Progress Report
Monday, April 20, 2020

Evaluation of Measures to Reduce Wildlife-Vehicle Collisions and Promote Connectivity in a Sonoran Desert Environment – State Route 77

Santa Catalina – Tortolita Mountain Corridor

Presented to the: Regional Transportation Authority

Submitted by the:
Arizona Game and Fish Department
Wildlife Contracts Branch

Collaborators Include:

INTRODUCTION

With continued human population growth and ongoing investment in transportation infrastructure, there is growing interest in excluding wildlife from roadways for safety reasons, in addition to maintaining landscape connectivity for wildlife populations (Bissonette and Adair 2008, Huijser et al. 2008). This concern has generated an interest in safe crossing structures for wildlife by both transportation and resource management agencies as a tool for mitigating the negative interactions between roadways and wildlife (Forman et al. 2003, Huijser et al. 2008).

Work toward habitat conservation has been a priority for Pima County since the inception of the Sonoran Desert Conservation Plan in 1999. In 2001, a team of biologists identified biologically-important lands. Part of this analysis included six "Critical Landscape Connections," or lands that have been shown to have landscape barriers between protected areas. The Santa Catalina Mountains – Tortolita Mountains linkage is one of these Critical Landscape Connections.

Although connection of the unique sky island ecosystems in southern Arizona has long been a priority for many, in 2004 local stakeholders had the opportunity to identify specific areas where habitat connectivity efforts should be focused through a statewide workshop hosted by the Arizona Wildlife Linkages Workgroup (AWLW, Nordhaugen et al. 2006). This workshop identified 152 potential linkage zones across the state. Linkage #81 identified the importance of the connection between the Santa Catalina and Tortolita Mountains for various wildlife species, with State Route (SR) 77 as the primary barrier to wildlife movements (Figure 1). With the imminent widening of SR 77, it was essential to determine where efforts to provide connectivity should be focused. Through least-cost modelling efforts that included information for 9 different species and thorough linkage zone evaluations, three main corridors across SR 77 were identified (Beier et al. 2006). Ultimately, through coordination between multiple entities, that included natural resource and transportation and wildlife agencies, NGO's and landowners, the main southernmost corridor was selected for wildlife crossing opportunities. In May 2006, Pima County residents voted for the half-cent excise tax to fund the Regional Transportation Plan, a comprehensive transportation plan including 2.1 billion dollars for transportation planning throughout Pima County. A portion of this funding is reserved to address wildlife connectivity and linkage plans associated with roadway development and improvement within Pima County. With financial support from Pima County's Regional Transportation Authority (RTA), implementation of wildlife crossings became a reality when the RTA approved a total of $11 million for a large wildlife overpass and a large wildlife underpass across SR 77 in 2009.

In 2014, the Arizona Department of Transportation (ADOT) began upgrading key sections of SR 77 within the identified corridor. As SR 77 is expanded and the two wildlife crossing structures are built, we are presented with a unique opportunity to evaluate conservation measures that will allow for the safe passage of wildlife across this roadway, while simultaneously increasing motorist safety. These wildlife crossing structures are located in a zone of high wildlife mortality (Ostergaard 2006), Sky Island Alliance, unpublished data) and

– along with wildlife funnel fencing – are designed to reduce wildlife-vehicle collisions (WVCs).

Though wildlife crossing structures have recently become more common in North America as a means to enhance permeability and reduce wildlife-vehicle collisions for a range of wildlife species, there is limited information on the efficacy of crossing structures in promoting permeability in the Sonoran Desert. While examples of successful crossing structures for large animals exist in other ecosystems (Clevenger and Waltho 2000, Gagnon et al. 2011, Sawyer et al. 2012), this is the first time that an overpass will be constructed in the Sonoran Desert. It is within the context of the Sonoran Desert's unique habitat and species assemblages that we propose to implement a monitoring program to evaluate the effectiveness of the crossing structures in an effort to document the multiple species benefits that the structures are designed to provide.

Given the commitment by ADOT and RTA to ensure motorist safety and mitigate the effects of the newly constructed SR 77 on local wildlife populations, as well as its status as one of the first comprehensive efforts to promote wildlife connectivity within the Sonoran Desert, evaluation of the crossing structures on SR 77 is necessary to determine their success. Effectiveness monitoring will be conducted by the AGFD Wildlife Contracts Branch in cooperation with ADOT Environmental Planning Group, the Coalition for Sonoran Desert Protection, and Sky Island Alliance. Monitoring activities will include camera documentation of wildlife use of the passage structures and tracking of WVC incidence, and desert tortoise movement monitoring. ADOT Environmental Planning Group, in cooperation with AGFD, have already invested substantial resources into the incorporation of a wildlife video surveillance system at the overpass along with still cameras at the underpass. The Coalition for Sonoran Desert Protection has invested substantial resources into documenting wildlife occurrence in the vicinity of the project with their volunteer-supported Remote Wildlife Camera Project that they started in 2012. The Coalition has over 30 volunteers monitoring 18 motion-activated wildlife cameras in the project area. The Coalition has also been instrumental in garnering public support for the project. Sky Island Alliance conducts wildlife tracking workshops in the area, has a group of volunteers that regularly monitor transects for wildlife tracks, and has recently launched an iNaturalist project in the area (iNaturalist is an online platform that enables citizens to record wildlife sightings).

Information gathered from this monitoring effort will inform the design and management of future wildlife crossing projects for the benefit of multiple species across multiple ecosystems. The insights we gain from this project will be extremely valuable for finding solutions to wildlife-highway conflicts in southern Arizona and fill a significant information gap.

