tracking transects.

US 101 Site 15. Northern opening.

US 101 Site 15. Northern opening close-up.

US 101 SITE 16 (Habitat Island)	
Postmile	SBT, US 101, PM 0.49
GPS location	Latitude: 36.86084 Longitude: -121.62256
Dimensions	Large concrete box culvert 6′ wide and 6′ high.
Direction	Northeast – southwest
Visibility	Yes. There is high visibility throughout this culvert.
Substrate	Sand throughout the culvert.
Habitat/land use	This culvert runs only under the southbound lanes, however is possibly large enough to facilitate large mammal movement. It connects open habitat on the north side via a small riparian strip and opens into the habitat median island leading to a dual box culvert.
Wildlife track and sign	Multiple species tracks including bobcat, racoon, and skunk throughout the substrate within the culvert.
Track and sign transects	The sand within and beyond the southern entrance is suitable for tracking transects.

US 101 Site 16. Northeastern opening.

US 101 Site 16. Example of sandy substrate beyond southwestern opening.

US 101 SITE 17 (Habitat Island)	
Postmile	SBT, US 101, PM 0.43
GPS location	Latitude: 36.86003 Longitude: -121.62255
Dimensions	Concrete dual box culverts with the western section 4′ 11″ wide and 3′ 10″ high, and the eastern section 4′ 3″ wide and 5′ high.
Direction	North – south
Visibility	Yes. Moderate visibility. The culvert can be seen through to each end. At the southern opening extended barriers angle to the west. There is thick vegetation at the northern opening.
Substrate	Sandy substrate throughout both sections.
Habitat/land use	Culvert connects the northern habitat median island to the southern riparian habitat leading to large tracts of open habitat of the Gabilan Range. This culvert runs only under the northbound lanes of US 101.
Wildlife track and sign	Multiple species tracks including bobcat, racoon, and skunk. A mountain lion was hit by a vehicle near the culvert on the northbound lane closest to the median habitat island on May 23, 2018. This culvert was monitored from 2013–2014 for the Big Sur Land Trust's Central Coast Wildlife Connectivity Study. Species recorded traveling through this culvert include: bobcat, gray fox, raccoon, and skunk.
Track and sign transects	The sandy substrate throughout both sections are suitable candidates for tracking transects.

US 101 Site 17. Northern opening with thick vegetation.

US 101 Site 17. Example from within western section of angle at southern opening. Photo faces south.

US 101 SITE 19	
Postmile	MON, US 101, PM 100.95
GPS location	Latitude: 36.85359 Longitude: -121.63467
Dimensions	Large concrete triple box culvert. The northern section is 8′ wide and 5′ 10″ high; the center section is 8′ wide and 5′ 9″ high, and the southern section is 10′ wide and 6′ high.
Direction	Northwest – southeast
Visibility	There is no visibility through the western or center sections as they both have two bends within them. The eastern section is straight and has visibility to the other side.
Substrate	All three sections have muddy sand substrate toward the northern openings. The southern openings are concrete (bare bottom).
Habitat/land use	Culvert connects riparian habitat on either side.
Wildlife track and sign	Multiple species tracks were found within all three sections. The eastern culvert had tracks for American beaver (*Castor canadensis*), bobcat, and raccoon.
Track and sign transects	The muddy sand substrate throughout all three sections is highly suitable for tracking transects.

US 101 Site 19. Southeastern opening of triple box culvert.

US 101 Site 19. Facing toward southeastern opening.

US 101 Site 19. American beaver rear track within culvert. Yellow arrow indicates the direction of travel.

US 101 SITE 20A	
Postmile	MON, US 101, PM 100.89
GPS location	Latitude: 36.85271 Longitude: -121.63529
Dimensions	This site has two sections: a large round culvert to the north (20A), and a large box culvert to the south (20B). Site 20A is a round culvert 8′ 7″ wide and 6′ 7″ high.
Direction	West – east
Visibility	Yes. There is high visibility throughout the culvert.
Substrate	Sandy substrate throughout.
Habitat/land use	Culvert connects riparian habitat with plenty of cover on either side.
Wildlife track and sign	Multiple species tracks inside the culvert including deer and coyote (*Canis latrans*). Also, deer, coyote, and bobcat scat identified on a wildlife trail leading down to the culvert.
Track and sign transects	The sandy substrate and wildlife trails are highly suitable candidates for tracking transects.

US 101 Site 20A. Northwestern opening of both sections.

US 101 Site 20A. Within round culvert. Photo faces east.

US 101 Site 20A. Western opening showing wildlife trail (indicated by measuring tape).

US 101 SITE 20B	
Postmile	MON, US 101, PM 100.89
GPS location	Latitude: 36.85271 Longitude: -121.63529
Dimensions	This site has two sections: a large round culvert to the north (20A), and a large box culvert to the south (20B). Site 20B is a large cement box culvert 9′ 10″ wide and 6′ high.
Direction	Northwest – southeast
Visibility	Yes. There is high visibility throughout the culvert.
Substrate	Sandy substrate throughout culvert.
Habitat/land use	Culvert connects riparian habitat on either side with plenty of cover.
Wildlife track and sign	Multiple species tracks identified within culvert including bobcat and raccoon. Deer, coyote, and bobcat scat found on wildlife trails leading down to the culvert.
Track and sign transects	The trails leading to the western opening and the substrate throughout the culvert are highly suitable for tracking transects.


US 101 Site 20B. Western opening.


US 101 Site 20B. Within western opening facing east.

4. SR 152 PAJARO VALLEY SECTION

SR 152 SITE 1 SAN FELIPE LAKE DUAL ROUND CULVERTS	
Postmile	SCL, SR 152, PM 16.58
GPS location	Latitude: 36.98539 Longitude: -121.46276
Dimensions	Double round culvert; each culvert is approximately 4′ in diameter.
Direction	Northwest – southeast
Visibility	Yes. Visibility from one side to the other.
Substrate	Both round culverts have approximately 2′ of sediment throughout the entire length.
Habitat/land use	San Felipe Lake to the south and expansive open grassland habitat to the north.
Wildlife track and sign	No notes taken.
Track and sign transects	The substrate approaching the culvert is somewhat suitable for tracking transects depending on seasonality.

SR 152 Site 1 San Felipe Lake dual round culverts. Photo faces northwest towards culvert entrance on SR 152 eastbound side.

SR 152 Site 1 San Felipe Lake dual round culverts. Photo faces southeast away from the culvert entrance on the SR 152 eastbound side.

SR 152 SITE 2 SAN FELIPE LAKE BOX CULVERT	
Postmile	SCL, SR 152, PM 17.24
GPS location	Latitude: 36.98883 Longitude: -121.45172
Dimensions	Single box culvert approximately 6′ wide and 4′ tall.
Direction	Northwest – southeast
Visibility	Yes. Visibility from one side to the other.
Substrate	Concrete bottom throughout culvert; a couple inches of sediment have been deposited on top of it.
Habitat/land use	San Felipe Lake to the south and expansive open grassland habitat to the north.
Wildlife track and sign	Numerous tracks observed.
Track and sign transects	Site is suitable for tracking transects.

SR 152 Site 2 San Felipe Lake box culvert. Photo faces southeast away from the culvert entrance on the SR 152 eastbound side.

SR 152 Site 2 San Felipe Lake box culvert. Photo faces northwest through the culvert from the SR 152 eastbound side.

SR 152 SITE 3 ORTEGA CREEK BRIDGE	
Postmile	SCL, SR 152, PM 19.32
GPS location	Latitude: 36.97282 Longitude: -121.42469
Dimensions	Small bridge with single middle pier dividing two sections. Bridge is approximately 8′ tall and each section is approximately 15′ wide.
Direction	Northeast – southwest. Direction is based on the alignment of Ortega Creek (also known as Hornstein Creek).
Visibility	Yes. Visibility from one side to the other.
Substrate	Bridge bottom/foundation is concrete, but sediment has deposited throughout most of the foundation.
Habitat/land use	Fragmented, intensive land use on south side, open grassland on north.
Wildlife track and sign	Numerous tracks observed under the bridge.
Track and sign transects	The substrate under the bridge is suitable for a wildlife tracking transect.

SR 152 Site 3 Ortega Creek Bridge. Photo taken from the SR 152 eastbound side of the bridge facing northeast.

SR 152 Site 3 Ortega Creek Bridge. Photo from the SR 152 eastbound side of the bridge facing northeast.

SR 152 SITE 4 COYOTE AND BADGER CULVERT	
Postmile	SCL, SR 152, PM 20.32
GPS location	Latitude: 36.96545 Longitude: -121.40928
Dimensions	Cement round culvert 4′ in diameter.
Direction	Northeast – southwest
Visibility	Yes. High visibility from one side to the other.
Substrate	Concrete bottom without sediment.
Habitat/land use	Grassland habitat on both sides of the culvert.
Wildlife track and sign	None
Track and sign transects	The site is not suitable for tracking transects due to the substrate.

SR 152 Site 4 Coyote and Badger culvert. Photo of culvert entrance on SR 152 westbound side.

SR 152 Site 4 Coyote and Badger culvert. Photo taken from culvert entrance on SR 152 westbound side.

