Wildlife Permeability and Hazards across Highway 152 Pacheco Pass: Establishing a Baseline to Inform Infrastructure and Restoration.

February 2020

PREPARED BY PATHWAYS FOR WILDLIFE FOR THE SANTA CLARA VALLEY HABITAT AGENCY.

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1.0 EXECUTIVE SUMMARY

SR-152 Pacheco Pass bisects the Diablo Range-Inner Coast Linkage as identified by the Bay Area Critical Linkages Project. Pathways for Wildlife, in collaboration with the Santa Clara Valley Habitat Agency (Habitat Agency), conducted the Wildlife Permeability and Hazards across SR-152 Pacheco Pass Project (Project), which was funded by the California Department of Fish and Wildlife (CDFW) Local Assistant Grant (LAG) and the Habitat Agency.

The purpose of the study was to identify bridges and culverts that wildlife are using to cross under SR-152 within the study area, and to make wildlife connectivity enhancement recommendations that would improve existing highway infrastructure for wildlife safe passage. The project involved 1) monitoring three bridges and two 5-foot-tall dual box culverts for wildlife passage, and 2) conducting routine roadkill surveys along SR-152 Pacheco Pass within the study area for a twelve-month monitoring period from August 1, 2018 to July 31, 2019.

Within the twelve month monitoring period, multiple species including, deer (*Odocoileus hemionus*), American badger (*Taxidea taxus*), coyote (*Canis latrans*), bobcat (*Lynx rufus*), gray fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and opossum (*Didelphis virginiana*) were recorded consistently traveling under each of the three bridges. Numerous medium-sized mammals such as coyote, bobcat, gray fox, raccoon, opossum, and skunk, were also consistently traveling through the cement box culverts. A total of 3,125 animals were recorded traveling under the bridges and through the culverts throughout the duration of the study.

The same species recorded crossing under the bridges and through the culverts were also routinely found dead-on-road during scheduled roadkill surveys and were recorded as wildlife-vehicle collision points. A total of 75 wildlife-vehicle collisions (datum points) were recorded on SR-152 within the study area.

Based on the project results, Pathways for Wildlife recommends four wildlife connectivity enhancements that would improve the ability for wildlife to safely cross SR-152 as well as improve highway safety for drivers by reducing wildlife-vehicle conflict. Enhancement recommendations are as follows:

1) Installation of directional fencing to guide wildlife to existing bridges and culverts where documented "successful crossings" by wildlife occur.

2) Increase the ability for wildlife to walk along the rip-rap at bridge abutments as they act as a barrier to wildlife movement when bridges become flooded and banks are not available for use.

3) Remove dead and invasive vegetation and with restore native vegetation to increase overall bank area available for wildlife to travel along when the creeks associated with the bridges and culverts become inundated with water from storm events.

4) Install "critter crossing" shelving units at culverts that become flooded during storm events to facilitate wildlife safe passage.

Given the high number of wildlife-vehicle collisions recorded on the highway, these proposed wildlife connectivity enhancements and improvements would benefit not just wildlife populations but would also improve highway safety for people driving on SR-152 Pacheco Pass.

2.0 Introduction

2.1 Background & Purpose

Project background

SR-152 Pacheco Pass bisects one of the Bay Area Critical Linkages, the Diablo Range to the Inner Coast Linkage (Figure 1). The Bay Area Critical Linkage project was a comprehensive modeling effort to identify important habitat linkages that connect large landscape features such as mountain ranges (Penrod et al. 2012). The project area is also identified as a priority for connectivity by the California State Wildlife Action Plan (CDFW 2015) and the draft Santa Clara County Regional Conservation Investment Strategy.

Focal species used to create the Bay Area Critical Linkage Diablo Range to the Inner Coast Linkage Design included mountain lion (*Puma concolor*), bobcat (*Lynx rufus*), American badger (*Taxidea taxus*), San Joaquin kit fox (*Vulpes macrotis mutica*), tule elk (*Cervus canadensis nannodes*), black-tailed deer (sp.), ringtail (*Bassariscus astutus*), and California quail (*Callipepla californica*).

The SWAP identifies connectivity among communities and ecosystems as a key ecological attribute for the Central California Coast Ranges region and identifies land acquisition and restoration as a conservation strategy (CDFW 2015). The Santa Clara Valley Habitat Conservation Plan/Natural Community Conservation Plan (NCCP) recognizes the importance of landscape linkages, and specifically identifies Pacheco Pass on SR-152 as a focal area in the Biological Goals and Objectives, Reserve System design, and long-term monitoring (Santa Clara Valley Habitat Plan 2012) (Figure 2).

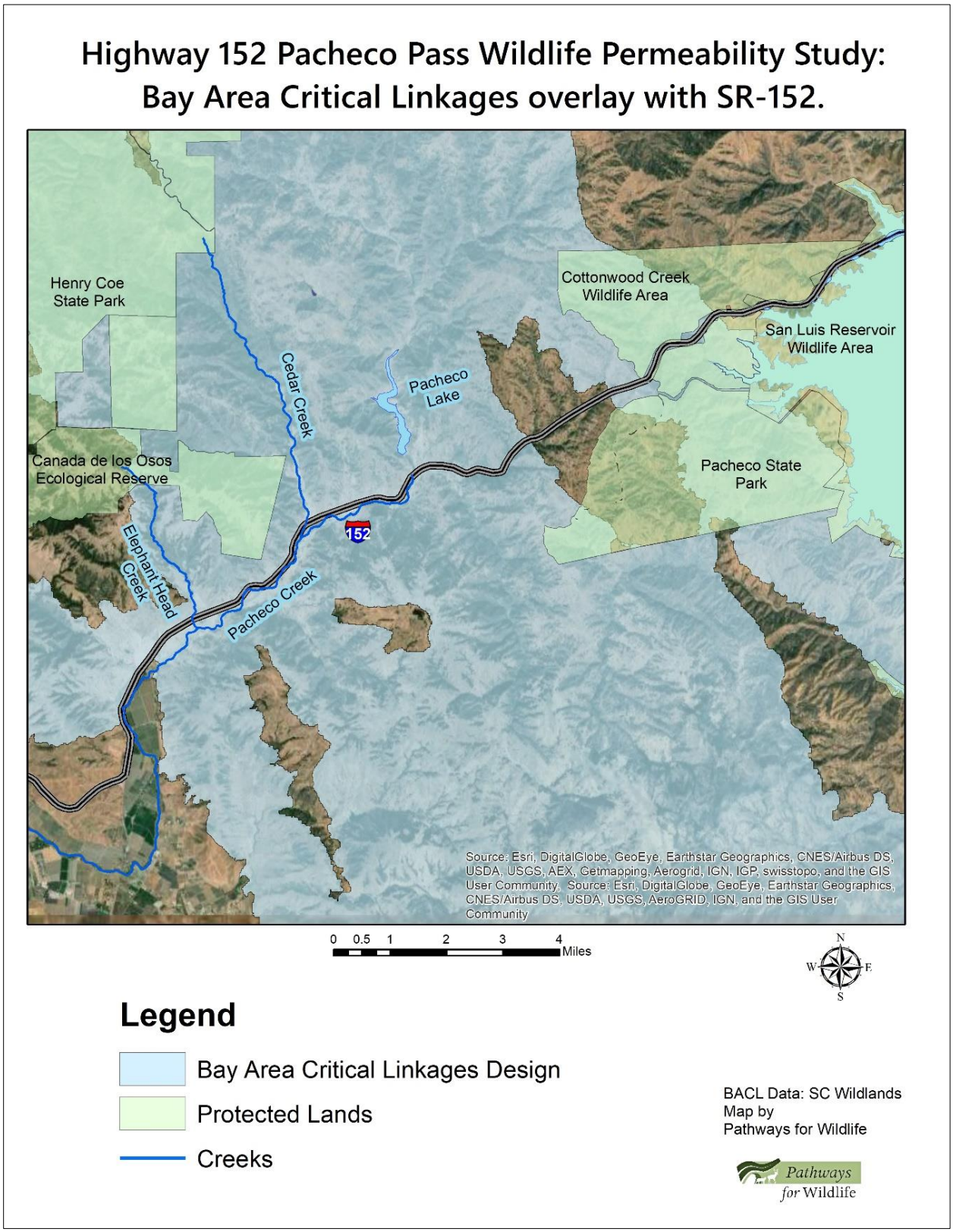


Figure 1. Bay Area Critical Linkage Design: Diablo Range to the Inner Coast Linkage.