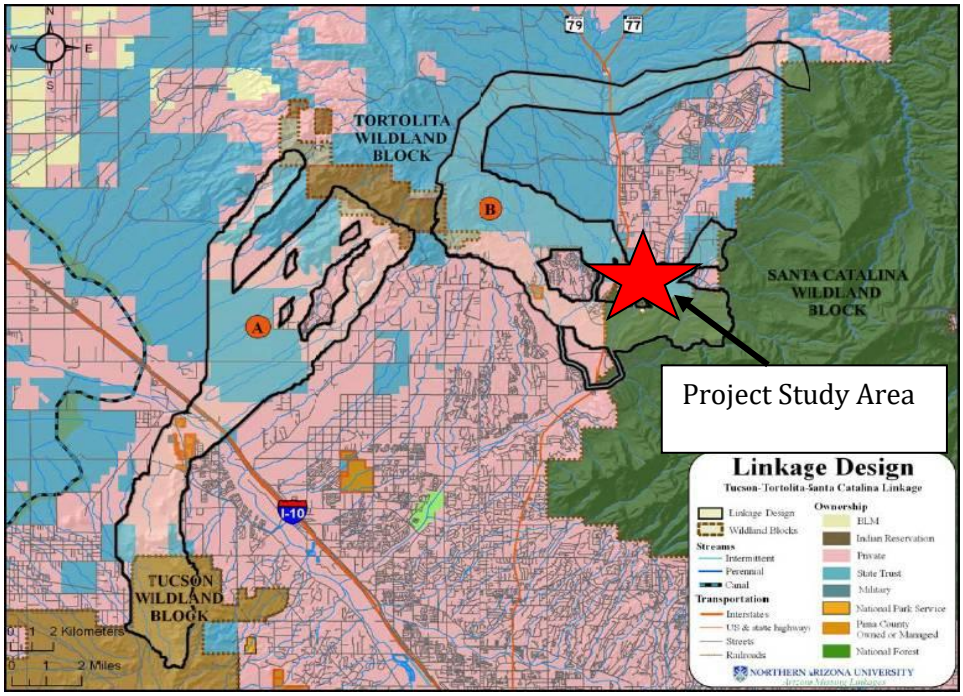

Figure 1. Least-cost linkage design for the Tucson, Tortolita, and Santa Catalina mountains and location of study area. Map from Beier et al. 2006.

RESEARCH OBJECTIVES

This project will utilize a staged approach to allow documentation of WVC and wildlife use of the overpass, underpass and associated funnel fencing. The specific objectives and associated procedures of our proposed SR 77 research project include:

1. Assess wildlife use and passage rates of the wildlife crossings using integrated video and still camera surveillance.

2. Investigate wildlife-vehicle collision patterns along SR 77.

3. Monitor movements of Sonoran Desert tortoise and activity centers in relation to SR 77.

4. Provide recommendations for the adaptive-management/maintenance of the structures and fencing as well as recommendations to guide future projects in southern Arizona.

Objective 1: Assess wildlife use and passage rates of the wildlife crossings using integrated video and still camera surveillance

Given the tremendous commitment by ADOT and RTA to provide wildlife crossing structures to reduce motorist collisions with wildlife and mitigate the impact of highway barrier effects, it is essential to evaluate their level of acceptance by Sonoran Desert wildlife. This is the primary objective of the post-construction monitoring study. To accomplish this objective, we are using 8-camera video (overpass) and rapid-still frame cameras (e.g., Reconyx®, underpass). Video and still cameras provide detailed documentation of wildlife use and behavior in and near the newly constructed wildlife crossings along SR. We also installed backup Reconyx® cameras on the overpass to ensure no loss of data, in the event of short-term video system failures. Long-term evaluation of the wildlife crossings is essential for a proper evaluation and future recommendations (Gagnon et al. 2011). All surveillance equipment was installed by AGFD and ADOT during the highway construction.

Figure 2. Structure surveillance system components: video camera with infra-red lights (left) with still camera (right) as backup documentation at the overpass and to capture wildlife use at the underpass.

Image data has been analyzed from project inception (April 8th, 2016) to April 8th, 2020. This represents four years of monitoring at the crossing structures, monitoring will continue at both structures to assess utilization trends over time for various species and complement deer movement data collected as part of Secretarial Order 3362 (see Supplemental Objective on Page 15 for more information).

A total of 26 native vertebrate species have been documented at the crossing structures, 11 at the overpass, and 25 at the underpass. Of these, 20 have been documented crossing SR77, 11 at the overpass, and 19 at the underpass (Table 1).

Table 1. Species detected and documented at crossing structures to April 8th, 2020.

Species	Overpass		Underpass	
	Detected	Crossed	Detected	Crossed
American Badger	-	-	X	X
Antelope Jackrabbit	X	X	X	X
Barn Swallow	-	-	X	X
Black-tailed Jackrabbit	X	X	X	X
Bobcat	X	X	X	X
Cactus Wren	-	-	X	-
Common Raven	-	-	X	X
Coyote	X	X	X	X
Desert Cottontail	X	X	X	X
Desert Spiny Lizard	-	-	X	-
Gambel's Quail	X	X	X	X
Gila Woodpecker	-	-	X	-
Gray Fox	X	X	X	X
Greater Roadrunner	X	X	X	X
Javelina	X	X	X	X
Mourning Dove	-	-	X	X
Mule Deer	X	X	X	X
Raccoon	-	-	X	-
Rock Squirrel	-	-	X	X
Striped Skunk	-	-	X	-
Tiger Whiptail	-	-	X	X
Unidentifiable Bat	-	-	X	-
Unidentifiable Hummingbird	-	-	X	X
Unidentifiable Pack Rat	X	X	-	-
White-nosed Coati	-	-	X	X
White-tailed Deer	-	-	X	X