SR 152 SITE 5 COYOTE PUPPY CULVERT

Postmile	SCL, SR 152, PM 20.74
GPS location	Latitude: 36.96143 Longitude: -121.40347
Dimensions	Cement round culvert approximately 30″ in diameter.
Direction	Southwest – northeast
Visibility	Yes. Visibility from one side to the other.
Substrate	Concrete bottom without sediment.
Habitat/land use	Grassland habitat on both sides of the culvert.
Wildlife track and sign	None
Track and sign transects	The site is not suitable for tracking transects due to the substrate.

SR 152 Site 5 Coyote Puppy culvert. Photo of entrance on SR 152 westbound side.

SR 152 Site 5 Coyote Puppy culvert. Photo of culvert entrance on SR 152 westbound side.

SR 152 SITE 6 TREE ROUND CULVERT	
Postmile	SCL, SR 152, PM 20.85
GPS location	Latitude: 36.96109 Longitude: -121.40189
Dimensions	Cement round culvert approximately 30" in diameter.
Direction	Southwest – northeast
Visibility	Yes. Visibility from one side to the other.
Substrate	Concrete bottom without sediment.
Habitat/land use	Grassland habitat on both sides of the culvert.
Wildlife track and sign	None
Track and sign transects	The site is not suitable for tracking transects due to the substrate.

SR 152 Site 6 Tree round culvert. Photo of culvert entrance on SR 152 westbound side.

SR 152 Site 6 Tree round culvert. Photo taken from culvert entrance on SR 152 westbound side.

5. SR 25 PAJARO VALLEY SECTION

SR 25 SITE 1 CARNADERO CREEK BRIDGE	
Postmile	SCL, SR 152, PM 1.55
GPS location	Latitude: 36.95997 Longitude: -121.53468
Dimensions	Moderate-sized bridge where Carnadero Creek (also known as Uvas–Carnadero Creek) runs under SR 25. Bridge is 20'+ tall directly over the creek. Two agricultural dirt roads run under the bridge on the west bank.
Direction	Northeast – southwest. Direction is based on the alignment of Carnadero Creek.
Visibility	Yes. High visibility under the bridge from one side to the other.
Substrate	Substrate is primarily dirt/soil. No hardscape under the bridge except for a small amount of rock armoring the banks of the creek.
Habitat/land use	Agricultural land adjacent to riparian corridor
Wildlife track and sign	No notes taken
Track and sign transects	The substrate under the bridge is suitable for tracking transects.

SR 25 Site 1 Carnadero Creek Bridge. Photo faces northeast along the west bank.

SR 25 Site 1 Carnadero Creek Bridge. Photo from west bank facing southeast towards the east bank.

SR 25 SITE 2 PAJARO RIVER BRIDGE

Postmile	SBT, SR 152, PM 60.08
GPS location	Latitude: 36.94805 Longitude: -121.51211
Dimensions	Moderate-sized bridge where Pajaro River runs under SR 25. Bridge is 20'+ tall directly over the river.
Direction	Northeast – southwest. Direction is based on the alignment of Pajaro River.
Visibility	Yes. High visibility under the bridge from one side to the other.
Substrate	Substrate is primarily dirt/soil. No hardscape under the bridge.
Habitat/land use	Agricultural land adjacent to the riparian corridor.
Wildlife track and sign	Numerous tracks from several species present including bobcat, coyote (*Canis latrans*), and black-tailed deer (*Odocoileus hemionus* ssp. *columbianus*).
Track and sign transects	The substrate under the bridge is highly suitable for tracking transects.


SR 25 Site 2 Pajaro River Bridge. Photo faces northeast along the west bank.


SR 25 Site 2 Pajaro River Bridge. Photo from west bank faces southeast towards the east bank.

6. US 101 PAJARO VALLEY SECTION

US 101 SITE 1 CARNADERO CREEK BRIDGE	
Postmile	SCL, US 101, PM 4.21
GPS location	Latitude: 36.97637 Longitude: -121.55564
Dimensions	Large bridge where Carnadero Creek (also known as Uvas–Carnadero Creek) runs under US 101. Bridge is 20′+ tall directly over the creek. Bridge consists of two separate spans, one for southbound lanes and one for northbound lanes; these spans are connected by a single set of continuous piers.
Direction	Northwest – southeast. Direction is based on the alignment of Carnadero Creek.
Visibility	Yes. Visibility under the bridge from one side to the other.
Substrate	Mix of soils, cobbles, and boulders.
Habitat/land use	Riparian corridor with adjacent row crop agricultural and commercial land uses.
Wildlife track and sign	No notes taken.
Track and sign transects	The substrate under the bridge is suitable for tracking transects.

US 101 Site 1 Carnadero Creek Bridge. Photo faces northwest from the east side of the bridge.

US 101 SITE 2 GAVILAN CREEK CULVERT	
Postmile	SCL, US 101, PM 3.17
GPS location	Latitude: 36.96145 Longitude: -121.55131
Dimensions	Single box culvert approximately 12′ wide by 6′ tall.
Direction	Northwest – southeast
Visibility	Yes. Visibility from one side to the other.
Substrate	Culvert likely has a concrete bottom throughout culvert; however, at least 1′ of sediment has deposited on top of it. Ponding water was present during inspection, and it is presumed that ponding is present most of if not all of the year.
Habitat/land use	Private residence on west side of crossing and row crop agriculture on east side.
Wildlife track and sign	None
Track and sign transects	Due to ponding water, site is not suitable for tracking transects.

US 101 Site 2 Gavilan Creek culvert. Photo faces southeast towards the culvert entrance on the southbound side of US 101.

US 101 Site 2 Gavilan Creek culvert. Photo faces northwest towards the culvert entrance on the northbound side of US 101.

US 101 SITE 3 TICK CREEK CULVERT	
Postmile	SCL, US 101, PM 1.90
GPS location	Latitude: 36.94274 Longitude: -121.55243
Dimensions	Double box culvert with each box approximately 11′ wide by 3′ 4″ tall.
Direction	Northwest – southeast
Visibility	Yes. Visibility from one side to the other.
Substrate	Culvert bottom is concrete, but sediment has deposited throughout most of the culvert.
Habitat/land use	High-quality habitat on both sides of the culvert — riparian on east side and grasslands, wetlands, and woodlands to the west.
Wildlife track and sign	Numerous tracks observed throughout the culvert.
Track and sign transects	The substrate throughout the culvert is suitable for a wildlife tracking transect.

US 101 Site 3 Tick Creek culvert. Photo faces northwest towards the culvert entrance on the northbound side of US 101.

US 101 Site 3 Tick Creek culvert. Photo from the southbound side of US 101 faces southeast through the northern box.

US 101 SITE 4 TAR CREEK OVERPASS	
Postmile	SCL, US 101, PM 0.84
GPS location	Latitude: 36.9289 ongitude: -121.54797
Dimensions	Large bridge where Tar Creek, the railroad, and a private road runs under US 101. Bridge is 20'+ tall directly over the creek. Bridge consists of two separate spans, one for southbound lanes and one for northbound lanes.
Direction	West – east. Direction is based on the alignment of Tar Creek.
Visibility	Yes. High visibility from one side to the other.
Substrate	Various substrates are present, both disturbed and undisturbed.
Habitat/land use	Residence on west side, includes train tracks, high-quality habitat on both sides other than those elements.
Wildlife track and sign	Numerous tracks observed under the bridge.
Track and sign transects	The substrate under the bridge is suitable for tracking transects.

US 101 Site 4 Tar Creek Overpass. Photo faces east from west side of US 101 southbound.

US 101 Site 4 Tar Creek overpass. Photo faces south/southwest from under northbound US 101.

US 101 SITE 5 PAJARO RIVER BRIDGE	
Postmile	SCL, US 101, PM 0.00
GPS location	Latitude: 36.91745 Longitude: -121.54797
Dimensions	Large bridge where Pajaro River runs under US 101. Bridge is 20′+ tall directly over the river.
Direction	West – east. Direction is based on the alignment of Pajaro River.
Visibility	Yes. High visibility from one side to the other.
Substrate	Undisturbed soils are present and hardscape bottom is absent.
Habitat/land use	Wide riparian corridor with high-quality habitat.
Wildlife track and sign	Numerous tracks observed under the bridge.
Track and sign transects	The substrate under the bridge is suitable for tracking transects.

US 101 Site 5 Pajaro River Bridge. Photo taken from north side Pajaro River on west side of US 101 southbound looking south.

US 101 Site 5 Pajaro River Bridge. Photo from south side of Pajaro River faces west under the bridge.

US 101 SITE 6 SAN BENITO RIVER BRIDGE	
Postmile	SBT, US 101, PM 5.25
GPS location	Latitude: 36.88724 Longitude: -121.55888
Dimensions	Large bridge over the San Benito River. Bridge is 20'+ tall directly over the river. Bridge consists of two separate spans, one for southbound lanes and one for the northbound lanes.
Direction	Northwest – southeast. Direction is based on the alignment of San Benito River.
Visibility	Yes. High visibility from one side to the other.
Substrate	Undisturbed soils are present and hardscape bottom is absent.
Habitat/land use	Wide riparian corridor with high-quality habitat.
Wildlife track and sign	Numerous tracks of numerous species were present under the bridge.
Track and sign transects	Fine substrates under the bridge are highly suitable for tracking transects.