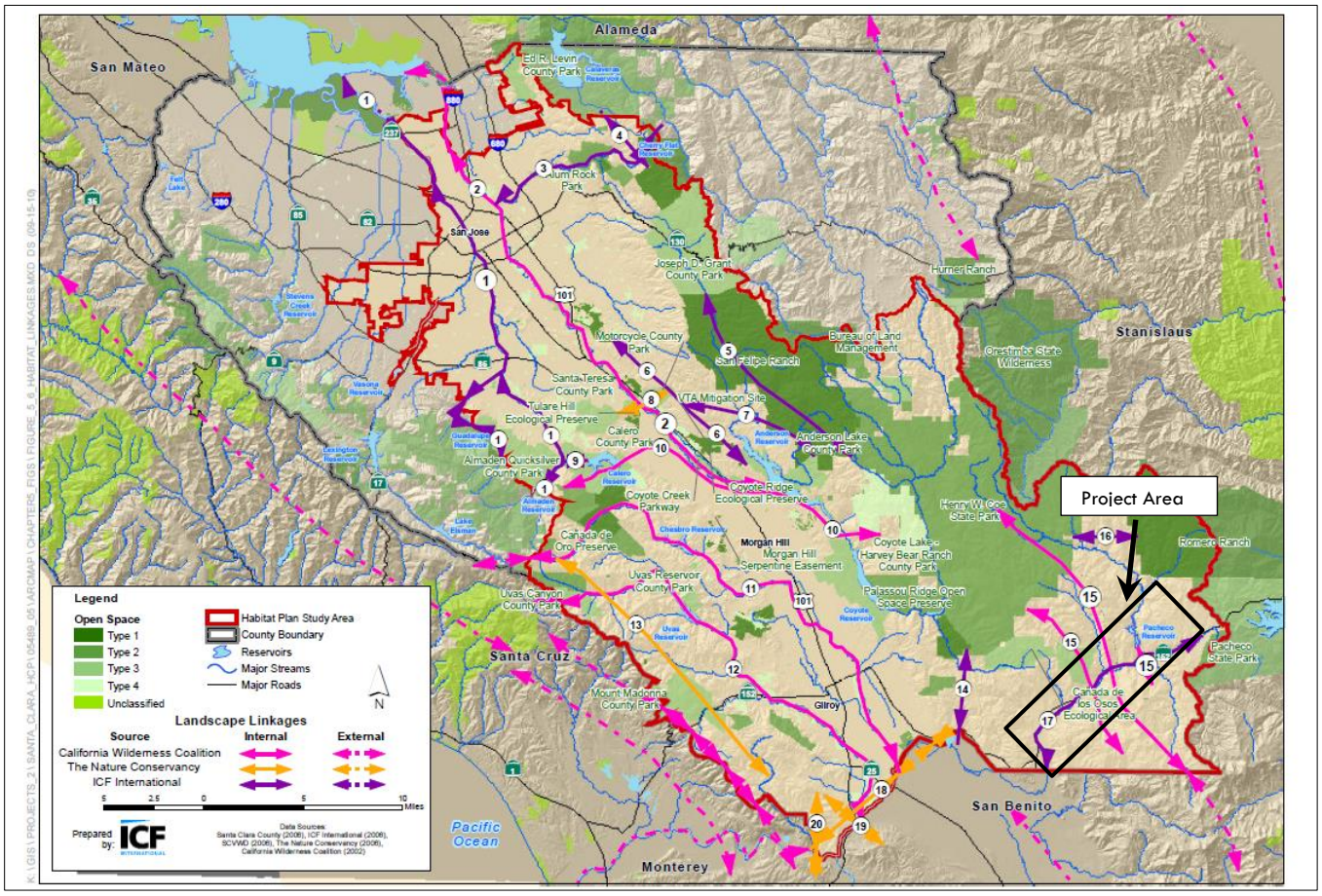


Figure 2. The Santa Clara Valley Habitat Conservation Plan Landscape Linkages.

Project purpose

The overall project goal was to help support the implementation of the wildlife connectivity strategies outlined in the Santa Clara Valley Habitat Plan by improving wildlife crossings along SR-152. To achieve this goal, we developed wildlife connectivity enhancement recommendations to improve wildlife permeability across the highway.

These recommendations were developed by data results from monitoring wildlife use of existing crossing structures within the study area, three bridges and two dual box culverts, which were monitored with remote cameras. Roadkill surveys were also conducted to identify locations in which animals were attempting to cross the highway and were hit by vehicles.

3.0 STUDY AREA AND MONITORING SITES

3.1Study Area

The SR-152 Pacheco Pass study area includes a 13 mile stretch of the highway beginning at Casa de Fruta on the west side of Pacheco Pass to the South Fork of Pacheco Creek on the east side of the Pass (Figure 1). SR-152 is built upon a south facing hillslope with the upland and lowland habitats on either side of SR-152 consisting of primarily undeveloped lands with a few rural residential parcels and cattle grazing operations. The upland habitat consists almost entirely of oak woodland savanna, while the lowlands consist of the Pacheco Creek riparian corridor.

There are several protected lands on both sides of the highway. On the north side and upslope from the highway, protected lands include Henry Coe State Park and the Cañada de los Osos Ecological Reserve (Figure 1). On the south and downslope side of the highway, protected lands include the Habitat Agency's Pacheco Creek Reserve. Pacheco Creek is perennial, making it important habitat for wildlife. The creek provides year-round resources such as water, food, and vegetation cover. The study area also provides a significant amount of climate change resilience, which is important as the upland habitats become hotter and drier (Appendix A). Please see Appendix A for a discussion on climate change resilience in relation to the study area and the benefits that provides in relation to wildlife connectivity.

Study sites

Three bridges and two dual box culverts where selected for monitoring within the study area (Table 1 & Figure 3). The three bridges include a bridge by the fire station, the Pacheco Creek bridge at the Pacheco Creek Reserve, and the Cedar Creek Bridge (Table 1 & Figure 3). The two dual box culverts included the Elephant Head Creek culvert and the Pacheco Creek Reserve culvert (Table 1 & Figure 3). Three additional bridges in the study area were not monitored due to access issues. These bridges may be monitored in future project phases (Figure 3).

The two dual box culverts are both 5 feet height and 5 feet wide cement box culverts. Each of the three bridges are large open span bridges that have three sections with a creek running through the middle section. The bridge by the Fire stations spans 59 meters long and 25 meters wide, the Pacheco Creek bridge spans 67 meters long and 54 meters wide, and the Cedar Creek bridge spans 54 meters long and 50 meters width.

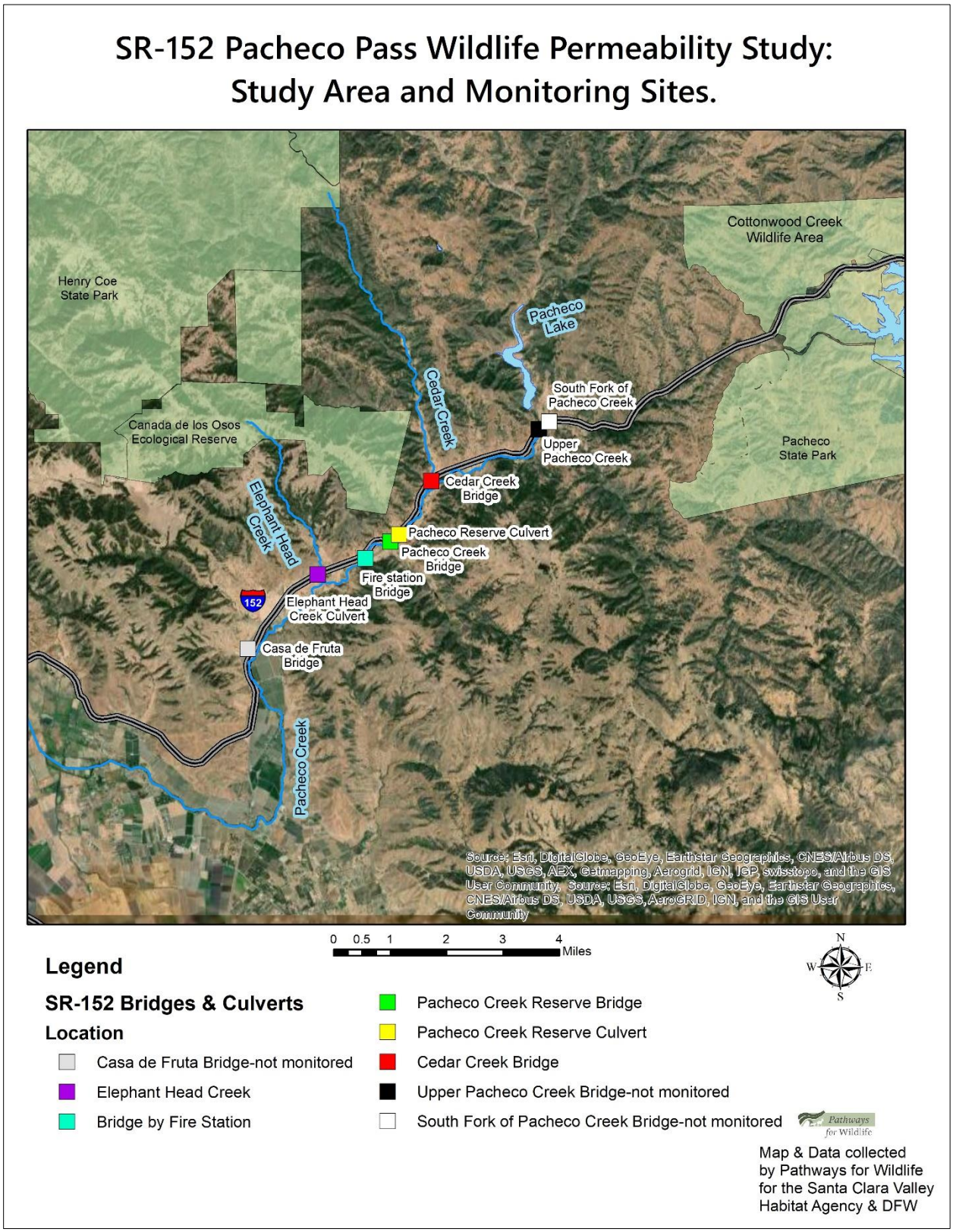


Figure 3. SR-152 Study area and monitoring sites.

Table 1. Monitoring Sites

Camera Number	Site
1	Elephant Head Culvert West
2	Elephant Head Culvert East
3	Firestation Bridge
4	Pacheco Bridge Midsection South
5	Pacheco Bridge Northeast section
6	Pacheco Bridge Southeast section
7	Pacheco Creek Culverts
8	Pacheco Reserve Trail
9	Pacheco Reserve Main Road
10	Cedar Creek South Midsection
11	Cedar Creek North Midsection
12	Cedar Creek Southwest section

4.0 STUDY METHODS

Camera Monitoring

All data were collected between August 1, 2018 and July 31, 2019. At each bridge and culvert, we placed 2 or more passive infrared motion activated cameras equipped with an Infrared LED flash for night detections that are unobtrusive to wildlife (as opposed to "white light flash" typically used on handheld cameras). Cameras were set up to maximize a view that could confirm passage through each structure. For dual box culverts and bridges with multiple sections, each section of the bridge and culvert was monitored to document passages by wildlife through each section. Cameras were checked and the data was downloaded on a bi-weekly basis.

Pathways for Wildlife recorded all camera data, including species recorded, number of animals, direction of travel, identification of individual animals and repeats of individuals, juveniles traveling with parents, date, time, temperature, moon phase, and relevant behavioral or ecological observations. Data were analyzed to determine if the structures were facilitating multiple species movement along with determining if there were any seasonal patterns in wildlife utilizing these sites as crossing structures.