10843 wildlife crossings have been documented across both structures, with 5490 and 5353 at the overpass and underpass respectively. Mule deer, coyote, and javelina utilize the overpass most regularly with 4338, 453, and 598 documented crossings respectively. At the underpass javelina, coyote, and mule deer are again the most regularly documented species with 2259, 1765, and 1019 crossings respectively (Table 2). Along with bobcat, these species account for over 98% of documented crossings at each structure. Species of note

observed crossing through the underpass include, a white-nosed coati in September 2017, and a white-tailed deer in January 2019 (Figure 3).

Table 2. Number of crossings by species collected through camera surveillance to April 8th, 2020.

	Overpass	Underpass	Combined
Mule Deer	4338	1019	5357
Javelina	598	2259	2857
Coyote	453	1765	2218
Bobcat	48	232	280
Other	53	78	131
Totals	**5490**	**5353**	**10843**

Figure 3. White-tailed deer crossing at the underpass in January 2019

Several disturbances have been documented at both structures, the most impactful to monitoring efforts has been the theft of monitoring cameras at the underpass in November 2016. This resulted in a total loss of data from October 11th, 2016 to November 18th, 2016 when monitoring cameras were installed on the ceiling of the structure to reduce the risk of theft. Unfortunately, this orientation proved less effective in detecting wildlife and cameras were remounted in their original configuration in July 2017. Regular encroachment by cattle was documented at the overpass from October 2016 to January 2017 and during December 2017.

Human activity at both crossing structures has been lower over the past 12 months when compared to the previous 12, with an average of 3.1 instances of human presence per month versus 5.7 instances at the overpass, and 7.3 versus 11.3 at the underpass.

Observed crossing accumulation trends at the overpass remain relatively consistent for mule deer, and bobcat since the fourth month of monitoring (Figure 4). Javelina crossings have been documented at an increased rate since July 2018, coinciding with an increase in vegetation cover at the structure. Coyote crossing rates have slowed since December 2018, corresponding with an increased crossing rate at the underpass (Figure 5).

As has been noted previously, trends at the underpass have been more difficult to track given the disruption to monitoring during 2016. However, crossings accumulated at a similar rate at the underpass prior to theft in October 2016 and after reinstallation of the original orientation in July 2017 (Figure 5). Coyote and Mule Deer crossings have accumulated at an increased rate since December 2018.

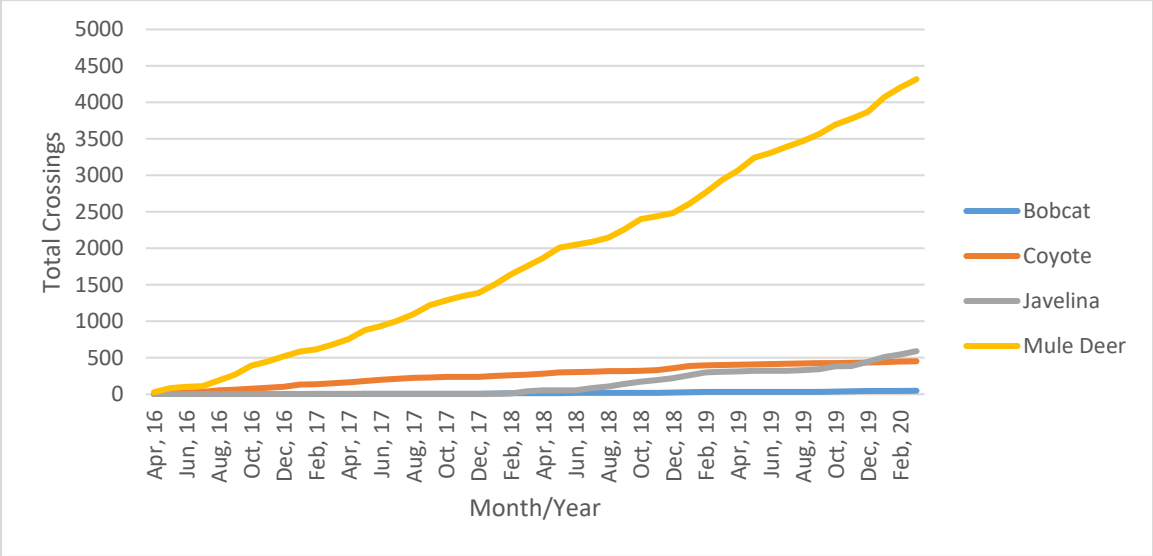

Figure 4. Wildlife use of the overpass located on SR77.