US 101 Site 6 San Benito River Bridge. Photo faces south from north side of San Benito River under US 101 southbound.

US 101 Site 6 San Benito River Bridge. Photo faces south taken from north side of San Benito River under US 101 northbound.

APPENDIX C

CROSSING INFRASTRUCTURE INFORMATION SHEETS

OVERVIEW

This appendix includes information sheets on various kinds of crossing infrastructure, based on *Handbook for Design and Evaluation of Wildlife Crossing Structures in North America* (Clevenger and Huijser 2011). These sheets provide an overview of each of the main methods to support wildlife road crossings and reduce wildlife–vehicle collisions.

Sheet 1: Wildlife overpasses

Sheet 2: Wildlife undercrossings

Sheet 3: Wildlife undercrossings with water flow

Sheet 4: Fencing

Sheet 5: Gates and ramps

SHEET 1 WILDLIFE OVERPASSES

GENERAL DESIGN

A wildlife overpass is one of the largest crossing structures to span highways. It is primarily intended to move wide-ranging large mammals.

Wildlife overpasses are vegetated, typically with native plants. If habitat elements are provided on the overpass, small mammals, medium-sized low-mobility mammals, and reptiles will also utilize these structures; with proper vegetation design, these crossings can also encourage use by bats and birds.

Example of a wildlife overpass near Iguazu, Argentina. Photo by Limba-Film Drone Project.

USE OF THE STRUCTURE

Wildlife overpasses are intended for the exclusive use of wildlife. Prohibiting human use and human-related activities adjacent to the structure is highly recommended.

GENERAL GUIDELINES

- Wildlife overpasses should be situated in areas with high landscape permeability, in known wildlife travel corridors, and with minimal human disturbance.
- Soils on and adjacent to the wildlife overpass should be as continuous as possible. Avoid importation of soils from outside the project area.
- Earth berms, solid walls, dense vegetation, or a combination of these should be used on the sides (lateral edges) of the overpass to reduce light and noise from vehicles (see photo).
- Wildlife overpasses should be closed to the public, with human use/activities prohibited.

A berm on the side of a wildlife overpass. Photo by Tony Clevenger.

DIMENSIONS — GENERAL GUIDELINES

Width	Minimum: 40–50m Recommended: 50–70m
Height	Varies based on width of highway
Berm / wall height	2.4m
Soil depth	1.0–1.5m

TYPES OF CONSTRUCTION

Span

- Bridge span (steel truss or concrete)

Arch

- Pre-fabricated cast-in-place concrete arches
- Corrugated steel

Parabolic arch designs create better opportunities for wildlife to locate the approaches; however, costs for arched designs are higher than those for rectangular or straight-edged designs (see Figure B1).

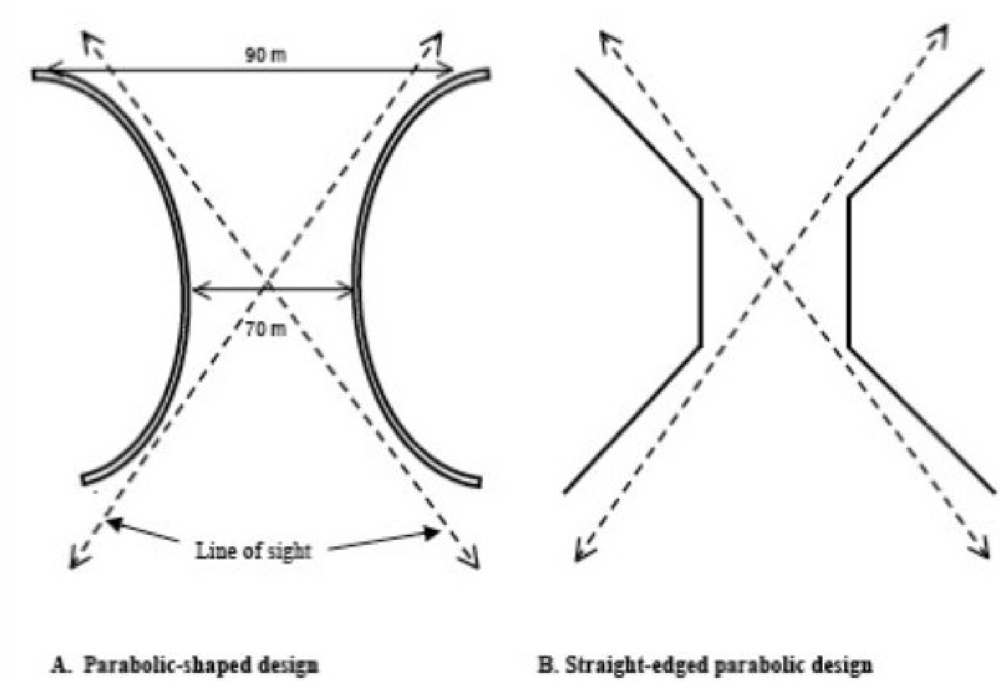


Figure B1. Cross-sections of a parabolic-shaped design (A) and straight-edged design (B) for a wildlife overpass.

SUGGESTED DESIGN DETAILS

Crossing structure

1. A wildlife overpass should be vegetated with native trees, shrubs, and grasses of varying height. Species that match or are taxonomically close to existing vegetation adjacent to structure should be employed. Site and environmental conditions (including climate) may require hardy, drought-tolerant species. The composition of trees, shrubs, and grasses used will vary depending on target species needs.
2. Plant shrubs on the edges of the overpass to provide cover and refuge for small- and medium-sized wildlife. The center portion of the overpass should be open, with low or herbaceous vegetation.
3. Place shrubs, piles of woody debris (logs), or rocks in stepping stone fashion to provide microhabitat and refuge for small, cover-associated fauna. In arid areas, more woody debris and rocks should be used to provide cover for small and medium-sized fauna.
4. Soil depth should be 1–1.5m in depth so that it can retain water for plant growth and support shrubs and trees. The structure must have adequate drainage.
5. Local topography can be created on surface with slight depressions and mounding of material used for fill.
6. Amphibian habitat can be created in a stepping stone fashion or with isolated ponds. Pond habitat may be artificial with impermeable substrates to hold water from rainfall or can be areas otherwise designed to retain water.
7. Earth berms, solid walls, fences, dense vegetation, or a combination of these should be installed on the sides of the structure to attenuate sound and light from traffic. This protection should extend down to the approach ramps and curve around to a wildlife exclusion fence.
8. Exclusionary/directional fencing should be integrated with the wildlife crossing structure.

Local habitat management

1. Wildlife overpasses are best situated in areas bordered by elevated terrain so that the approach ramps and structure surface are at the same level as adjacent land. If the structure is built on level ground, the approach ramps should have gentle slopes (e.g., 5:1). In mountainous areas, one or both slopes may be steeper.
2. Trees and shrubs should be planted along the edges of approach ramps to guide wildlife to the structure entrance. The vegetation should integrate with the adjacent habitat.
3. There is a trade-off between slope and retaining vegetative cover on approach ramps. A steep ramp will retain vegetative cover close to the overpass structure. Gentle slopes (3:1 or 4:1) generally require more fill, which extends the approach ramp farther from the structure and will bury vegetation, including trees.

4. Wildlife fencing is the preferred and most effective way to guide wildlife to the structure and prevent intrusions onto the road right-of-way. Mechanically stabilized earth (MSE) walls, if high enough, can substitute for fencing and is not visible to motorists.
5. Efforts should be made to avoid having any roads pass in front of or near the entrances to the wildlife overpass, as it will hinder wildlife use of the structure.
6. Large boulders can be used to block any vehicle passage on the overpass.
7. Existing or planned human development in adjacent area must be at a sufficient distance to not affect long-term performance of the undercrossing. Long-range planning must ensure that adjacent lands are not developed and the wildlife corridor network is functional.

POSSIBLE VARIATIONS

- Berms on approach ramps
- Berm in middle of overpass

MAINTENANCE

1. Wildlife overpasses are relatively low maintenance. Walls and fences should be checked annually and repaired if necessary.
2. It may be necessary to irrigate new plantings on the structure (particularly in extended periods with little precipitation) for the first few years, until the vegetation becomes established.
3. Monitor and document any human use in the area that might affect wildlife use of the structure and take action necessary to control.

SHEET 2: WILDLIFE UNDERCROSSING

GENERAL DESIGN

While smaller than most large-span bridge and viaducts, a wildlife undercrossing is the largest undercrossing designed specifically for wildlife use. It is designed primarily for large mammals; use by some large mammals will depend on whether it is adapted for their specific crossing requirements. Small- and medium-sized mammals (including carnivores) generally utilize these structures, particularly if cover is provided along the sides of the undercrossing (brush or root wads). Undercrossing structures can be readily adapted for amphibians, semi-aquatic, and semi-arboreal species.

USE OF THE STRUCTURE

A wildlife undercrossing is designed exclusively for use by wildlife.