Data were analyzed for specific focal species, including deer, coyote, bobcat, mountain lion, gray fox, raccoon, skunk, opossum and domestic animals such as domestic cats (*Felis catus*)

and domestic dogs (*Canis familiaris*). Other wildlife species recorded, including snakes, lizards, amphibians, rabbit, mice, and birds, are summarized in Appendix B of this report.

Roadkill surveys

Roadkill surveys were conducted on a bi-weekly basis while checking the cameras. For each wildlife-vehicle collision point, a picture was taken, GPS coordinates recorded, location information was noted along with notes on the animal's age, sex, and other relevant ecological information. These data were compiled into a Master Database and mapped in ArcMap.

5.0 CAMERA DATA RESULTS

5.1 Total Detections of Passages by Species

Cameras recorded a total of 3,125 wildlife passages at the three bridges and two culverts monitored (Table 2). The Pacheco Creek Bridge and the Pacheco Creek Reserve Dual Box Culvert had the highest number of wildlife passages recorded, with 845 detections of wildlife traveling under the bridge, and 720 detections of wildlife traveling through the culvert (Table 2). In this report, the terms detection(s), record(s), and document(ed) all refer to the photographic evidence of the presence of wildlife, which was recorded into a database.

Table 2. Total wildlife passages recorded.

Study Site	Total Wildlife Passages Recorded from July 2018-July 2019.
Pacheco Creek Bridge	845
Pacheco Reserve Dual Box Culvert	720
Firestation Bridge	700
Cedar Creek Bridge	485
Elephanthead Dual Box Culvert	375
Grand Total	**3,125**

The species most frequently documented in the passages included deer (906), bobcat (464), skunk (454), and gray fox (423) (Table 3 and Chart 1). Deer are the species documented using the bridges to travel the most under SR-152. Multiple individuals of deer were recorded at each of the three bridges.

Table 3. Number of passages by species per site.

Study Site & Number of Passages by Species	American Badger	Bobcat	Coyote	Deer	Domestic cat	Gray fox	Opossum	Raccoon	Red Fox	Skunk	Wild Pig	Grand Total for Study Site
Pacheco Creek Bridge	1	98	42	327	0	127	78	43	0	129	0	**845**
Pacheco Reserve Dual Box Culvert	0	31	0	0	71	289	65	35	0	229	0	**720**
Fire station Bridge	3	80	161	395	0	5	1	11	0	10	34	**700**
Cedar Creek Bridge	10	105	132	184	0	1	1	29	1	22	0	**485**
Elephant Head Dual Box Culvert	0	150	46	0	3	1	0	111	0	64	0	**375**
Grand Totals	**14**	**464**	**381**	906	74	423	145	229	1	454	34	**3125**

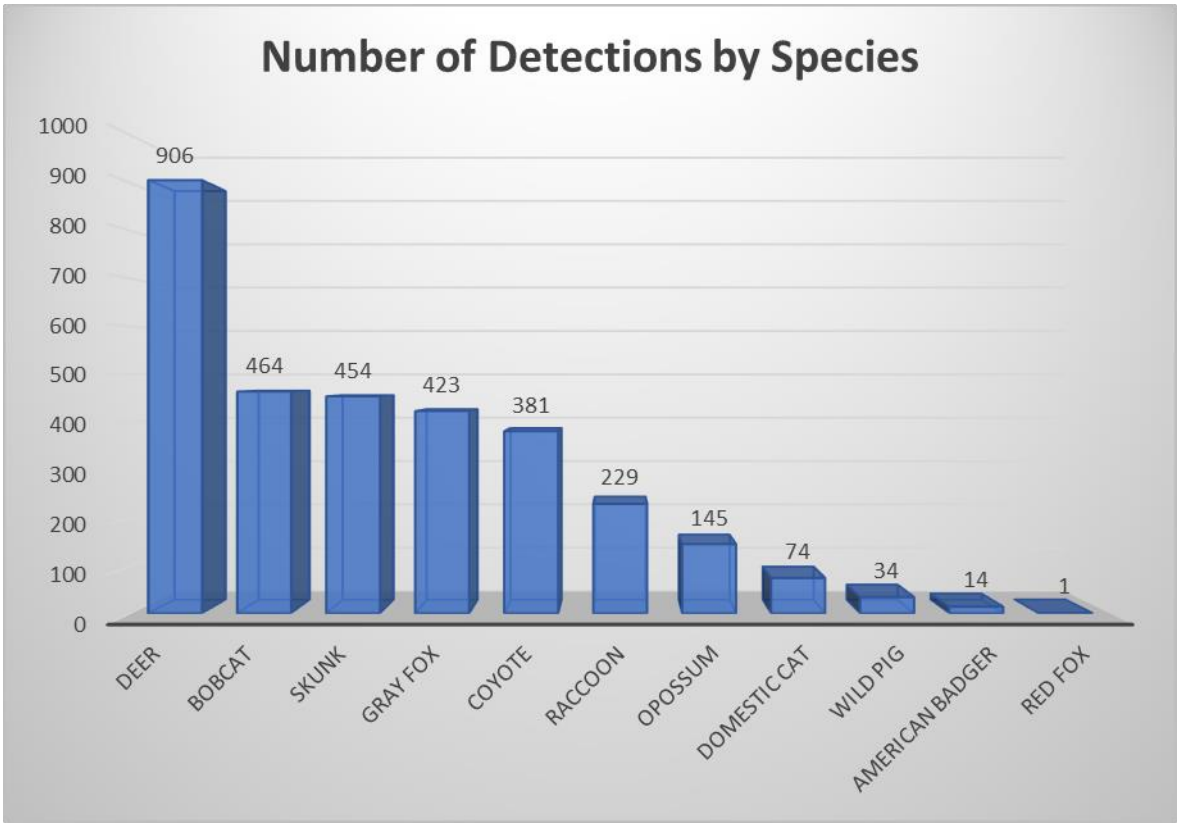


Chart 1. Number of detections recorded by species.

There were 14 American badger detections recorded (Table 3). The badger detections were recorded at each of the three bridges monitored (Table 3 & Figure 4). Since 2010, we have monitored over ten major highways in linkage areas in five counties and have found it relatively rare to record badgers traveling under bridges. The American badger is a Species of Special Concern and exists in low population densities (American badger Species of Special Concern Report, Quinn 2009). Interestingly, we recorded a bobcat that appeared to be following a badger at the Cedar Creek bridge on September 4, 2018 (Figure 4).

Figure 4. Photos of badger and bobcat detections at the Cedar Creek bridge and fire station bridge.

5.2 Data Results by Study Site

1. Elephant Head Creek dual box culvert

There was a total of 375 passages of wildlife traveling through the Elephant Head Creek dual box culvert. The species with the highest detections include bobcat (150) and raccoon (111) (Table 4). The culvert facilitated small to medium sized mammal movement through it consistently throughout the year except for when it was flooded with water (Figure 5).

Table 4. Elephant Head Creek culvert detections.

Species	Number of Passage Records	Number of Detections without Crossing
American badger	0	0
Bobcat	150	0
Coyote	46	0
Deer	0	0
Domestic cat	3	0
Gray fox	1	0
Opossum	0	0
Raccoon	111	0
Red fox	0	0
Skunk	64	0
Wild Pig	0	0
Total	**375**	**0**

Figure 5. Multiple species use of the Elephant Head creek culvert.

2. Fire Station bridge

There was a total of 700 passages of wildlife traveling through the Fire Station bridge. The species with the highest detections include deer (395), coyote (161), and bobcat (80) (Table 5). The bridge facilitated small to large sized mammal movement consistently throughout the year (Figure 6). The bridge is playing an important role in facilitating multiple individuals of deer in traveling safely under the highway (Figure 6).

Table 5. Fire station bridge detections.

Species	Number of Passage Records	Number of Detections without Crossing
American badger	3	0
Bobcat	80	8
Coyote	161	4
Deer	395	25
Domestic cat	0	0
Gray fox	5	1
Opossum	1	0
Raccoon	11	2
Red fox	0	0
Skunk	10	1
Wild Pig	34	1
Total	**700**	**42**

Figure 6. Multiple species use of the Fire Station bridge.

3. Pacheco Creek bridge at the Pacheco Creek Reserve

There was a total of 909 passages of wildlife traveling through the Pacheco Creek bridge. The species with the highest detections include deer (351), gray fox (130), skunk (130), and bobcat (109) (Table 6). The bridge facilitated smalll to large sized mammal movement consistently throughout the year (Figures 7, 8 & 9). The bridge is playing an important role in facilitating multiple individuals of deer in traveling safely under the highway (Figure 7).

Table 6. Pacheco Creek bridge detections.

Species	Number of Passage Records	Number of Detections without Crossing
American badger	1	0
Bobcat	109	5
Coyote	42	4
Deer	351	158
Domestic cat	0	0
Gray fox	130	59
Opossum	79	1
Raccoon	67	2
Red fox	0	0
Skunk	130	20
Wild Pig	0	5
Total	**909**	**254**

Figure 7. Multiple species use of the Pacheco Creek bridge middle east section.

Figure 8. Multiple species use of the Pacheco Creek bridge north east section.

Figure 9. Multiple species use of the Pacheco Creek bridge south east section.

4. Pacheco Creek Reserve dual box culvert and the Pacheco Creek Reserve

There was a total of 720 passages of wildlife traveling through the Pacheco Creek dual box culvert. The species with the highest detections include gray fox (289) and skunk (229) (Table 7). The culvert facilitated small to medium size mammal movement through it consistently throughout the year except for when it was flooded with water (Figure 10). Of special note, this culvert facilitated the highest amount of gray fox passages within the study area (Table 3).

Table 7. Elephant Head Creek culvert detections.

Species	Number of Passage Records	Number of Detections without Crossing
American badger	0	0
Bobcat	31	18
Coyote	0	3
Deer	0	5
Domestic cat	71	0
Gray fox	289	23
Opossum	65	26
Raccoon	35	39
Red fox	0	0
Skunk	229	50
Wild Pig	0	0
Total	**720**	**164**

Figure 10. Multiple species use of the Pacheco Reserve dual box culvert.