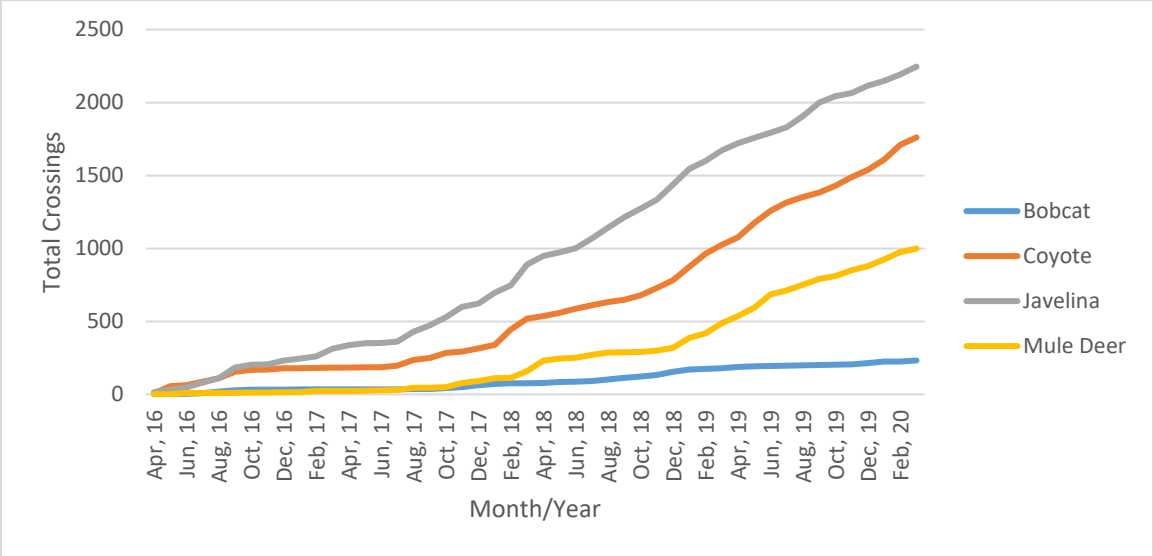

Figure 5. Wildlife use of the underpass located on SR 77.

Total wildlife crossings at each structure have increased year on year since project inception (Table 3). Crossings by mule deer, javelina and bobcat at the overpass have increased each year, while coyote use remained at a similar level through the initial three years of monitoring before dropping in year 4 (Figure 6). Crossings by coyote and mule deer at the underpass have increased each year, while use by javelina and bobcat increased through the first three years of monitoring then dropped in year 4 (Figure 7).

Table 3. Year on year wildlife crossings by structure from April 8th, 2016 through April 7th, 2020.

Year	Overpass	Underpass	Combined
Year 1	875	564	1439
Year 2	1275	1173	2448
Year 3	1605	1724	3329
Year 4	1735	1892	3627
Totals	**5490**	**5353**	**10843**

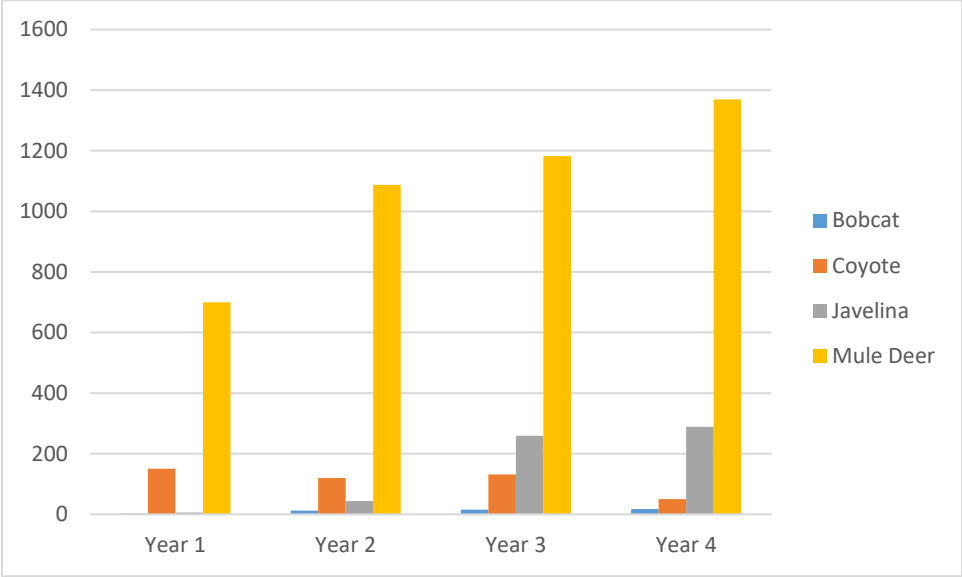

Figure 6. Year on year wildlife crossings by species at the overpass from April 8th, 2016 through April 7th, 2020.

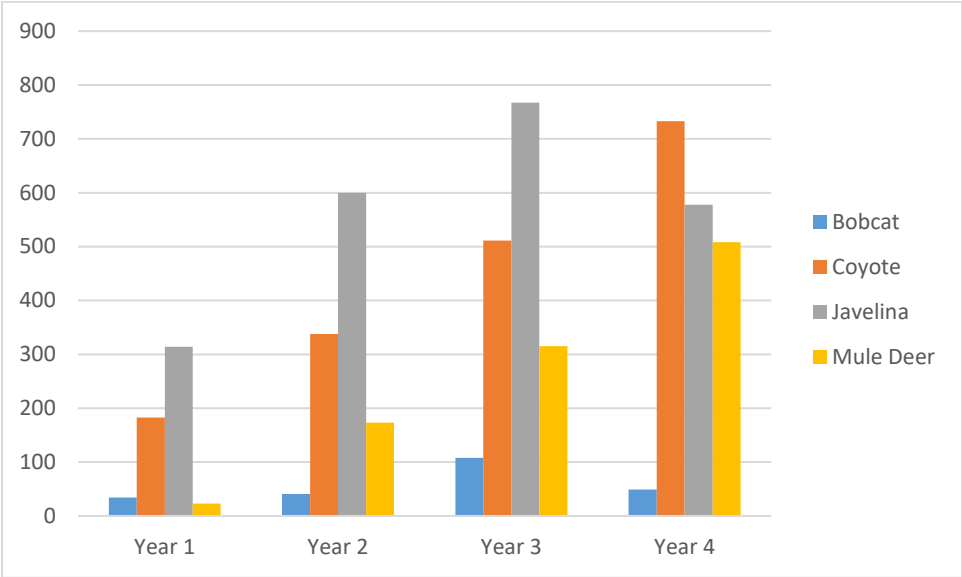

Figure 7. Year on year wildlife crossings by species at the underpass from April 8th, 2016 through April 7th, 2020.