GENERAL GUIDELINES

1. Wildlife undercrossings should be situated in areas with high landscape permeability that are known wildlife travel corridors and that experience only minimal human disturbance.
2. Because of the relatively small size of a wildlife undercrossing, options for habitat restoration underneath are limited. Open designs that provide ample natural lighting will promote native vegetation.
3. Undercrossings should be designed to conform to local topography. Design drainage features to avoid flooding within the undercrossing. Highway runoff near structure should be directed away from the undercrossing.
4. Maximize continuity of native soils adjacent to and within the undercrossing. Avoid importation of soils from outside the project area.
5. Prohibit all motor vehicle use. Eliminating public access and all human use, activity or disturbance at the undercrossing and adjacent area is recommended.
6. Monitor and document any human use in the area that might affect wildlife use of the structure and take action necessary to control.

Wildlife underpass. Photo by AP Clevenger.

DIMENSIONS — GENERAL GUIDELINES

Width	Minimum: 7m Recommended: <12m
Height	Minimum: 4m Recommended: >4.5m

TYPES OF CONSTRUCTION

Span

- Concrete bridge span (open-span undercrossing)
- Steel beam span

Arch

- Concrete bottomless arch
- Corrugated steel bottomless arch
- Elliptical multi-plate corrugated steel culvert

Box culvert

- Pre-fabricated concrete

SUGGESTED DESIGN DETAILS

Crossing structure

1. A wildlife undercrossing should be designed to meet the needs of the widest possible range of species, e.g., high- and low-mobility species.
2. Habitat in the undercrossing should attempt to mirror the habitat on either sides of the road and provide continuous habitat adjacent to and within the structure.
3. Maximize microhabitat complexity and cover within the undercrossing. Use of salvage materials (logs, root wads, rock piles, boulders, etc.) can encourage use by semi-arboreal mammals, small mammals, reptiles, and other species associated with rocky habitats (see photo).
4. It is preferable that the substrate of the undercrossing is of native soils. If construction type has a closed bottom (e.g., concrete box culvert), a soil substrate > 15cm deep must be applied to interior.
5. Revegetate with native species as much as possible, especially in areas of the undercrossing closest to the entrance. Light conditions may limit vegetation in the center of the structure.
6. Design the undercrossing to minimize the intensity of noise and light coming from the road and traffic.

Local habitat management

1. Protect existing habitat. Design with minimal clearing widths to minimize impacts on existing vegetation. Where habitat loss occurs, reserve all trees, large logs, and root wads to be used in and adjacent to the undercrossing.
2. Wildlife fencing is the preferred and most effective method to guide wildlife to the structure and prevent intrusions onto the road right-of-way. Mechanically-stabilized earth walls, if high enough, can substitute for fencing and may be more aesthetically pleasing.
3. If possible, encourage use of undercrossing by using bait or cutting trails leading to the structure.
4. Avoid building an undercrossing where a road runs parallel and adjacent to the entrances.
5. If traffic volume on the road above the undercrossing is high, it is recommended that sound attenuating walls be constructed above the entrance to reduce noise and light disturbance from passing vehicles.
6. The undercrossing must be within a cross-highway area known to be important for linking habitats and connected to a larger corridor network.
7. Existing or planned development in adjacent areas must be at a sufficient distance to not affect long-term performance of the undercrossing. Long-range planning must ensure that adjacent lands will not be developed and that the wildlife corridor network is functional.

Brush and root wads along the edges of the undercrossing wall provide cover for mammals Photo by Nancy Newhouse.

POSSIBLE VARIATIONS

Divided road (two structures)

- In-line
- Offset

Undivided road (one structure)

MAINTENANCE

1. If the wildlife undercrossing is not regularly monitored, periodic visits should be made to ensure that there are no obstacles or foreign matter in or near the undercrossing that might affect wildlife use.
2. Fences should be checked, maintained, and repaired periodically (at least once per year, preferably twice per year).

SHEET 3: WILDLIFE UNDERCROSSINGS WITH WATER FLOW

GENERAL DESIGN

This is an undercrossing structure designed to accommodate dual needs of moving water and wildlife (see photo). Structures are generally located in wildlife movement corridors given their association with riparian habitats; however, some may be only marginally important. Structures aimed at restoring proper function and connection of aquatic and terrestrial habitats should be situated in areas with high landscape permeability, that are known wildlife travel corridors and that experience only minimal human disturbance. These undercrossing structures are frequently used by several large mammal species; use by some large mammals will depend on whether it is adapted for their specific crossing requirements. Small- and medium-sized mammals (including carnivores) generally utilize these structures, particularly if riparian habitat is retained or cover is provided along walls of the undercrossing by using logs, brush, or root wads. These undercrossing structures can be readily adapted for amphibians, semi-aquatic and semi-arboreal species.

Example of a wildlife undercrossing designed to accommodate water flow. Photo by Tony Clevenger.

USE OF THE STRUCTURE

These structures are exclusively for wildlife, but may have some human use. As with other structures intended for wildlife passage, minimizing human use (including non-motorized and motorized vehicles) is critical for their effectiveness.

GENERAL GUIDELINES

1. The undercrossing structure should span the portion of the active channel migration corridor of unconfined streams needed to restore floodplain, channel, and riparian functions.
2. If the undercrossing structure covers a wide span, support structures should be placed outside the active channel.
3. Design the undercrossing structure with minimal clearing widths to reduce impacts on existing vegetation.
4. Even with large span structures the ability to restore habitat underneath will be limited. Open designs that provide ample natural lighting will encourage greater development of important native riparian vegetation.
5. Maximize the continuity of native soils adjacent to and within the undercrossing. Avoid importation of soils from outside project area.
6. Motor vehicle or all-terrain-vehicle use should be prohibited. Eliminating public or any other human use, activity or potential disturbance at the undercrossing and adjacent area is recommended for proper function and maximizing wildlife use.
7. The undercrossing should be designed to conform to local topography. Design drainage features so flooding does not occur within the undercrossing. Run-off from highway near structure should not end up in the undercrossing.

DIMENSIONS — GENERAL GUIDELINES

Dimensions will vary depending on width of active channel of water flow (creek, stream, river). Guidelines are given below for dimensions of a wildlife pathway alongside an active channel and for height of the undercrossing structure.

Width	Minimum: 3m pathway Recommended: >3m pathway
Height	Minimum: 3m Recommended: >4m

TYPES OF CONSTRUCTION

- Concrete or steel beam bridge span (open-span undercrossing)
- Concrete bottomless arch

SUGGESTED DESIGN DETAILS

Crossing structure

1. Structures should be designed to meet the movement needs of the widest range possible of species that live in the area or might be expected to re-colonize the area — e.g., high- and low-mobility species.
2. Attempt to mirror habitat conditions found on both sides of the road and provide continuous riparian habitat adjacent to and within the structure.
3. Maximize microhabitat complexity and cover within undercrossing using salvage materials (logs, root wads, rock piles, etc.) to encourage use by semi-arboreal mammals, small mammals, reptiles and species associated with rocky habitats.
4. Preferable that the substrate of the undercrossing is of native soils.
5. Revegetation will be possible in areas of undercrossing closest to the entrance, as light conditions tend to be poor in the center of the structure.
6. Design undercrossing to minimize the intensity of noise and light coming from the road and traffic.

Local habitat management

1. Protect existing habitat. Design with minimal clearing widths to reduce impacts on existing vegetation. Where habitat loss occurs, reserve all trees, large logs, and root wads to be used adjacent to and within the undercrossing.
2. Wildlife fencing is the most effective and preferred method to guide wildlife to structure and prevent intrusions to the right-of-way. Mechanically stabilized earth (MSE) walls, if high enough, can substitute for fencing and is not visible to motorists (see photo).
3. Encourage use of undercrossing by either baiting or cutting trails leading to structure, if appropriate.
4. Avoid building undercrossing in a location with road running parallel and adjacent to entrance, as it will affect wildlife use.
5. If traffic volume is high on the road above the undercrossing, it is recommended that sound attenuating walls be placed above the entrance to reduce noise and light disturbance from passing vehicles.
6. The undercrossing must be within the cross-highway habitat linkage zone and connect to larger corridor network.
7. Existing or planned human development in adjacent area must be at sufficient distance to not affect long-term performance of the undercrossing. Long-range planning must ensure that adjacent lands are not developed and the wildlife corridor network is functional.

Mechanically stabilized earth wall serving as wildlife exclusion "fence." Photo by Tony Clevenger.

POSSIBLE VARIATIONS

- Divided road (two structures)
    - In-line
- Undivided road (one structure)
- Critter shelves

MAINTENANCE

1. If the wildlife undercrossing is not regularly monitored, periodic visits should be made to ensure that there are no obstacles or foreign matter in or near the undercrossing that might affect wildlife use.
2. Fences should be checked, maintained, and repaired periodically (at least once per year, preferably twice per year).
3. Monitor and document any human use in the area that might affect wildlife use of the structure and take action necessary to control.

Metal shelving such as the units made by Critter-Crossing allow animals passage through flooded culverts and undercrossings. At top, Professor Kerry Foresman of Critter-Crossing Technology in Montana; middle photos show shelving in a 1.2m wide culvert; lower camera trap photos show small- and medium-sized mammals using the shelving during flooding. Photos courtesy Kerry Foresman.