5. Cedar Creek Bridge

There was a total of 485 passages of wildlife traveling through the Cedar Creek bridge. The species with the highest detections include deer (184), coyote (132), and bobcat (105) (Table 5). The bridge facilitated large to small mammal movement consistently throughout the year (Figure 11). The bridge is playing an important role in facilitating multiple individuals of deer in traveling safely under the highway (Figure 11).

Table 8. Cedar Creek bridge detections.

Species	Number of Passage Records	Number of Detections without Crossing
American badger	10	0
Bobcat	105	9
Coyote	132	6
Deer	184	22
Domestic cat	0	4
Gray fox	1	6
Opossum	1	12
Raccoon	29	3
Red fox	1	0
Skunk	22	0
Wild Pig	0	0
Total	**485**	**62**

Figure 11. Multiple species use of the Cedar Creek bridge.

6.0 WILDLIFE-VEHICLE COLLISION DATA RESULTS

6.1 Wildlife-Vehicle collision rates by Species

In a twelve-month period from August 2018-July 2019, a total of 75 animals have been recorded hit from bi-weekly roadkill surveys (Table 9 and Figure 12). The species with the highest mortality due to the recorded wildlife-vehicle collisions includes raccoon (21), coyote (15), skunk (15), and deer (10) (Chart 2).

Table 9. Wildlife-Vehicle collision data results.

Species	Total Animals Recorded Hit from Aug 2018-July 2019
Raccoon	21
Coyote	15
Skunk	15
Deer	10
Bobcat	4
Gray fox	3
Opossum	3
American badger	3
Red fox	1
Mountain lion	0
Total	75

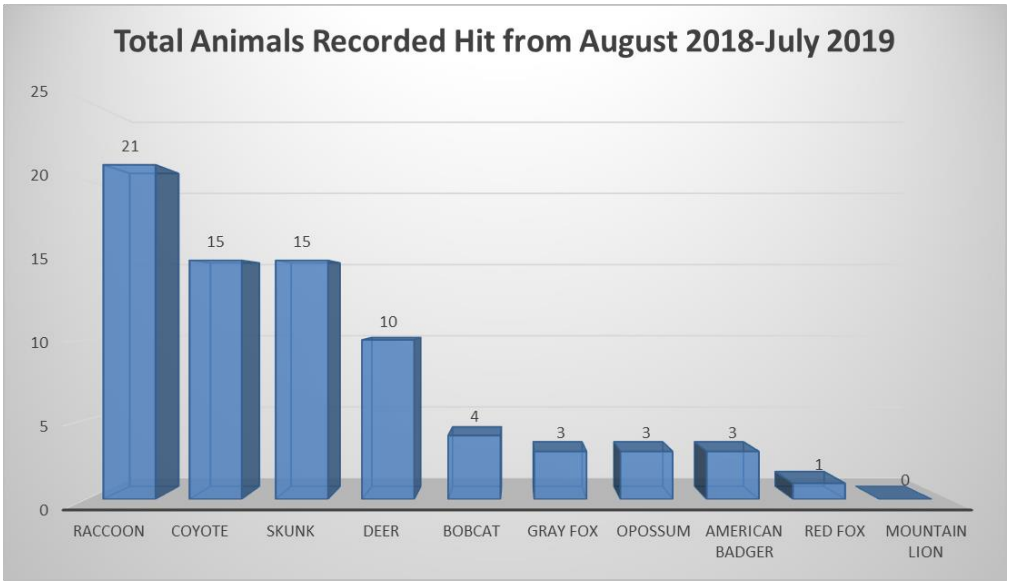


Chart 2. Total animals hit during the study period.

Figure 12. Examples of Wildlife-Vehicle Collision Data. Each month animals have been recorded hit on SR-152 Pacheco Pass.

The recorded wildlife-vehicle collisions span across the entire stretch of the study area, including animals hit by the culverts and bridges. (Figure 13). The same species recorded using the bridges and culverts to travel under the highway were also being recorded as hit by cars.

To note, the roadkill surveys we conducted were bi-weekly. During each survey we would record multiple species hit on the highway. This indicates that there are most likely more animals being hit on the road than we were recording.

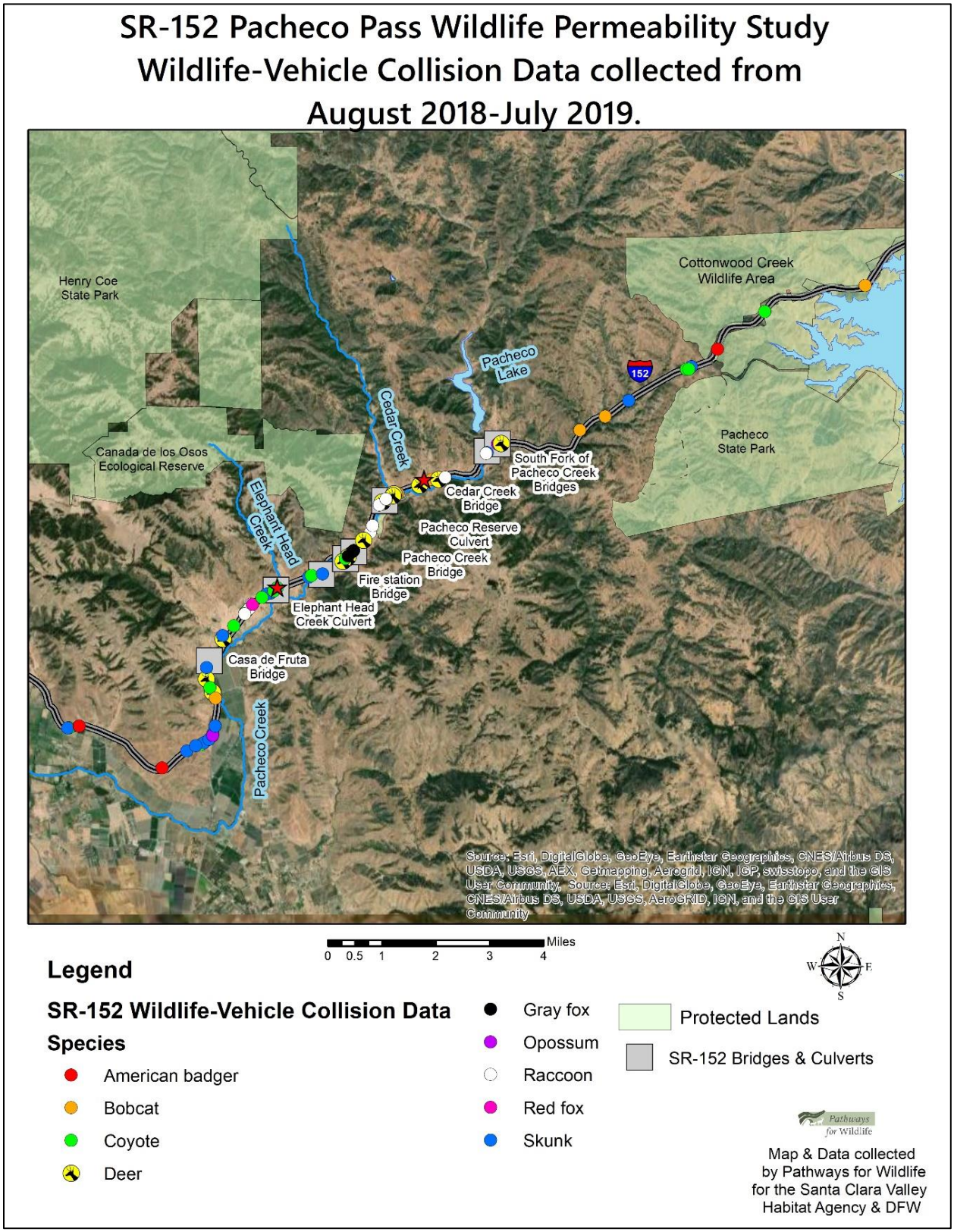


Figure 13. Wildlife-vehicle collision data collected from August 2018-July 2019.

6.2 Wildlife-Vehicle collision data combined with contributed data

Other wildlife-vehicle collision data was made available by project collaborators. This dataset includes Tule elk vehicle-collision data contributed by wildlife biologist Cristen Langner (CDFW), who is currently working on a Tule elk radio collar study. Other contributed data includes locations animals were recorded as hit during The Nature Conservancy's Pajaro Wildlife Connectivity Study conducted by Pathways for Wildlife from 2012-2013 and the CDFW's CNDDB.

These contributed datasets included 31 other animal-vehicle collision locations, including six Tule elk (*Cervus canadensis nannodes*) and two mountain lions (*Puma concolor*), which were not hit on the highway during this August 2018-July 2019 study period (Figure 14).

With the data collected from this study combined with the contributed data, the total records of available wildlife-vehicle collision data includes 106 animals documented hit on the highway. The species with the highest mortality due to the recorded vehicle collisions includes raccoon (22), coyote (19), deer (17), and skunk (16) (Table 10). Of note 8 American badgers, a Species of Special Concern, have been recorded hit on SR-152.

Species	Total Animals Recorded Hit including data from the CDFW Tule Elk Study & TNC Pajaro Study
Raccoon	22
Coyote	19
Deer	17
Skunk	16
American badger	8
Bobcat	8
Tule Elk	6
Opossum	4
Gray fox	3
Mountain lion	2
Red fox	1
Total	106

Table 10. Wildlife-Vehicle collision data results combined.