Figure 8. Examples of wildlife and non-wildlife events documented at the SR 77 overpass and underpass.

Objective 2: Investigate wildlife-vehicle collision patterns along SR 77

Determining the number and composition of roadkill following completion of the two wildlife crossings and funnel-fencing along the newly improved stretch of SR 77 will allow for understanding their combined effectiveness in reducing collisions for various species types (mammal, reptile, amphibian, bird). It is essential to thoroughly collect data on larger wildlife, which is a higher safety concern to motorists, and equally important to document road kill trends for smaller species important to the Sonoran Desert ecosystem. Studies conducted elsewhere in Pima County documented a large portion of game species along with other birds, mammals, reptiles and amphibians were killed on local roads. Although, pre-construction road kill data along SR 77 was "opportunistic" and emphasis was placed on large mammals, it nevertheless provided a sample of species found prior to construction (Ostergaard 2006). Additional intensive roadkill studies will be important to determine the effectiveness of the fencing in excluding both large and smaller animals from SR 77 and guiding them to wildlife crossings and culverts.

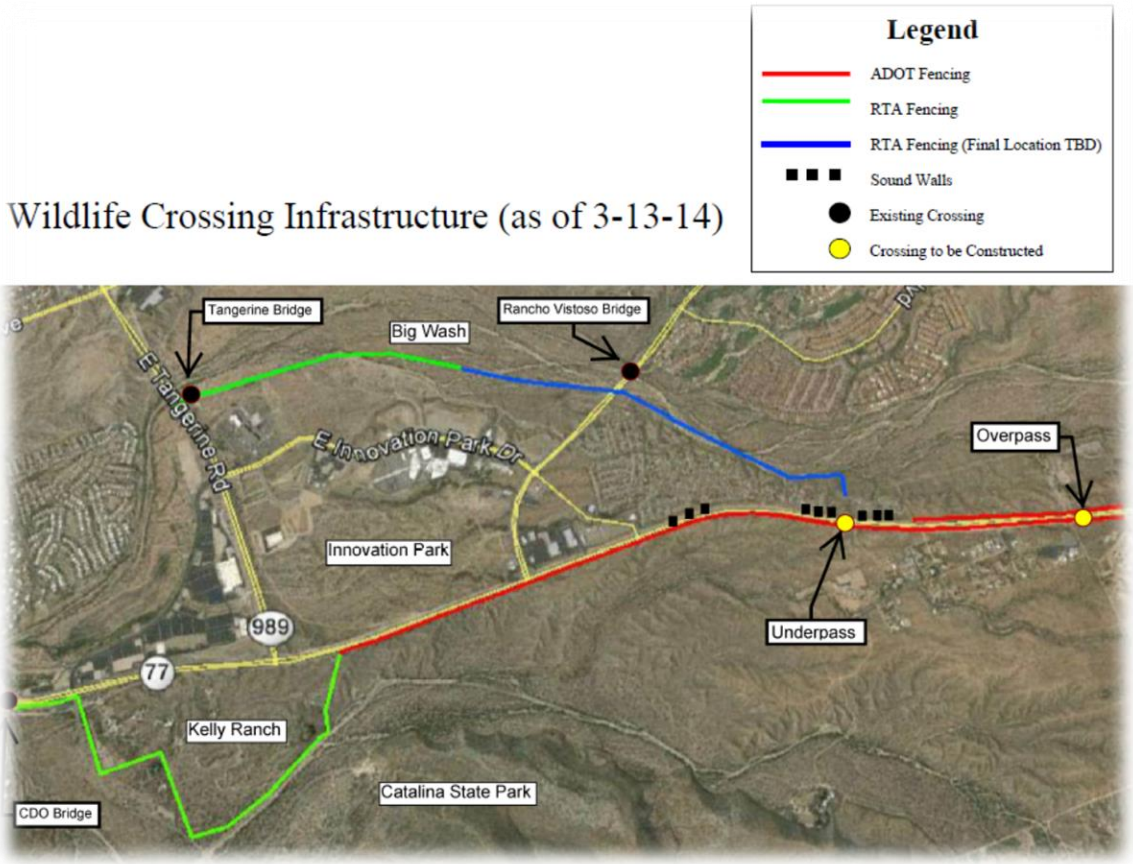

Figure 9. Map showing alignment of wildlife funnel-fencing and the complexities that will need to be accounted for (e.g. fencing distance from road) during road kill analysis. Map courtesy Coalition for Sonoran Desert Protection.

Funnel-fencing associated with most highway projects is generally placed along the right-of-way on each side of the road. Along the SR 77 project, designers have been forced to deviate from this traditional alignment and take the fencing away from the road to avoid local communities/business (Figure 9). This orientation provides a unique opportunity to evaluate the effectiveness of fencing as it is pulled away from the road and encompasses additional habitat. These differences will be accounted for during road kill analysis and we will compare their relative effectiveness.