SHEET 4: FENCING

GENERAL PURPOSE

Fences can keep animals away from roadways and lead them to wildlife crossings where they can travel safely under or above the highway. Fencing is one part of a two-part strategy — fencing and wildlife crossing structures.

To minimize vehicle-related mortality, fences should be impermeable to wildlife. Because of this, fencing can create barriers to movement, isolating wildlife populations, limiting interchange and access to resources — all of which affect the long-term survival of the population.

Wildlife exclusion fencing and culvert undercrossing. Photo by Tony Clevenger.

CONFIGURATIONS

There is little scientific information or best practices regarding effective fence designs to keep wildlife away from roads. However, we can offer configuration guidelines.

The configuration of fencing will depend on several variables associated with the specific location, primarily adjacent land use and traffic volumes. Both sides of the road must be fenced, and fence ends across the road must be symmetric, rather than offset or staggered.

Continuous fencing — Most often associated with large tracts of public land with little or no interspersed private property or inholdings.

Advantages: Long stretches of continuous fencing have fewer fence ends and thus fewer end-runs

Disadvantages: Access roads with continuous fencing will need Texas Gates (cattleguards), electro-mats, painted crosswalks, or gates to keep animals off roads.

Partial (discontinuous) fencing — More common in rural areas characterized by mixed land use (public and private land). Partial fencing is recommended in locations where it is not feasible to fence long sections, private lands cannot be fenced, or there is a need to fence long stretches of highway.

Advantages: Generally accepted by public stakeholders. Few benefits to wildlife and usually the only alternative when there is mixed land use.

Disadvantages: Results in multiple segments of fenced and unfenced stretches of road, each fenced section having two fence ends. Additional measures need to be installed and carefully monitored to discourage end-runs at fence ends and to promote wildlife use of crossing structures (see Terminations below). Escape ramps or jump-outs are also needed near fence ends to allow trapped animals to escape; these are discussed later in this Appendix.

MODIFICATIONS FOR FENCING INTERCEPTIONS

Fences invariably intersect other linear features such as access roads, recreational trails, and waterways (creeks and streams). These breaks or interceptions in fencing require modifications to limit wildlife intrusions into the road right-of-way.

Roads

Texas Gates — Transportation and land management agencies commonly install Texas Gates (also called cattleguards or cowcatchers) where fences intersect access roads (see photo). There are many different designs varying in in dimension, grate material (flat or cylindrical steel grates), and adaptations for safe passage by pedestrians and cyclists.

Few designs have been tested for their effectiveness with wildlife. However, a recently-developed grate pattern is 95% effective in blocking movement of Key deer and is safe for pedestrians and cyclists (Peterson et al 2003). Work by Allen et al. (2013) on fenced sections of US 93 in Montana showed that Texas gates were more than 85% effective in keeping deer from accessing the road, and that 93.5% of deer used the crossing structure instead of the adjacent wildlife guard when crossing the road. The gates were less effective in keeping black bear and coyote from accessing the road (33–55%). However, all black bears and 94.7% of coyotes used the crossing structure instead of the adjacent wildlife guard when crossing

Cattle guard (Texas gate) in road. Photo by Tony Clevenger.

Electro-mats — These electrified mats act like electric Texas Gates to discourage wildlife from crossing at the gap in the fence. Pedestrians wearing shoes and bicyclists can cross the mats safely, but wildlife, dogs, horses, and people without shoes will receive an electric shock. Electro-mats are generally 2–3m wide, but can be designed to any width and can be built into access roads where they breach fences. Cross-Tek® has taken the lead in developing e-mats with success both in high snowfall areas (Alaska) and dry areas (Arizona). The company is currently designing and testing e-mats in Banff National Park.

Painted crosswalks — Painted crosswalks are a visual cue used to guide ungulates across highways at grade level. White lines are painted across the road, emulating a Texas Gate. Painted crosswalks have not been studied, but offer an inexpensive alternative to the more costly cattle guards. See Lehnert and Bissonette 1997 for more details.

Trails

Swing gates (for anglers and hikers) — Where fences impede public access to recreation areas, swing gates can be used. Gates must have a spring-activated hinge that ensures that the gate will not remain open.

SUGGESTED DESIGN DETAILS

Mesh type, gauge and size

Fences may be made of woven-wire (page-wire) or galvanized chain-link. Fence material must be attached to the non-highway side of the posts, so any impacts from vehicles will take down only the fence material and not the fence posts.

1. Woven-wire or page-wire fence consists of smooth horizontal (line) wires held apart by vertical (stay) wires. Spacing between line wires may vary from 8cm at the bottom for small animals to 15–18cm at the top for large animals. Wire spacing generally increases as you move up the fence. Mesh wire is made in 11, 12, 12-1/2, 14, and 16 gauges, and fences are available in different mesh and knot designs. The square-shaped mesh may facilitate climbing by some wildlife. A smaller mesh will deter climbing. Wildlife fences along the Trans-Canada Highway in Banff National Park consist of 12-1/2 gauge line wires with tensile strength of 1390 N/sq. mm. Stay wires have a tensile strength of 850N/mm^2. All wires had Class III zinc galvanized coating (see below) at a minimum of 260g/m^2. Woven- or page-wire fencing is the most common type of fencing used for these types of projects.
2. Chain-link fence is made of heavy steel wire woven to form a diamond-shaped mesh affixed to steel posts. Chain-link is used in industrial, commercial, and residential applications, including highway mitigation fencing along I 75 and SR 29 in Florida. Chain-link fencing is less attractive than woven-wire fencing, and does not blend into the landscape. It is not used as commonly as woven- or page-wire fencing.
3. Most wire sold today for fencing has a coating to protect the wire from rust and corrosion. Chain-link fencing, for example, can be galvanized mesh, plastic-coated galvanized mesh or aluminum mesh. Galvanizing is the most common coating, and is classified into three categories; Classes I, II, and III. Class I has the thinnest coating and the shortest life expectancy. Nine-gauge wire with Class I coating will start showing general rusting in 8 to 10 years, while the same wire with Class III coating will show rust in 15 to 20 years.
4. Electric fences are a safe and effective means to exclude large wildlife. These deliver a mild electric shock to animals that touch the fence, discouraging them from passing through. Electric fencing is made of several horizontal strands of rope-like wire (about 1cm in diameter) that can deliver a quick shock that is enough to sting, but not seriously harm humans. Wildlife respond differently to standard electric fences. There are public safety issues associated with electrified fencing along public roads and highways where hikers, anglers, and motorists may contact the fence, so it is best used along private roads and lands.

Post types

1. Wood posts are common and can be less expensive than other materials if cut from a local woodlot or if untreated posts are purchased. In California, softwoods such as Douglas fir, hem-fir, and southern yellow pine are most commonly used for posts when fencing highways. Post durability varies with species.
2. The life expectancy of pressure-treated wooden posts is generally 20 to 30 years, depending on the type of wood. For Trans-Canada Highway wildlife fences, all round fence posts were pressure treated with a chromate copper arsenate (CCA) wood preservative, though are various types of other preservatives available to treat fence posts (see Lebow et al. 2019).
3. Wood posts are highly variable in size and shape. Typical 2.4m-high fencing uses unsharpened wooden posts 3.7m and 4.2m long. The posts are sharpened and then installed by preparing a pilot hole approximately 125mm in diameter, vibrating the post down to specified post height, and backfilling around the post with a compacted non-organic material to ground level.
4. The strength of wood posts increases with top diameter. Post strength is especially important for corner and gate posts, which should have a top diameter of at least 16cm. Line posts can be as small as 13cm and should not need to be more than 14cm on top diameter, although larger diameter posts make fences stronger and more durable.
5. Steel posts are used to support fences across rock substrate. They are more expensive than wooden posts, but lighter and more durable. Steel posts are typically 3.7m high and 8cm in diameter, and installed in concreted 1m-long sleeves.
6. Tension between posts can be maintained with metal tubing (on metal posts) or reinforced cable (on wooden posts).

REINFORCEMENTS

1. Unburied fences are used where wildlife is not likely to dig under the fence. The fence material should be flush with the ground to minimize animals crawling beneath the fence.
2. Buried fences are strongly recommended in areas with wildlife capable of digging under the fence (e.g., canids, badgers, wild boar). Buried fence in Banff National Park significantly reduced wildlife intrusions to the road right-of-way compared to unburied fence (Clevenger et al. 2002). Buried fence consists of a 1 -1.2m-wide section of galvanized chain-link fence spliced to the bottom of unburied fence material (see photo). The chain-link section is buried at a 45° angle away from the highway and is approximately 1.1m below ground. Swing gates should have a concrete base to prevent digging under them.
3. A protective high-tensile cable strung on top of fence posts can help break the fall of trees onto fencing. Such falls can provide openings for wildlife, and use of a protective cable should minimize fence damage, repair costs, and maintenance time (see photo).

Wildlife exclusion fence with buried apron. Photo by Tony Clevenger.

High tensile cable designed to break fall of trees onto fence material. Photo by Tony Clevenger.

TERMINATIONS (FENCE ENDS)

Fence ends are notorious locations for wildlife movements across roads and subsequent vehicle collisions. The problem is most acute immediately after fence installation as wildlife are unsure where to cross the road, follow fences to their termination, and then make end-runs across the road or graze inside the fence.