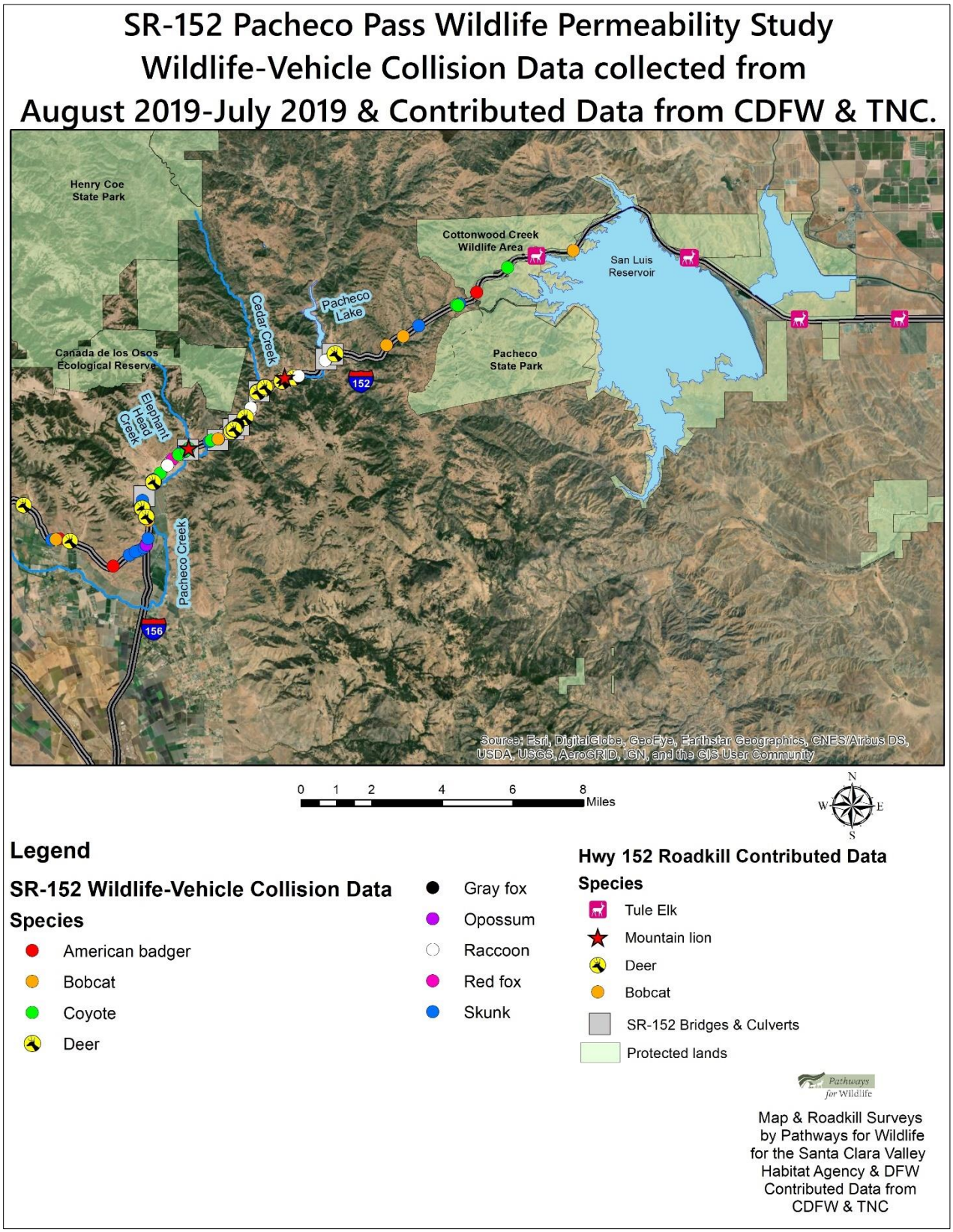


Figure 14. Wildlife-vehicle collision data collected from August 2018-July 2019 combined with contributed data.

7.0 STORM EVENTS & SEASONAL VARIATION

7.1 Storm events in relation to a decrease of wildlife passages & an increase of wildlife-vehicle collisions.

During the winter season of the study, there were several storm events that caused the bridges and culverts to flood with water (Figures 15 & 16). Before the flooding events occurred, multiple species were recorded to consistently travel through the bridges and culverts during the months of August-December 2018 (Chart 3).

Figure 15. Pacheco Creek bridge flooded during February 2019.

Figure 16. Cedar Creek bridge flooded during February 2019.

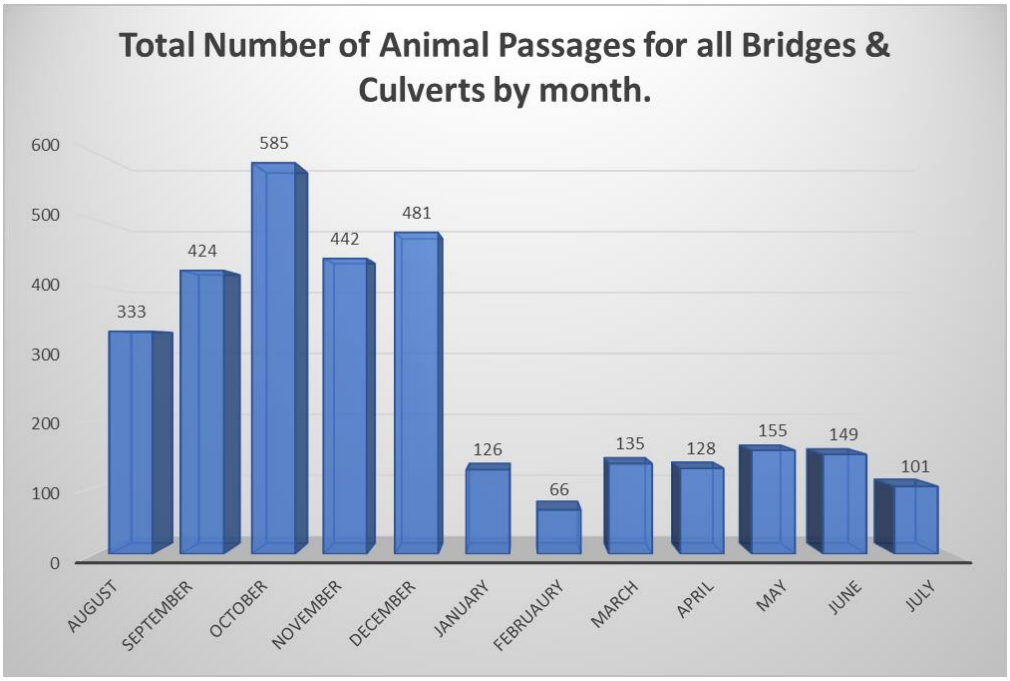


Chart 3. Total number of animal passages for all bridge and culverts by month.

During the storm season from January to February, there was a sharp decline in wildlife passages at the bridges and culverts when they were flooded with water (Chart 3). During the months the bridges and culverts were flooded, there was an increase in wildlife being hit by cars in the vicinity of the structures (Chart 4). This may have been due to the bridges and culverts being inundated with water as we were also recording wildlife approaching the bridges and culverts but then turning away (Figure 17).

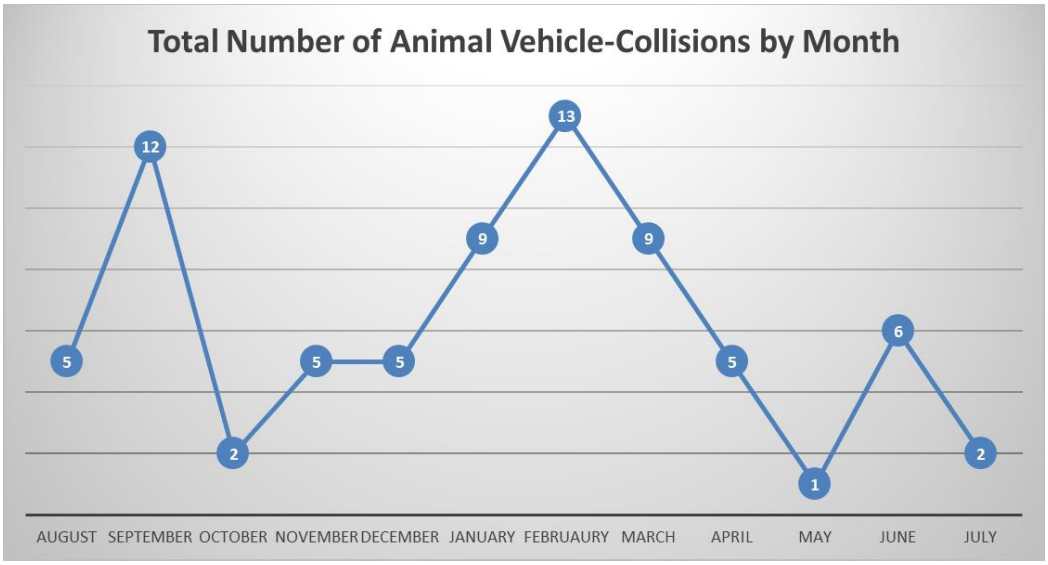


Chart 4. Number of animal vehicle-collisions for all bridges and culverts by month.