Roadway Walking Surveys

To accomplish this objective we will conduct road-kill surveys between MP 80.8 (CDO Bridge) and MP 86.0 (Hawser St) focusing on peak roadkill times identified through nearby mortality studies on Tangerine Road (Lowery et al. 2011). Road kill surveys will begin ½ hour before sunrise in order to minimize the loss of wildlife mortalities due to scavenger activity. We will document all road-killed wildlife by species and location. The complete road right-of-way will be surveyed (i.e., the area between the two right-of-way boundary fences). In areas where the wildlife funnel-fencing has been pulled back from the road we will still only evaluate the area associated with the ADOT right-of-way. All individual mortalities will be marked or removed from the roadway once they are recorded. We will compare the frequency of road mortalities for several taxonomic groups (i.e., amphibians, lizards, snakes, small mammals, carnivores, and ungulates) with the expectation that the frequency of road mortality should be lower on the segment of road where wildlife fencing has been installed on both sides of SR 77 versus area where only one side is fenced adjacent to SR 77, or fence ends.

Roadway Driving Surveys

Daily walking surveys will complement daily driving surveys along the remainder of the project area (approximately 4 miles). A single surveyor will drive along the edge of the paved roadway at 25 – 30 mph and scanned for larger-sized mortalities (i.e., rabbit and larger) or unusual (e.g. snakes, Gila monsters, desert tortoises, etc.) wildlife that otherwise might go undetected between alternating survey segments which were not scheduled to be intensively walked until the following days. This strategy will minimize loss of detections due to scavenger removal of animal remains across the project area. In addition, this method will allow for the collection of data points which would be removed by passers-by, degraded by repeated friction by passing vehicles, and extreme environmental conditions. Detections during the driving segments will be recorded on physical data forms and exact coordinates will be documented using the AGFD Roadkill App. Roadway driving survey data will then be added to the overall road mortality database prior to analysis.

Additionally, the project team will coordinate with AGFD, ADOT, Pima County, DPS, Coalition for Sonoran Desert Protection, Tucson Audubon Society, Sky Island Alliance, and local volunteers to document and compile a comprehensive list of roadkill throughout the duration of the study.

Road mortality surveys were completed in August 2018, a preliminary review of results can be found in the March 15, 2019 progress report.

Objective 3: Monitor movement of Sonoran Desert tortoise in relation to SR 77

As with most wildlife species, roads are a nearly impermeable barrier to Sonoran Desert tortoises (SDT). Tortoises rarely cross roads due to their lack of mobility and they suffer high rates of mortality when they do attempt to cross. There is speculation that wildlife crossings can facilitate movement of desert tortoise across roads, however opportunities to evaluate the effectiveness of wildlife crossings for this species have been limited to date (Leavitt and Hoffman 2014). During the early stages of construction, project personnel removed several tortoises from the construction site, including one that attempted crossing through the underpass in October 2015 (Figure 10).

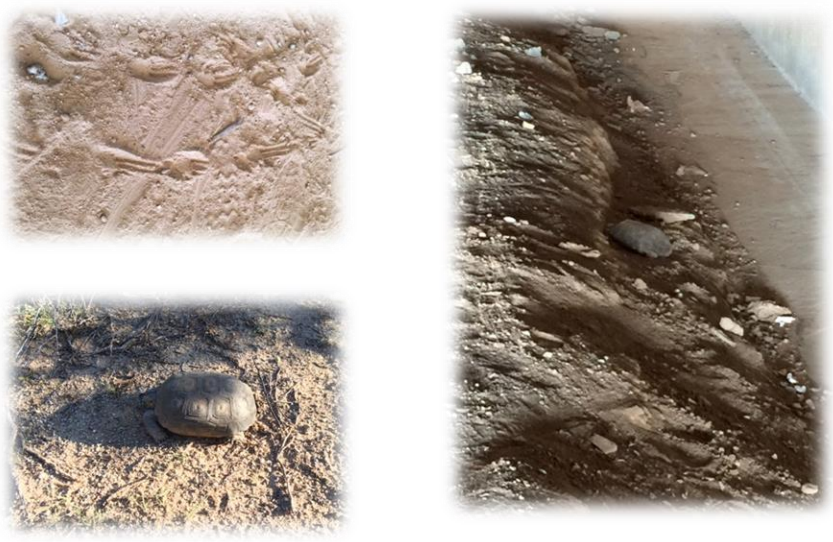

Figure 10. Sonoran Desert tortoise found in the wildlife underpass during construction, tracks in underpass that alerted contractor (upper left), leading to location of tortoise in underpass (right) for safe removal from the site (lower left).

The tortoise population in the vicinity of the SR 77 wildlife crossings provides a unique opportunity to determine the combined effectiveness of an overpass, underpass, and multiple culverts linked with funnel fencing in minimizing road mortality while allowing for habitat connectivity for SDT. This knowledge is essential for long-term population persistence of desert tortoise and coexistence with humans as populations increase and additional infrastructure is required to accommodate this growth.

Tortoises are infrequently detected on wildlife cameras even where they are abundant (Leavitt and Hoffman 2014). However, GPS telemetry has proven an effective method to determining permeability of wildlife species across roadways and is an appropriate approach for Sonoran desert tortoise (Dodd et al. 2007a, Dodd and Gagnon 2011, Gagnon et al. 2013).

To evaluate SDT movements along SR 77 we conducted visual surveys for the presence of SDTs and their sign adjacent to SR 77. These surveys were conducted on foot by qualified AGFD biologists where rights-of-entry have been granted. Upon detecting a live SDT, we fit the tortoises with a VHF radio-transmitter (Holohil RI-2B) and a GPS tracking unit. GPS tracking units are replaced monthly and data will be downloaded into ArcGIS so that we may estimate home range size, activity patterns, and movement corridors for each individual.