Each situation is different and will require a site-specific assessment, but as a general rule, fence ends should terminate at a wildlife crossing structure.

If a wildlife crossing cannot be installed at the fence ends, then fences should be designed to terminate in locations least suitable for wildlife movement—i.e., places wildlife are least likely to cross roads. Some examples are:

- Steep, rugged terrain such as rock-cuts
- Habitats that tend to limit movement, e.g., open areas for forest-dwelling species
- Human-altered habitats and areas with frequent human activity and disturbance

A technical solution for addressing terminations is an animal detection system at fence ends. These detect wildlife approaching or crossing roads and alert motorists with electronic signage or lights, effective creating an automatic crosswalk.

Animal detection systems (ADS) have been found to reduce WVC with large mammals by 33–97%, but should be considered experimental due to technological and maintenance challenges, as well as current difficulty using this technology for small and medium wildlife (Huijser et al. 2021). Furthermore, ADS do not address the barrier effect of a road and associated traffic (Huijser et al. 2021).

DIMENSIONS — GENERAL GUIDELINES

Highway fencing for large mammals, including native ungulates such as elk and deer, should be a minimum of 2.4m high with post separation on average every 4.2 to 5.4m.

Height	Minimum 2.4m
Post separation	Avg. 4.2–5.4m

Alternate fence design and specifications will need to reflect not only requirements for species present, but also species that may recolonize or disperse into the area in the future.

MAINTENANCE

1. Fences are neither permanent nor indestructible. They are subject to frequent damage from vehicles, falling trees and rocks, and vandalism. Soil erosion, excavation by animals, and flooding can loosen fence posts and collapse portions of fencing.
2. Fences must be checked every six months by walking entire fence lines to look for gaps, breaks and other defects.
3. Monitor and document any human use in the area that might affect wildlife use of the structure and take action necessary to control.

SHEET 5: GATES AND ESCAPE RAMPS

GENERAL PURPOSE

An animal that becomes trapped inside a fenced area needs to be able to safely exit. The most effective way to allow such escape is through a steel swing gate or an earthen escape ramp, also called a jump-out (see photo). The number, type and location of escape structures will depend on the target species, terrain, and habitat adjacent to the fence.

Wildlife escape ramp (jump-out). Photo by Tony Clevenger.

APPLICATION

1. Swing gates are generally used (with or without ramps) in areas where highways are regularly patrolled by wardens or rangers (see photo). When an animal is found inside the fence, the ranger can open the nearest gate and move the animal towards the opened gate. Double swing gates are more effective than single gates, especially for larger mammals such as elk or deer.

Single swing gate on a wildlife exclusion fence. Photo by Tony Clevenger.

2. Earthen escape ramps or jump-outs allow wildlife (large and small) to safely exit right-of-ways on their own. Typically wildlife find the ramps and exit by jumping over the fence and down. Deer and elk are the most common users, but mountain lions use these structures as well. The outside walls of the escape ramp must be high enough to discourage wildlife from jumping up onto the ramp and accessing the road right-of-way. However, the walls should not be so high they discourage wildlife from jumping off.
3. The outside wall height and materials should be designed with consideration for the behavior and ecology of native wildlife. The landing spot must consist of loose soil or other soft material to prevent injury to jumping animals. The outside walls must be smooth to prevent animals from climbing up.
4. Escape ramps should be positioned in a setback in the fence, and ideally would be protected with vegetative cover so that panicked animals can calm down before deciding to use the jump-out or continue walking along the fence. A right-angle jog in the fence is recommended for positioning the escape ramp.

   Escape ramps are important at fence termination, where animals can perform "end runs" and become trapped inside the fenced-off highway. Such problems can be mitigated by providing at least two escape ramps near each fence end — one on each side of the highway. If animals come inside the fenced portion of a highway, they typically travel close to the fence searching for an exit. A jump-out near the fence end maximizes the chances that the animal will find the jump-out and exit safely.

Escape ramp (jump-out) for wildlife trapped inside highway right-of-way. Photo by Tony Clevenger.

MAINTENANCE

1. Like fences, gates and ramps are neither permanent nor indestructible. They are subject to constantly occurring damage from vehicle accidents, falling trees, and vandalism. Natural events also can cause damage, obstruct gates and affect how well they perform.
2. Like fences, escape structures must be checked every six months to ensure that they are functioning properly. These can be inspected together with fence inspections.
3. Monitor and document any human use in the area that might affect wildlife use of the structure and take action necessary to control.

REFERENCES FOR APPENDIX C

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APPENDIX D

HOT SHEETS FOR CONNECTIVITY EMPHASIS SITES

Each hot sheet provides a quick reference with a summary of opportunities at each CES, including site-specific information relevant to connectivity, target species, wildlife objectives, and recommendations o improve safe passage opportunities for wildlife.

High priority, critically urgent

1.	US 101 Site 4 Tar Creek overpass	SCL, US 101, PM 0.84
2.	US 101 Site 11 (Eucalyptus Grove)	SBT, US 101, PM 1.57
3.	US 101 Site 16 (Habitat Island)	SBT, US 101, PM 0.49
4.	US 101 Site 6 San Benito River Bridge	SBT, US 101, PM 5.25

Functional sites to maintain and enhance

5.	SR 25 Site 2 Pajaro River Bridge	SBT, SR 25, PM 60.08
6.	US 101 Site 5 Pajaro River Bridge	SCL, US 101, PM 0.00
7.	SR 129 Site 5 Pajaro River Bridge	SBT, SR 129, PM 0.00
8.	SR 129 Site 8	SCR, SR 129, PM 7.88
9.	US 101 Site 20B	MON, US 101, PM 100.89
10.	SR 129 Site 3	SBT, SR 129, PM 1.31
11.	SR 25 Site 1 Carnadero Creek Bridge	SCL, SR 25, PM 1.55
12.	SR 129 Site 1	SBT, SR 129, PM 2.27

Near-term maintenance sites with additional enhancement opportunities

13.	SR 152 Site 2 San Felipe Lake box culvert	SCL, SR 152, PM 17.24
14.	SR 152 Badger hotspot	SCL, SR 152, PM 20.3-21.85
15.	US 101 Site 7	SBT, US 101, PM 2.65
16.	SR 152 Site 1 San Felipe Lake dual round culverts	SCL, SR 152, PM 16.58
17.	US 101 Site 3 Tick Creek culvert	SCL, US 101, PM 1.90
18.	SR 156 Site 3	SBT, SR 156, PM 1.38
19.	US 101 Site 2 Gavilan Creek culvert	SCL, US 101, PM 3.17

HOT SHEET **1**

US 101 Site 4 Tar Creek overpass

High priority, critically urgent

DESCRIPTION	NOTES
Postmile SCL 0.84 **Lat/Long: 36.9289, 121.54797**	
Existing infrastructure: Elevated road segment	
Mean score: 4.3 Regional connectivity: **5** Local connectivity: **5** Land-use security: **3**	
TARGET SPECIES FOR CONNECTIVITY ENHANCEMENTS	
Conservation and connectivity: American badger, long-tailed weasel, gray fox, coyote, bobcat, deer	
WILDLIFE OBJECTIVES	
• Provide safe movement for wildlife traveling between Sargent Hills and Upper Pajaro Valley. • Maintain connectivity as currently facilitated at this site.	
LAND-USE SECURITY	
• Protected habitat on the east side of the highway (Carnadero Preserve). • Proposed development adjacent to Tar Creek (Sargent Quarry in Sargent Ranch, currently undergoing environmental review).	
RECOMMENDATIONS	
Near-term • Add fencing (with gate, as needed) at the access road from northbound 101 to reduce roadkill. • Modify and/or improve fencing on the east side of northbound 101 as needed. **Near- and long-term** • Focus on improving land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity across Highway 101.	

HOT SHEET **2**

US 101 Site 11 (Eucalyptus Grove)

High priority, critically urgent

DESCRIPTION	NOTES
Postmile SBT 1.57 **Lat/Long: 36.86008, -121.60507**	
Existing infrastructure: Existing culverts of varying sizes; no structures provide clear/straight passage under all traffic lanes	
Mean score: 4.0 Regional connectivity: **5** Local connectivity: **4** Land-use security: **3**	
TARGET SPECIES FOR CONNECTIVITY ENHANCEMENTS	
WVC reduction: Primarily mountain lion **Conservation and connectivity:** Primarily mountain lion	
WILDLIFE OBJECTIVES	
▪ Restore mountain lion population (genetic) connectivity.	
LAND-USE SECURITY	
▪ Protected land to the south (Rocks Ranch).	
RECOMMENDATIONS	
Near-term ▪ Modify fences along the protected habitat at Rocks Ranch to increase permeability. ▪ In the eucalyptus grove on north side of highway, create unpaved roads/trails with native vegetation on periphery, which may increase use of existing new structure(s) in the near-term. **Near- and long-term** ▪ Add new primary class crossing structure (overpass or open-span underpass that spans the northbound and southbound lanes of US 101 and the vegetated median). ▪ Install fencing to guide animal movement to structure and keep animals off road; incorporate escape ramps/jump-outs near ends of fence as appropriate. ▪ Improve land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity. ▪ Landscape-scale habitat restoration/enhancement should be determined in subsequent detailed planning for a new wildlife crossing structure.	