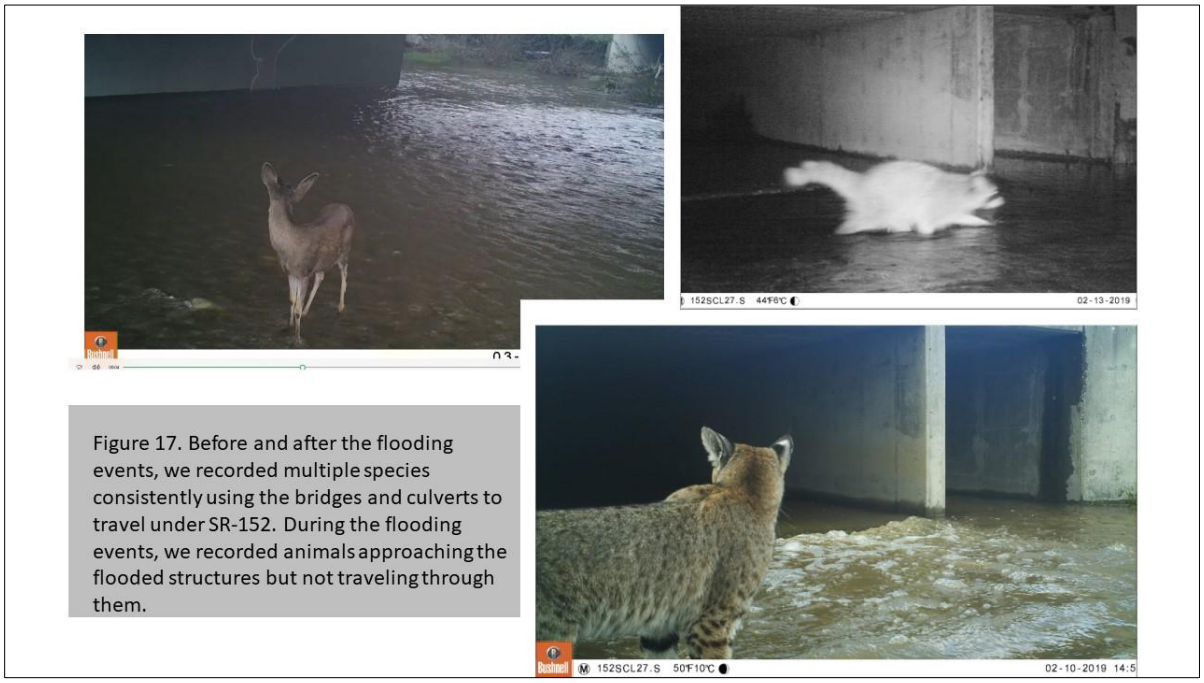


Figure 17. Before and after the flooding events, we recorded multiple species consistently using the bridges and culverts to travel under SR-152. During the flooding events, we recorded animals approaching the flooded structures but not traveling through them.

At the Pacheco Creek bridge, where multiple species had been recorded consistently traveling under the bridge, we recorded wood ducks (*Aix sponsa*) swimming by the camera (Figure 18). The only species we recorded during January and February traveling under the bridge were raccoons (Figure 18).

Figure 18. Pacheco Creek bridge in February 2019 and camera data.

8.0 WILDLIFE CONNNECTIVITY ENHANCEMENT RECOMMENDATIONS

8.1 Recommendations for improving the permeability of the highway for wildlife passages at locations identified from the analysis.

The species with the highest number of detections is deer (906). This indicates the bridges are playing an important role in facilitating deer movement under the highway, thus helping the safety of the highway for both wildlife and drivers. However, after the storm events, the creeks remained flooded and there was a drastic decrease in passages by deer and other species at the bridges (Chart 3). Furthermore, there was also an increase in wildlife-vehicle collisions by the bridges and culverts during the flooding events (Chart 4).

Compared to other wildlife-vehicle collision surveys that we have conducted over the past ten years along multiple highways, such as US-101, SR-17, SR-156, SR-129, SR-25, and SR-68, and in multiple counties, such as Santa Clara, Santa Cruz, San Benito, Sonoma, and Monterey County we have never recorded American badgers, mountain lion, and Tule Elk hit on the same stretch of a highway. This is significant as American badgers and Tule Elk exist in low densities, therefore needing the ability to travel farther to find mates. This is critical for genetic flow and maintaining healthy populations of the species.

From this data collection we have developed four wildlife connectivity enhancements that could help improve the ability for wildlife to safely travel under SR-152 and improve the safety of the highway for both wildlife and drivers.

These enhancements include:

1) Installing wildlife directional fencing to guide wildlife to several bridges and culverts in which wildlife have been documented to routinely use.

2) Modifications to make rip-rap at bridges more permeable as they act as a barrier to wildlife movement when bridges become flooded and banks are not available for use.

3) The removal of dead and invasive vegetation along with restoring native vegetation to increase available bank for wildlife to travel along when the creeks associated with bridges and culverts are full of water.

4) Installing critter crossing shelving units at culverts which become flooded during storm events in order to facilitate wildlife safe passage. This is especially critical for species that have already been documented utilizing the culverts on a routine basis during seasons when water levels do not pose an obstacle to safe passage.

8.2 Modifications for improving the ability for wildlife to travel through bridges and culverts that flood during storm events.

These proposed wildlife connectivity enhancement projects would restore or enhance ecosystems that result in enduring direct and measurable improvements in the ability for wildlife to move within existing habitat linkages (wildlife corridors) that are bisected by SR-152. We recommend the following:

1. Directional Fencing Pilot Project

Select several bridges and culverts under SR-152 where we have consistently recorded wildlife successfully traveling through for safe passage during the study to install directional fencing to guide wildlife to the structures. Along with installing wildlife directional fencing at locations in which we have recorded a high rate of wildlife-vehicle collisions. These locations would then be monitored in order to record whether there is an increase in the number of wildlife crossings at the structures, and/or if there is a decrease in wildlife-vehicle collisions. This will allow us to evaluate if additional directional fencing would be beneficial at other culverts and bridges along the highway where wildlife are consistently being documented as hit-by-vehicle and are roadkill hot spot locations.

The SR-68 Scenic Plan & the Highway 17 Wildlife Connectivity Designs are using directional fencing recommendations developed by Tony Clevenger who designed the land bridges and associated directional fencing at Banff, Canada. The fencing recommendations include using wooden posts with 8-ft fence design. These designs were used to develop costs for a directional fencing pilot project for a section of SR-152, which would include; two sections of fencing for both the eastbound and southbound lanes of 152 from Pacheco Bridge to Cedar Creek Bridge (4,208 meters) and two jump out gates. These would be located both in the Pacheco Creek Reserve and on Caltrans' property.

2. Rip Rap modifications at the SR-152 Pacheco Creek Bridge at the Pacheco Creek Reserve

The Pacheco Creek bridge had the second highest number of wildlife passages (845). However, the bridge was flooded from January 2019 to June 2019 and there was a sharp decline in the number of passages (Chart 5).

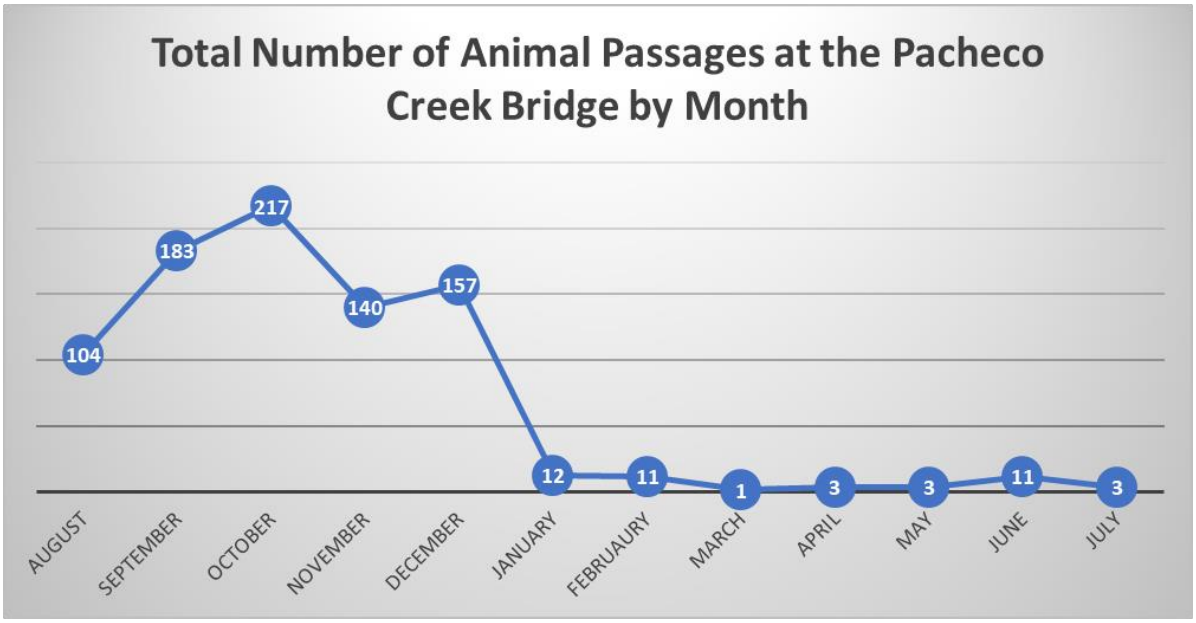


Chart 5. Number of animal passage at the Pacheco Creek bridge by month.

The east and west sides of the Pacheco Creek bridge are lined with large rip rap rocks (Figure 19). The rip rap [or RSP] makes it difficult for some wildlife species to travel under the bridge when the creek is full and inundates the bank below the RSP. The only species recorded traveling along the rip rap were raccoons and bobcats; both species are agile climbers, which allow them to navigate the large rip rap at the bridge abutments.

Figure 19. The east side of the Pacheco Creek bridge at the Pacheco Reserve.

On March 20, 2019, the Santa Clara Habitat Agency, Caltrans, CDFW, and Peninsula Open Space Trust (POST) toured the wildlife crossings. The site visit was conducted to review data collected up to date and discuss potential wildlife connectivity enhancements (Figure 20). Removal of the rip-rap rocks is not advised as it would interfere with the structural integrity of the bridge. However, both Caltrans and CDFW suggested it would be feasible to fill the spaces between the rip-rap with a type of cement substrate. This would create a hard surface for wildlife to walk on. A CDFW biologist would approve the design. This project would engage the San Jose Conservation Corps to fill in the rip-rap.