GPS transmitters were pulled for the 2019 tracking season in October 2019. A review of tracking data through the 2019 season can be found in the December 11, 2019 progress report.

GPS transmitters were redeployed for the 2020 tracking season in March. Surveys will be conducted around the crossing structures during the 2020 monsoon to outfit additional individuals with transmitters.

Objective 4: Provide recommendations for the adaptive-management of the structures as well as recommendations to guide future projects in southern Arizona.

Using lessons learned from the implementation of the SR 77 structures and fencing, combined with current literature and research findings, we will provide general recommendations regarding the applicability of these measures for use in other scenarios throughout southern Arizona and the southwest.

- **Ongoing**
- **Participating in the development of recommendations for designs and alignments of ROW wildlife fencing in urban residential settings.**
- **Identified the need for scheduled survey and maintenance of installed ROW wildlife fence and crossing guards to detect and mitigate breaches caused by wear and tear, erosion, vandalism, carelessness, and traffic collisions. Several access points for tortoise, coyote, and javelina have been identified.**

Supplemental Objective: Monitor movement of mule deer in relation to SR 77 and wildlife crossing structures.

In response to Secretarial Order # 3362, Improving Habitat Quality in Western Big-Game Winter Range and Migration Corridors, AGFD secured funding to evaluate mule deer movements within the Catalina-Tortolita corridor. Mule deer crossings of SR77 at the wildlife overpass and underpass have been well documented by camera, however, it is unclear whether deer are completing movements between the two mountain ranges.

Figure 11. Two collared mule deer bucks traversing the SR77 wildlife overpass.

In late February of 2019 20 mule deer were collared in and around the Catalina-Tortolita corridor in a landscape-scale effort to assess the effectiveness of wildlife crossings in relation to targeted corridor conservation. Data collected from these individuals will provide important context when evaluating the landscape-scale conservation value of the SR77 mitigation measures and crossing structures in addition to their already demonstrated value in reducing wildlife-vehicle-collisions by facilitating mule deer highway crossings.

> **Over 45,000 GPS locations from 20 mule deer have been recorded within the Catalina-Tortolita corridor between February 25, 2019 and February 23, 2020 (Figure 12). Regular crossings of SR77 within the redeveloped section have been documented by two individuals which were collared in proximity to the wildlife underpass. Crossing patterns have been strongly associated with the two wildlife crossing structures (Figure 13). Three mortalities of collared deer have been recorded, one being a mountain lion kill, one of unknown cause, and one a vehicle collision at the northern terminus of the wildlife fence.**