HOT SHEET **3**

US 101 Site 16 (Habitat Island)

High priority, critically urgent

DESCRIPTION	NOTES
Postmile SBT 0.49 **Lat/Long: 36.86084, -121.62256**	
Existing infrastructure: Existing culverts of varying sizes; no structures provide clear/straight passage under all traffic lanes	
Mean score: 4.0 Regional connectivity: **5** Local connectivity: **4** Land-use security: **3**	
TARGET SPECIES FOR CONNECTIVITY ENHANCEMENTS	
WVC reduction: Multiple species, including deer and mountain lion **Conservation and connectivity:** Multiple species, including mountain lion	
WILDLIFE OBJECTIVES	
• Provide safe passage for wildlife between high-quality habitat on both sides of the highway. • Reduce WVC/road mortality.	
LAND-USE SECURITY	
• Protected land to the south (Rocks Ranch).	
RECOMMENDATIONS	
Near-term • Perform selective vegetation management (clearing). • Add directional fencing to increase wildlife access to the existing culvert system while maintaining cover and structure. **Near- and long-term** • Add new primary class crossing structure (overpass or open-span underpass over north-bound and southbound lanes of US 101 and the vegetated median) with associated fencing. • Improve land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.	

HOT SHEET **4**

US 101 Site 6 San Benito River Bridge

High priority, critically urgent

DESCRIPTION	NOTES
Postmile SBT 5.25 **Lat/Long: 36.88724, -121.55888**	
Existing infrastructure: Large, open underpass (bridge)	
Mean score: 4.0 Regional connectivity: **5** Local connectivity: **5** Land-use security: **2**	
TARGET SPECIES FOR CONNECTIVITY ENHANCEMENTS	
Conservation and connectivity: Multiple species, including mountain lion and deer	
WILDLIFE OBJECTIVES	
• Maintain and enhance safe passage for wildlife living in and moving through the San Benito River corridor.	
LAND-USE SECURITY	
• While this site has some level of protection through the existing Riparian Protection Ordinance (San Benito County), development activities continue to take place near the riparian corridor. • The proposed Betabel Road project, a commercial proposal along US 101, is located north of the site.	
RECOMMENDATIONS	
Near-term • Incorporate fencing between highway lanes (at median) to prevent wildlife from accessing middle of highway from the riparian area. • Maintain existing structure, ensuring that wildlife can travel on dry land along the river bank. **Near- and long-term** • Focus on improving land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.	

HOT SHEET **5**

SR 25 Site 2 Pajaro River Bridge

Functional site to maintain and enhance

DESCRIPTION	NOTES
Postmile SBT 60.08 **Lat/Long: 36.94805, -121.51211**	
Existing infrastructure: Large, open underpass (bridge)	
Mean score: 4.0 Regional connectivity: **5** Local connectivity: **5** Land-use security: **2**	
TARGET SPECIES FOR CONNECTIVITY ENHANCEMENTS	
Conservation and connectivity: Multiple species, including deer	
WILDLIFE OBJECTIVES	
• Maintain and enhance function as safe passage for wildlife under the highway. • Maintain value relative to cross-valley connectivity.	
LAND-USE SECURITY	
• While this site has some level of protection through the existing Riparian Protection Ordinance (San Benito County), it is vulnerable to conversion and other intensification of human activity in proximity to the corridor.	
RECOMMENDATIONS	
Near-term • Maintain existing structure. **Long-term** • Focus on improving land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.	

HOT SHEET **6**

US 101 Site 5 Pajaro River Bridge

Functional site to maintain and enhance

DESCRIPTION	NOTES
Postmile SCL 0.00 **Lat/Long: 36.91745, -121.54797**	
Existing infrastructure: Large, open underpass (bridge)	
Mean score: 4.0 Regional connectivity: **5** Local connectivity: **5** Land-use security: **2**	
TARGET SPECIES FOR CONNECTIVITY ENHANCEMENTS	
Conservation and connectivity: Multiple species, including deer	
WILDLIFE OBJECTIVES	
▪ Maintain safe passage for wildlife under the highway. ▪ Maintain value relative to cross-valley connectivity.	
LAND-USE SECURITY	
▪ While this site has some level of protection through the existing Riparian Protection Ordinance (San Benito County), it is vulnerable to conversion and other intensification of human activity in proximity to the corridor.	
RECOMMENDATIONS	
Near-term ▪ Maintain existing structure. **Long-term** ▪ Focus on improving land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.	

HOT SHEET **7**

SR 129 Site 5 Pajaro River Bridge

Functional site to maintain and enhance

DESCRIPTION	NOTES
Postmile SBT 0.00 **Lat/Long: 36.90051, -121.5976**	
Existing infrastructure: Large, open underpass (bridge)	
Mean score: 3.3 Regional connectivity: **4** Local connectivity: **4** Land-use security: **2**	
TARGET SPECIES FOR CONNECTIVITY ENHANCEMENTS	
Conservation and connectivity: Multiple species, including deer	
WILDLIFE OBJECTIVES	
▪ Maintain function as safe passage for wildlife under the highway.	
LAND-USE SECURITY	
▪ Protected property on the northwestern side of the structure (Land Trust of Santa Cruz County).	
RECOMMENDATIONS	
Near-term ▪ Maintain existing structure, ensuring that wildlife can travel on dry ground along the river bank. **Long-term** ▪ Focus on improving land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.	

HOT SHEET **8**

SR 129 Site 8

Functional site to maintain and enhance

DESCRIPTION	NOTES
Postmile SCR 7.88 **Lat/Long: 36.91135, -121.63035**	
Existing infrastructure: Large, open underpass (bridge)	
Mean score: 2.7 Regional connectivity: **2** Local connectivity: **2** Land-use security: **4**	
TARGET SPECIES FOR CONNECTIVITY ENHANCEMENTS	
Conservation and connectivity: Mesocarnivores	
WILDLIFE OBJECTIVES	
▪ Maintain and enhance function as safe passage for wildlife under the highway.	
LAND-USE SECURITY	
▪ With the river to the south and very steep topography to the north, this site likely has a low likelihood of being converted to non-habitat uses.	
RECOMMENDATIONS	
Near-term ▪ Maintain structure. **Long-term** ▪ Replace existing structure with new tertiary class wildlife crossing structure. ▪ Consider modifying outlet (south) side topography to promote wildlife access from river to culvert. ▪ Improve land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.	

HOT SHEET **9**

US 101 Site 20B

Functional site to maintain and enhance

DESCRIPTION	NOTES
Postmile MON 100.89 **Lat/Long: 36.85271, -121.63529**	
Existing infrastructure: Large culvert	
Mean score: 2.7 Regional connectivity: **2** Local connectivity: **4** Land-use security: **2**	
TARGET SPECIES FOR CONNECTIVITY ENHANCEMENTS	
Conservation and connectivity: Multiple species, including deer	
WILDLIFE OBJECTIVES	
• Maintain and enhance function as safe passage for wildlife under the highway.	
LAND-USE SECURITY	
• No adjacent lands are protected. • Rural residential, commercial, and agricultural uses adjacent to highway; some level of protection from riparian protection ordinance.	
RECOMMENDATIONS	
Near-term • Maintain existing structure. • Focus on improving land-use security in the area and manage adjacent lands in a way that protects permeability for wildlife. **Long-term** • Consider adding/integrating directional fencing with existing structures at Sites 20A and 20B.	

HOT SHEET **10**

SR 129 Site 3

Functional site to maintain and enhance

DESCRIPTION	NOTES
Postmile SBT 1.31 **Lat/Long: 36.89307, -121.57847**	
Existing infrastructure: Culvert	
Mean score: 2.3 Regional connectivity: **3** Local connectivity: **3** Land-use security: **1**	
TARGET SPECIES FOR CONNECTIVITY ENHANCEMENTS	
WVC reduction: Bobcat, striped skunk **Conservation and connectivity:** Multiple species, especially mesocarnivores	
WILDLIFE OBJECTIVES	
▪ Maintain and enhance function as safe passage for wildlife under the highway. ▪ Reduce WVC/road mortality.	
LAND-USE SECURITY	
▪ No adjacent lands are protected. ▪ Rural residential uses adjacent.	
RECOMMENDATIONS	
Near-term ▪ Maintain structure. **Long-term** ▪ Focus on improving land-use security in the area and manage adjacent lands in a way that protects permeability for local wildlife. ▪ Consider replacing existing structure with tertiary class undercrossing structure and associated directional fencing.	

HOT SHEET **11**

SR 25 Site 1 Carnadero Creek Bridge

Functional site to maintain and enhance

DESCRIPTION	NOTES
Postmile SCL 1.55 **Lat/Long: 36.95997, -121.53468**	
Existing infrastructure: Large underpass (bridge)	
Mean score: 2.0 Regional connectivity: **2** Local connectivity: **3** Land-use security: **1**	
TARGET SPECIES FOR CONNECTIVITY ENHANCEMENTS	
Conservation and connectivity: Multiple species, especially mesocarnivores	
WILDLIFE OBJECTIVES	
▪ Maintain and enhance function as safe passage for wildlife under the highway	
LAND-USE SECURITY	
▪ Adjacent lands show relatively intensive human use (including within the riparian area) and lack protected status.	
RECOMMENDATIONS	
Near-term ▪ Maintain existing structure. **Long-term** ▪ Focus on improving land-use security in the area and manage area in a way that protects permeability for local and regional wildlife habitat conservation and population connectivity.	