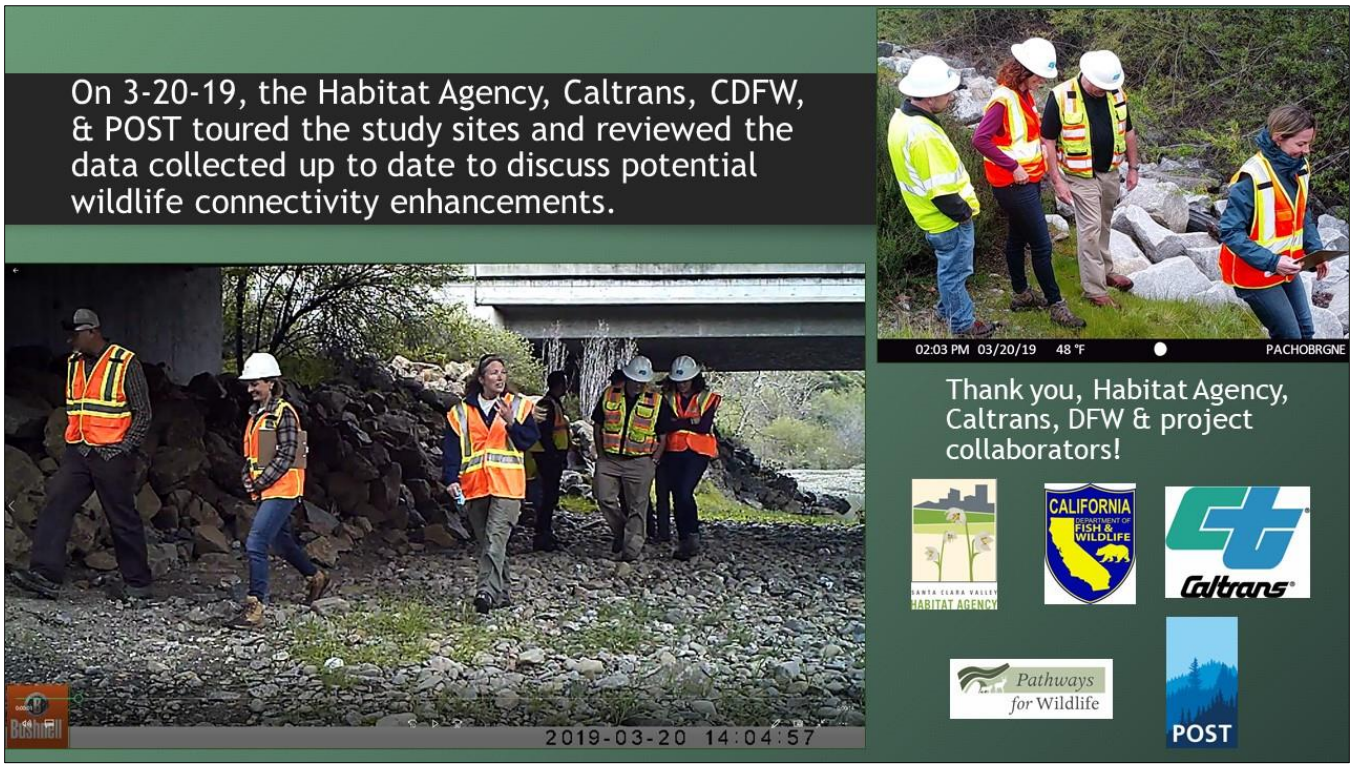


Figure 20. SR-152 Partner field tour of study sites.

3. Bank Improvements at the Pacheco Creek Bridge at the Pacheco Creek Reserve

Wildlife passage during high flows could be improved by removing dead trees, dead shrubs, and dense invasive vegetation along the banks to increase bank width at higher slope areas and restoring with native vegetation. Both the east and west sides of the bridge have large amounts of dead tree and invasive vegetation build up that can restrict species movement through the bridge (Figure 21). By removing this debris, it would increase the amount of creek bank available for wildlife to traverse under the bridge. As with the RSP improvement, this project would engage the San Jose Conservation Corps to conduct the work.

Figure 21. The east side of the Pacheco Creek bridge.

4. Critter Crossing Shelf unit at Pacheco Creek Reserve Dual box culvert

Installing wildlife shelving units at culverts could help facilitate passage of the culverts when inundated with water. For example, there was a high number of gray fox detections pre-flooding events at the Pacheco Reserve culvert (289) and at the Pacheco Creek bridge (127) (Table 3). During the flooding events two gray foxes were recorded hit by the Pacheco Creek Reserve culvert (Figure 13). After the flooding events, gray foxes were no longer detected at either the Pacheco Reserve culvert or the Pacheco Creek bridge. The pair using the bridge and culvert may have been the gray foxes recorded hit above the culvert when it was flooded.

Critter Crossing shelves are metal shelving units that can be installed in the culverts to allow wildlife crossing when there are high water level events flowing through the culvert. A benefit of the shelving units is that they are removable and not permanent structures. This project would involve installation of a single shelf in the by Pathways for Wildlife (Figure 22).

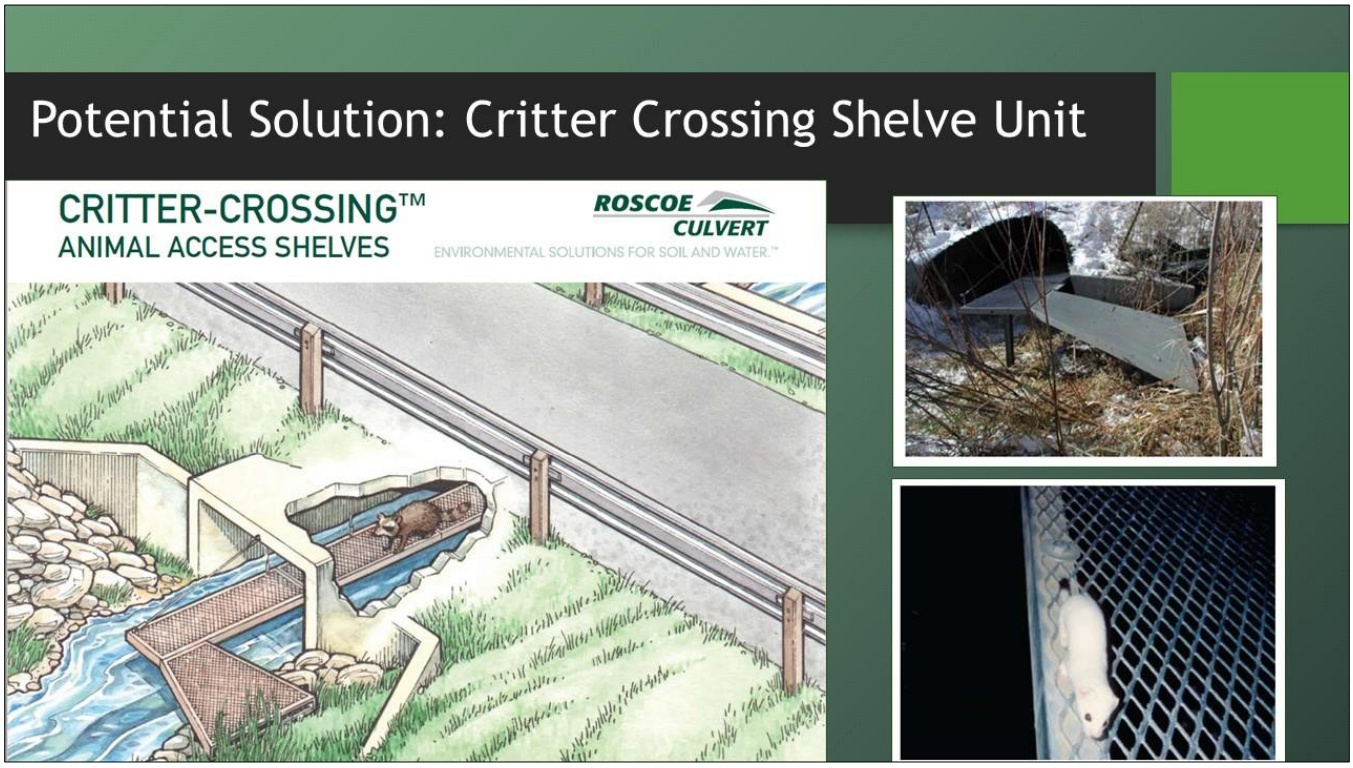


Figure 22. SR-152 Critter crossing shelving unit.

Monitoring

These enhancements should be monitored for efficacy using the same protocol as the Project described in this report. During high creek flows, we would expect to see a decrease in wildlife-vehicle collisions compared to the first year of monitoring and an increase of wildlife passages at the bridges and culverts with the enhancements. If found to be effective, we can implement these wildlife crossing enhancements at other sections of the highway with similar wildlife passage challenges. Enhancing crossings along the length of SR-152 would improve landscape connectivity for wildlife.

9.0 NEXT STEPS FOR RESEARCH

SR-152 Pacheco Pass Site Planning for Wildlife Crossings

This proposed project would further efforts that identify processes that lead to the successful implementation of future wildlife connectivity projects. Elk in particular are very reluctant to use undercrossing and culverts and mainly use land bridges (Cramer, 2012). We would coordinate with Tony Clevenger on a vegetated land bridge design for large mammal movement across SR-152 for species like Tule elk and mountain lions. We would also coordinate and consult with the CDFW biologist leading a Tule Elk movement study in the area.

After conducting several site assessments, we would then monitor existing culverts and bridges within the proposed land bridge sites to determine what species are moving through the area, and whether there are other potential undercrossings that could be built or improved.

Weekly roadkill surveys would also be conducted to determine if there are locations which animals are routinely attempting to cross the road and hit by vehicles. A **GIS Hot Spot analysis** would be conducted to determine the locations in which wildlife are most often hit by vehicle to prioritize areas for wildlife connectivity enhancements.