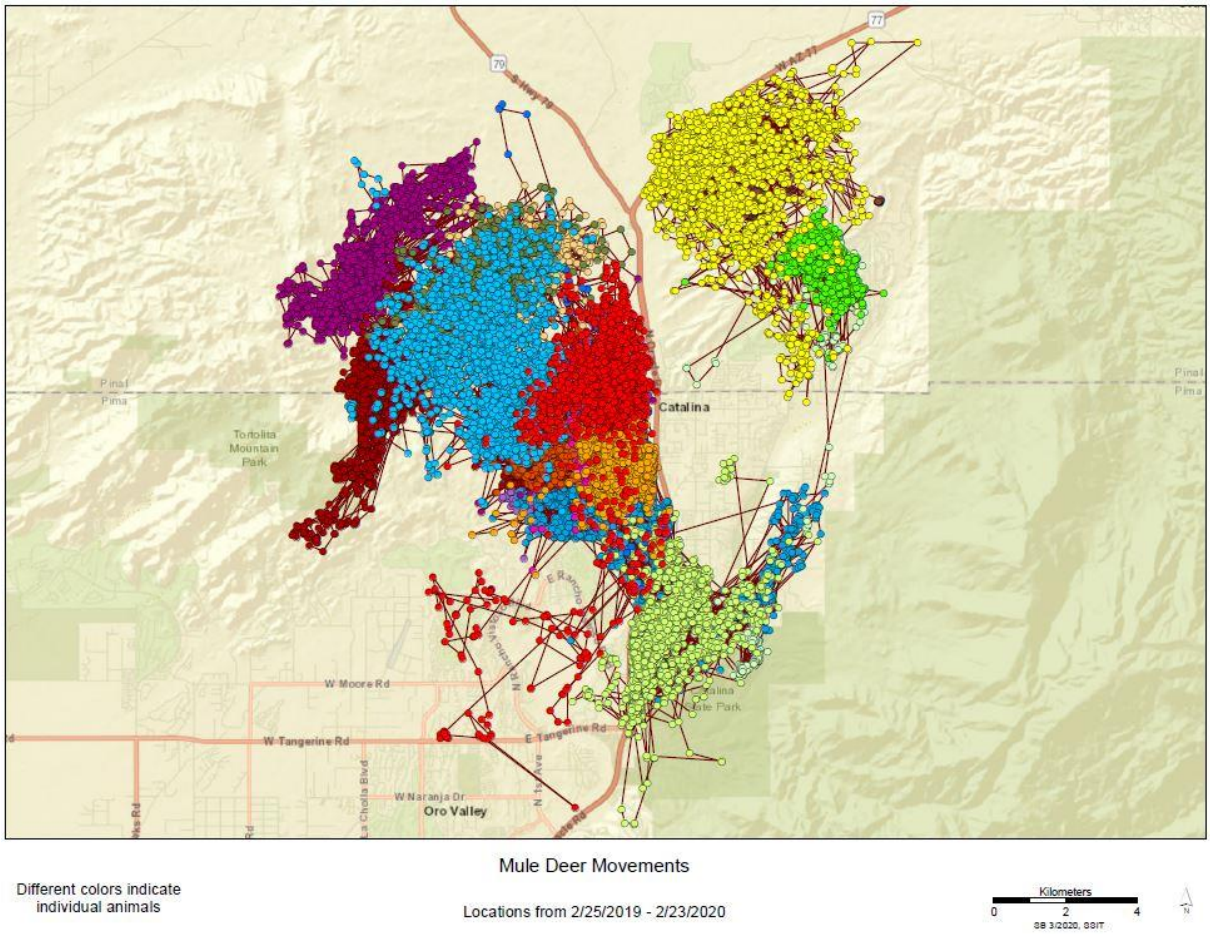

Figure 12. GPS locations from collared mule deer from February 25, 2019 through February 23, 2020, each color represents a distinct individual.

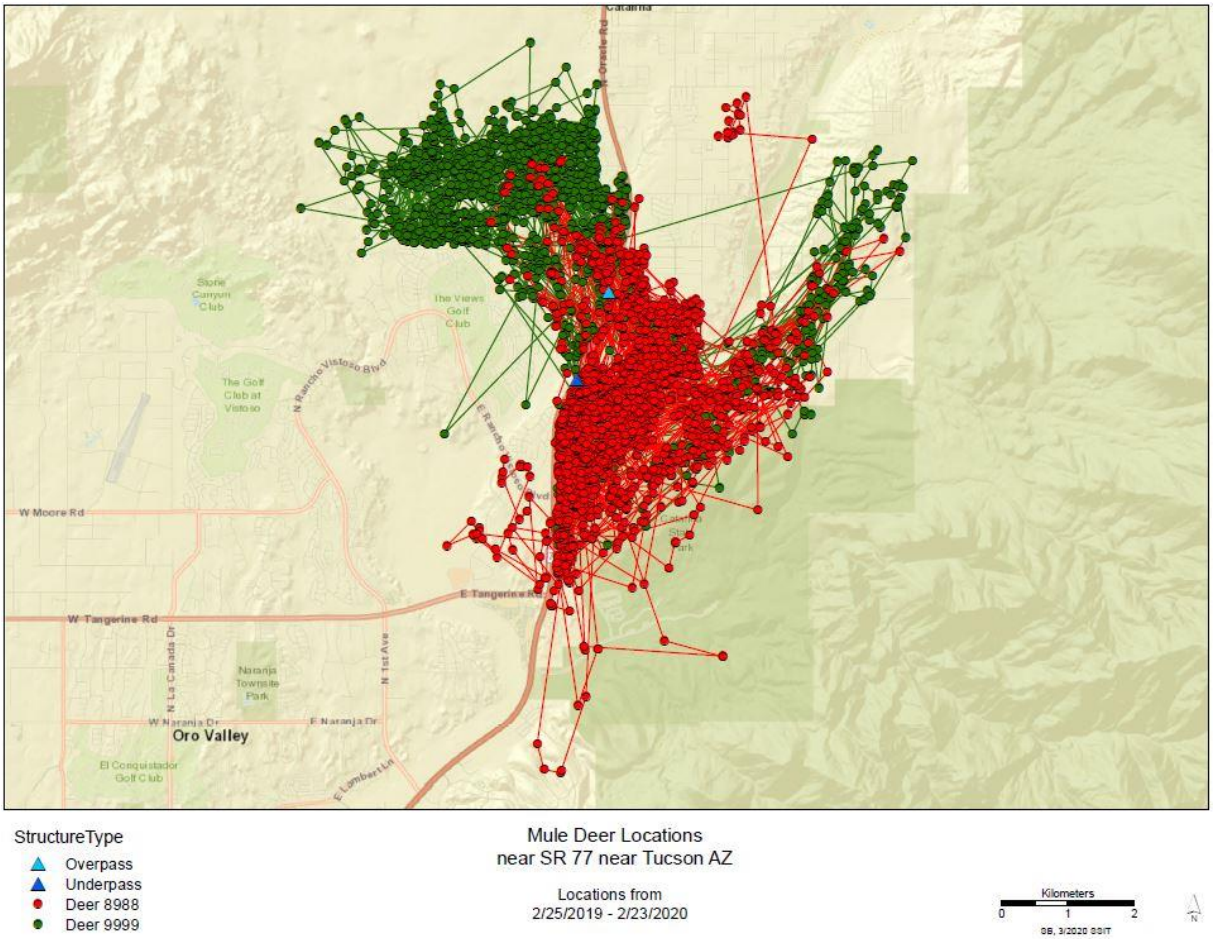

Figure 13. GPS locations from collared mule deer around the SR77 wildlife underpass and overpass from February 25, 2019 through February 23, 2020, each color represents a distinct individual.

PROJECT SCHEDULE AND DELIVERABLES

Upon completion of the wildlife crossings and fencing in 2016, along with installation of camera systems by AGFD and ADOT, AGFD with support and assistance from multiple stakeholders/volunteers AGFD began a three-year evaluation of wildlife crossing use and desert tortoise movements funded by RTA and AGFD. The project was initiated in April 2016. A no cost project extension was completed in February 2020 to extend the project until 2026 to allow additional long-term monitoring data collection.

Project Deliverable	**Completion date(s)**
Project status reports	Twice per year
Final Project Report	NTE 1 year following completion of monitoring
Scientific journal manuscripts	Various during and after the project
Professional/scientific symposia presentations	Various during and after the project

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