HOT SHEET **12**

SR 129 Site 1

Functional site to maintain and enhance

DESCRIPTION	NOTES
Postmile SBT 2.27 **Lat/Long: 36.88695, -121.56503**	
Existing infrastructure: Small culvert	
Mean score: 1.3 Regional connectivity: **1** Local connectivity: **2** Land-use security: **1**	
TARGET SPECIES FOR CONNECTIVITY ENHANCEMENTS	
WVC reduction: Bobcat, striped skunk, badger **Conservation and connectivity:** Multiple species, especially mesocarnivores	
WILDLIFE OBJECTIVES	
• Maintain and enhance function as safe passage for wildlife under the highway • Reduce WVC/road mortality	
LAND-USE SECURITY	
• No adjacent protected lands.	
RECOMMENDATIONS	
Near-term • Maintain structure. **Near- and long-term** • Focus on improving land-use security in the area and manage adjacent lands in a way that protects permeability for local wildlife. • Consider replacing existing structure with tertiary class undercrossing structure and associated directional fencing.	

HOT SHEET **13**

SR 152 Site 2 San Felipe Lake box culvert

Near-term maintenance site with additional enhancement opportunities

DESCRIPTION	NOTES
Postmile SCL 17.24 **Lat/Long: 36.98883, -121.45172**	
Existing infrastructure: Box culvert	
Mean score: 4.3 Regional connectivity: **5** Local connectivity: **5** Land-use security: **3**	
TARGET SPECIES FOR CONNECTIVITY ENHANCEMENTS	
WVC reduction: Multiple species **Conservation and connectivity:** Multiple species, especially mesocarnivores and deer. This site also overlaps critical habitat for California tiger salamander.	
WILDLIFE OBJECTIVES	
• Maintain and enhance function as safe passage for wildlife under the highway. • Reduce WVC/road mortality.	
LAND-USE SECURITY	
• Protected land on south side of the highway (San Felipe Lake Ranch Easement).	
RECOMMENDATIONS	
Near-term • Modify existing fence (south side) for wildlife permeability and perform vegetation management to enhance access to culvert opening (north side). **Long-term** • Add new tertiary class undercrossing structure and wing-fencing to guide animal movement to structure and keep animals off road; install escape ramps/jump-outs near ends of fence. • Improve land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.	

HOT SHEET **14**

SR 152 Badger hotspot

Near-term maintenance site with additional enhancement opportunities

DESCRIPTION	NOTES
SCL, SR 152, PM 20.3-21.85	
Existing infrastructure: Several round culverts within a stretch of highway	
TARGET SPECIES FOR CONNECTIVITY ENHANCEMENTS	
WVC reduction: American badger, deer **Conservation and connectivity:** Primarily badger, mesocarnivores, and deer. This stretch of highway also overlaps critical habitat for California tiger salamander and California red-legged frog.	
WILDLIFE OBJECTIVES	
• Reduce WVC/road mortality, especially for American badger (California Species of Special Concern). • Maintain and enhance function as safe passage for wildlife under the highway.	
LAND-USE SECURITY	
• No protected lands on either side of highway.	
RECOMMENDATIONS	
Near- and long-term • Add wildlife fencing between existing undercrossing structures. • Add additional undercrossing structures between existing culverts. At least one secondary or tertiary class undercrossing structure should be large enough to provide passage for deer. • Improve land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.	

HOT SHEET **15**

US 101 Site 7 (east of Eucalyptus Grove)

Near-term maintenance site with additional enhancement opportunities

DESCRIPTION	NOTES
Postmile SBT 2.65 **Lat/Long: 36.86161, -121.58629**	
Existing infrastructure: Culvert	
Mean score: 3.3 Regional connectivity: **5** Local connectivity: **4** Land-use security: **1**	
TARGET SPECIES FOR CONNECTIVITY ENHANCEMENTS	
Conservation and connectivity: Multiple species, including mountain lion and deer	
WILDLIFE OBJECTIVES	
▪ Create/enhance function as safe passage under the highway for wildlife, especially large mammals like deer and mountain lion.	
LAND-USE SECURITY	
▪ Rural residential development on both sides of the highway.	
RECOMMENDATIONS	
Near-term ▪ Manage vegetation immediately adjacent to the site to encourage species' use. **Near- and long-term** ▪ Retrofit structure (secondary class underpass). ▪ Improve land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.	

HOT SHEET **16**

SR 152 Site 1 San Felipe Lake dual round culverts

Near-term maintenance site with additional enhancement opportunities

DESCRIPTION	NOTES
Postmile SCL 16.58 **Lat/Long: 36.98539, -121.46276**	
Existing infrastructure: Two culverts, side by side	
Mean score: 3.3 Regional connectivity: **4** Local connectivity: **4** Land-use security: **3**	
TARGET SPECIES FOR CONNECTIVITY ENHANCEMENTS	
WVC reduction: Multiple species **Conservation and connectivity:** Multiple species, especially mesocarnivores	
WILDLIFE OBJECTIVES	
▪ Maintain and enhance function as safe passage for wildlife under the highway.	
LAND-USE SECURITY	
▪ Protected land on south side of the highway (San Felipe Lake Ranch Easement)	
RECOMMENDATIONS	
Near-term ▪ Clear blockages from culvert (e.g. sediment). **Long-term** ▪ Add new tertiary class undercrossing structure and wing-fencing to guide animal movement to structure and keep animals off road. ▪ Add escape ramps/jump-outs near ends of fence. ▪ Improve land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.	

HOT SHEET **17**

US 101 Site 3 Tick Creek culvert

Near-term maintenance site with additional enhancement opportunities

DESCRIPTION	NOTES
Postmile SCL 1.90 **Lat/Long: 36.94274, -121.55243**	
Existing infrastructure: Two box culverts, side by side	
Mean score: 2.7 Regional connectivity: **3** Local connectivity: **3** Land-use security: **2**	
TARGET SPECIES FOR CONNECTIVITY ENHANCEMENTS	
Conservation and connectivity: Mesocarnivores	
WILDLIFE OBJECTIVES	
• Maintain and enhance function as safe passage for wildlife under the highway.	
LAND-USE SECURITY	
• Protected agricultural land on east side of the highway with riparian habitat (Carnadero Preserve).	
RECOMMENDATIONS	
Near-term • Manage seasonal vegetation to increase access to the culvert while maintaining some cover. **Long-term** • Replace the existing culvert with a tertiary class wildlife undercrossing and wing-fencing to guide animal movement to structure and keep animals off road. • Improve land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.	

HOT SHEET **18**

SR 156 Site 3

Near-term maintenance site with additional enhancement opportunities

DESCRIPTION	NOTES
Postmile SBT 1.38 **Lat/Long: 36.84949, -121.56099**	
Existing infrastructure: Culvert	
Mean score: 2.3 Regional connectivity: **1** Local connectivity: **3** Land-use security: **3**	
TARGET SPECIES FOR CONNECTIVITY ENHANCEMENTS	
Conservation and connectivity: Mesocarnivores	
WILDLIFE OBJECTIVES	
▪ Maintain and enhance function as safe passage for wildlife under the highway.	
LAND-USE SECURITY	
▪ Protected land on south side of Highway 156 (Nyland property).	
RECOMMENDATIONS	
Near-term ▪ Modify gate at culvert opening to promote wildlife passage. **Near- and long-term** ▪ Create a mix of vegetated/cover and open conditions to promote increased use by a variety of wildlife (e.g. mountain lion and badger). ▪ Improve land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.	

HOT SHEET **19**

US 101 Site 2 Gavilan Creek culvert

Near-term maintenance site with additional enhancement opportunities

DESCRIPTION	NOTES
Postmile SCL 3.17 **Lat/Long: 36.96145, -121.55131**	
Existing infrastructure: Culvert	
Mean score: 1.0 Regional connectivity: **1** Local connectivity: **1** Land-use security: **1**	
TARGET SPECIES FOR CONNECTIVITY ENHANCEMENTS	
Conservation and connectivity: Multiple species	
WILDLIFE OBJECTIVES	
▪ Enhance function as safe passage for wildlife under the highway.	
LAND-USE SECURITY	
▪ Developed land on both sides of highway. ▪ Intensive agriculture with little habitat value on the east side of the highway.	
RECOMMENDATIONS	
Near- and long-term ▪ Work with adjacent landowners to reduce the use of the culvert by domestic animals. ▪ Add critter shelves to allow species passage when the culvert experiences ponded water. ▪ Incorporate mix of vegetation/refugia and open conditions to encourage wildlife use. ▪ Attention/interventions would likely be more effective/impactful at CES further south on Highway 101, absent of comprehensive habitat restoration actions in the vicinity of this structure.	

More information:
openspacetrust.org/connectivity-study