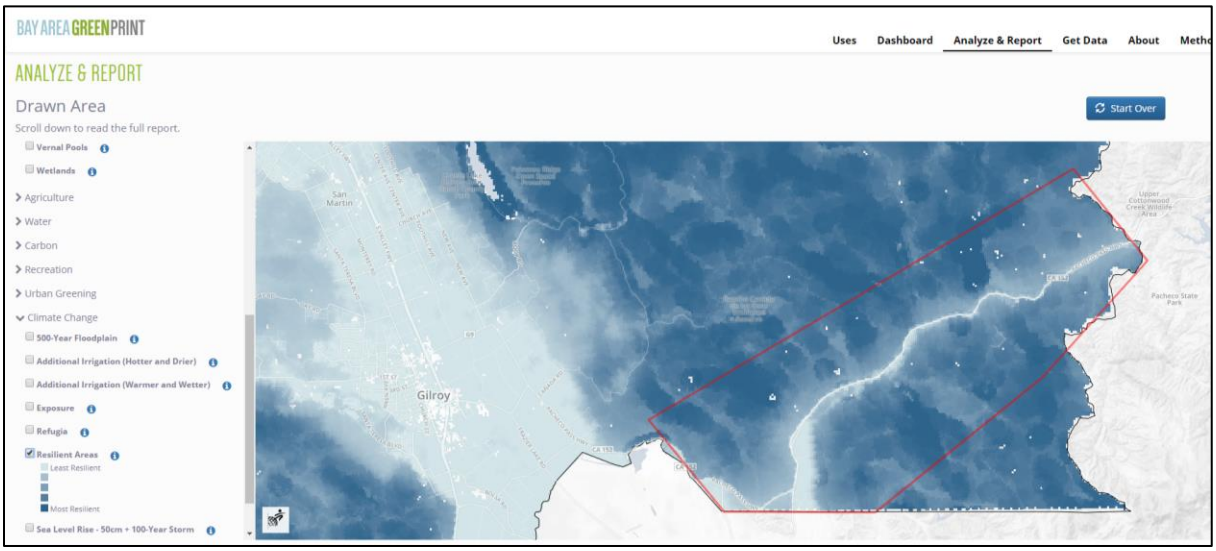
Lastly, a **cost-benefit analysis** would be conducted to determine if the benefits of installing wildlife crossing structures would outweigh the costs of installing them.

10.0 ACKNOWLEDGMENTS

We would like to thank the Santa Clara Valley Habitat Agency and the California Department of Fish & Wildlife for funding this project and for their support of the study. We would also like to thank our project partners at Caltrans and POST for their collaboration on the project. The feedback given from these project partners on the findings from this study was a critical component for the development of the wildlife connectivity enhancements and we are grateful for their time and guidance.

Appendix A. Study Area in relation to Climate Change Resilience & Habitat Connectivity

In terms of climate change, as the upland grassland and oak woodland savannah habitats become hotter and drier on the north side of SR-152, wildlife will need to be able to travel from the upland habitats of the Diablo Range down south to the Pacheco Creek watershed. The majority of the study area provides habitat that would be considered most resilient to climate change- the intact habitats with low levels of development upslope and downslope of the side of SR-152 (Figure 23). Henry Coe State Park is located on the north side of SR-152 while Pacheco Creek, a perennial stream, is on the south side of SR-152 (Figure 22). The study area is also important refugia for wildlife as the city of Gilroy to the west is considered least resilient and highly fragmented by human development.



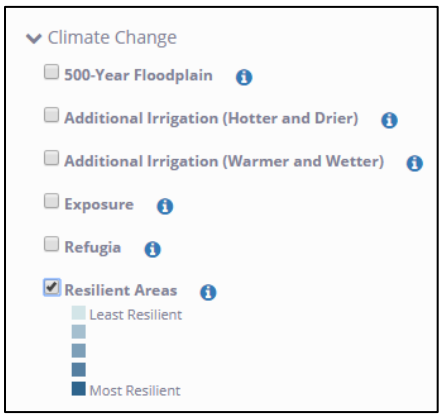


Figure 23. Climate Change Resilience within the Study Area (red outline).

The study area also provides a significance amount of above ground soil carbon storage in providing landscape climate change resilience (Figure 24).

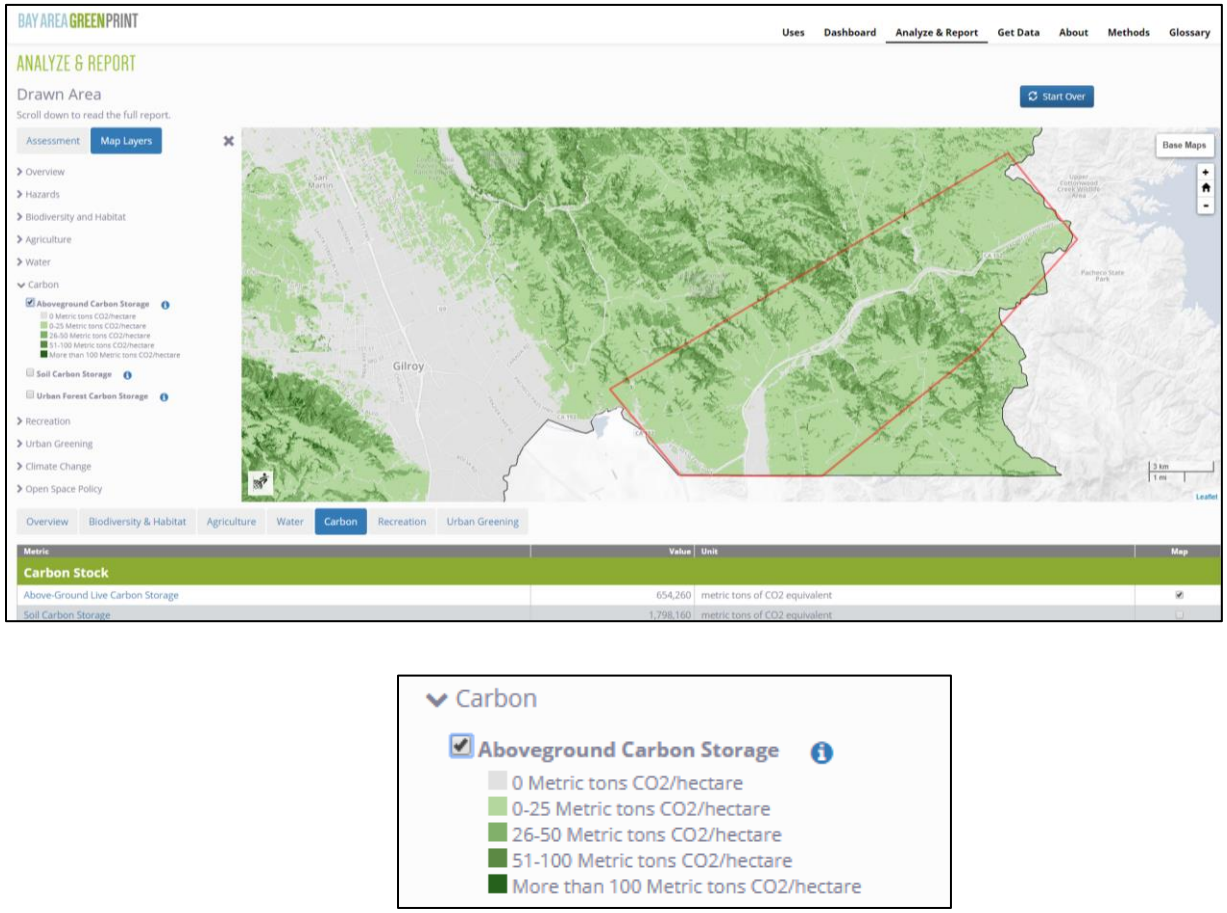


Figure 24. Above ground carbon storage within the Study Area (red outline).

Enhancing connectivity is an essential conservation strategy in the face of climate change. Without habitat linkages animals will not be able to seek out refugia as the landscape transforms as a result of climate change. Landscape connectivity is the most frequently recommended conservation strategy to protect biodiversity as climate changes (Kostyack, John, et al. 2011).

As climate warms, plants and animals are moving to cooler places. Yet, their path to cooler places may be blocked by human-created barriers such as cities or roads. Where species ranges need to shift, it is important to ensure that individual plants and animals are able to move through landscapes so they can make it to new climates that are now suitable, and corridors can provide a path to those new places. Climate change may also increase population

variability and reduce the likelihood of local extinction; corridors provide paths for individuals to recolonize habitats where populations have been lost. Since many species' response to climate change is still unpredictable, habitat linakges can provide the necessary outlet for species to expand as needed throughout the landscape and ensure that fewer local populations go extinct.

Given this, it is critical to provide connectivity between the Diablo Range, Santa Cruz Mountains, and Gabilan Range which together consist of multiple species metapopulations. These species need to be able to travel between the mountain ranges to 1. find resources such as food and water, 2. find viable mates to allow for gene flow, and 3. provide habitat for juveniles to disperse out of their parental home ranges to establish their own ranges.

Within the Diablo Range of the study area, as the upland grassland and oak woodland savannah habitats become hotter and drier on the north side of SR-152, wildlife will need to be able to travel from the upland habitats of the Diablo Range down south to the Pacheco Creek watershed, which acts as a natural refugia providing important resources such as water, food, and riparian habitats.

The Pacheco Creek riparian corridor provides habitat for numerous sensitive and special-status wildlife species. Documented species occurrences include: Tule elk (*Cervus canadensis nannodes*), yellow-legged frogs (*Rana boylii*), California red-legged frogs (*Rana draytonii*), western pond turtles (*Emys* marmorata) California tiger salamander (*Ambystoma californiense*), and bald eagles (*Haliaeetus leucocephalus*) Spawning South Central Coast steelhead (*Oncorhynchus mykiss*) also migrate through the Pacheco Creek Reserve property. Furthermore, as the Central Valley becomes hotter due to climate change, it is critical to provide connectivity for the San Joaquin kit fox (*Vulpes macrotis mutica*), which have been documented east of the study area.

However, wildlife will need to cross SR-152 to access Pacheco Creek. Our data has shown there is a high amount of wildlife-vehicle collisions throughout SR-152 Pacheco Pass, so it is important to increase the permeability of the highway for wildlife to safely cross it, which is the objective of both the wildlife connectivity enhancement recommendations and proposed next steps for research.

Furthermore, in terms of genetic flow, a new paper recently published on mountain lion genetics has revealed that the Santa Cruz Mountain lion population has low genetic diversity and effective genetic population size (Ne15-16) (Gustafson et al. 2019). It is important to provide connectivity between the Santa Cruz Mountains and within the Diablo Range to facilitate gene flow for mountain lions and other species to keep the greater metapopulations intact and healthy. There have been 5 records of a mountain lion recorded traveling within the Pacheco Creek Reserve, adjacent to SR-152 (Figure 25). This is important data in documenting mountain lions are traveling within the linkage area as they have also been recorded hit on the highway.

Figure 25. Mountain lion traveling into the Pacheco Creek watershed at the Pacheco Creek Reserve on 9-1-2018.

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