Progress Report

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:

Coalition for Sonoran Desert Protection

ADOT

SKY ISLAND ALLIANCE

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.

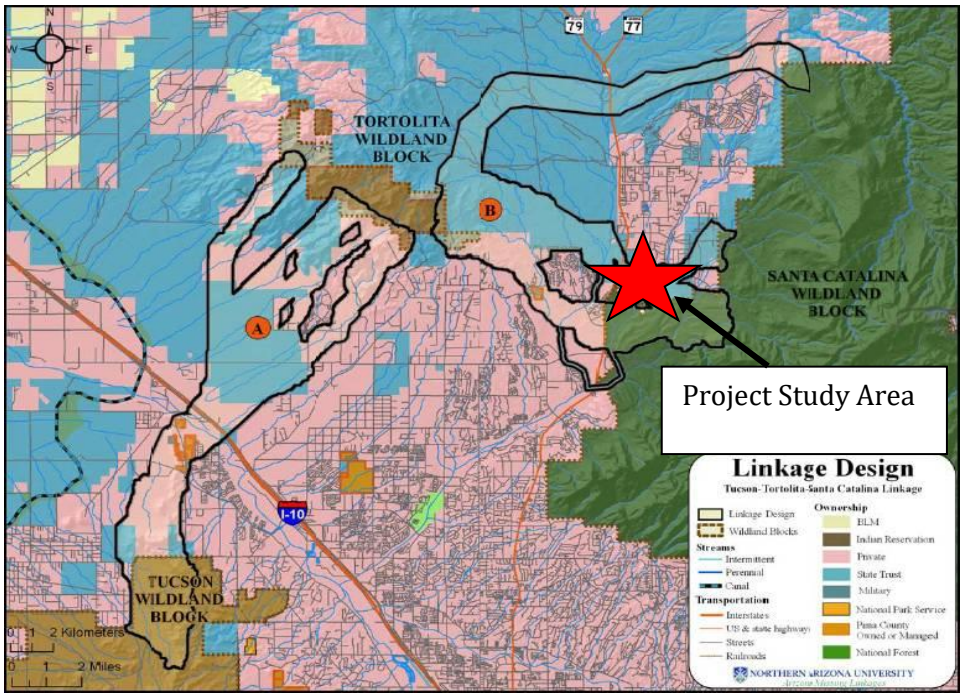

Figure 1. Least-cost linkage design for the Tucson, Tortolita, and Santa Catalina mountains and location of study area. Map from Beier et al. 2006.

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 18th, 2016) to January 7th, 2019. A total of 24 native vertebrate species have been documented at the crossing structures, nine at the overpass, and 23 at the underpass. 13 of these species have been documented crossing SR77 at the structures, nine at the overpass, and 12 at the underpass (Table 1).

5999 wildlife crossings have been documented across both structures, with 3187 and 2812 at the overpass and underpass respectively. Mule deer, coyote, and javelina utilize the overpass most regularly with 2528, 378, and 228 crossings respectively. At the underpass javelina, coyote, and mule deer are again the most regularly documented species with 1501, 794, and 299 crossings respectively (Table 2). One species of particular note has been documented crossing through the underpass, that being the white-nosed coati (*Nasua narica*) represented by a single record from September 2017 (Figure 3).

Figure 3. White-nosed coati (*Nasua narica*) documented crossing at the underpass in September 2017

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 presence at the overpass remains rare, averaging less than five instances per month. In contrast, human presence has been documented an average of 14 times per month at the underpass, though human encroachment events at the underpass were most regular during the first three full months of monitoring (Figure 4).

Observed crossing trends at the overpass for all wildlife can be seen to be relatively consistent through time (Figure 5). Trends at the underpass have been more difficult to track given the previously discussed disruption to monitoring. 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. Crossing accumulation rates at both structures exhibited an accelerating trend from December 2017 into early 2018, this was most pronounced at the underpass.

Mule deer use of the overpass began to pick up from the 4th month of monitoring and has remained relatively consistent since. Mule deer use of the underpass remains at a low level although a small surge was documented from February to April 2018 (Figure 6). Javelina use at the underpass fits the general trend, whereas their use of the overpass has picked up through 2018 while remaining at a relatively low level compared to mule deer. Coyote use of the overpass has been generally consistent since inception though crossing accumulation appeared to peak during the summer of 2017 and has been slower since. Use of

the underpass by each species saw a surge from February to April of 2018 consistent with the trend for all wildlife, though this was most pronounced for coyotes.

Table 1. Species detected and documented to have crossed at crossing structures to January 7th, 2019.

Species	Overpass		Underpass	
	Detected	Crossed	Detected	Crossed
Antelope Jackrabbit	-	-	X	X
Barn Swallow	-	-	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
Gambel's Quail	X	X	X	X
Gila Woodpecker	-	-	X	-
Gray Fox	-	-	X	X
Great Horned Owl	-	-	X	-
Greater Roadrunner	X	X	X	X
House Finch	-	-	X	-
Javelina	X	X	X	X
Lark Sparrow	-	-	X	-
Mourning Dove	-	-	X	-
Mule Deer	X	X	X	X
Painted Lady (Butterfly)	X	X	-	-
Raccoon	-	-	X	-
Rock Squirrel	-	-	X	-
Unidentifiable Hummingbird	-	-	X	-
Unidentifiable Pack Rat	X	X	-	-
Unidentifiable Skunk	-	-	X	-
Unidentifiable Songbird	-	-	X	X
White-nosed Coati	-	-	X	X

Table 2. Number of crossings by species collected through camera surveillance to January 7th, 2019.

	Overpass	Underpass	Combined
Mule Deer	2528	299	2827
Javelina	228	1501	1729
Coyote	378	794	1172
Bobcat	24	179	203
Other	29	39	68
Totals	**3187**	**2812**	**5999**

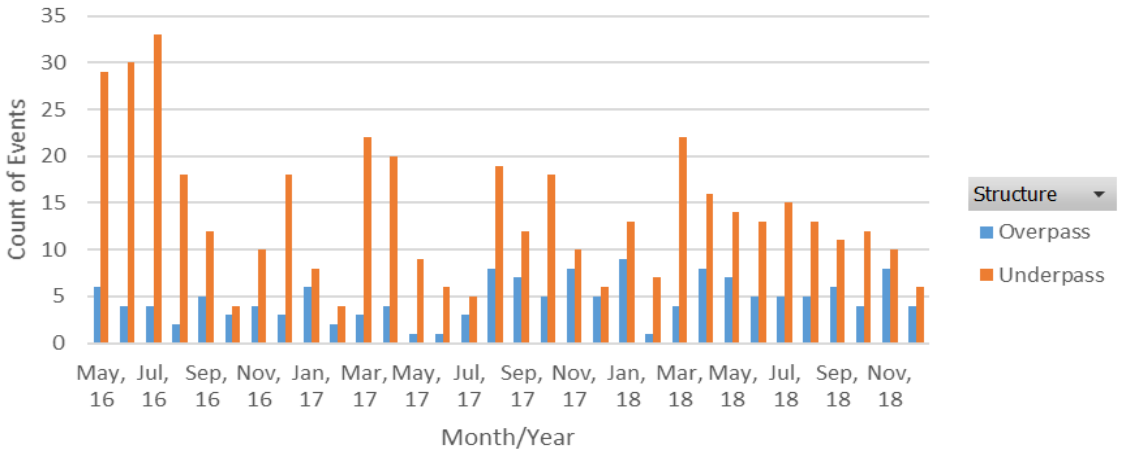

Figure 4. Instances of human presence at the overpass and underpass by month.

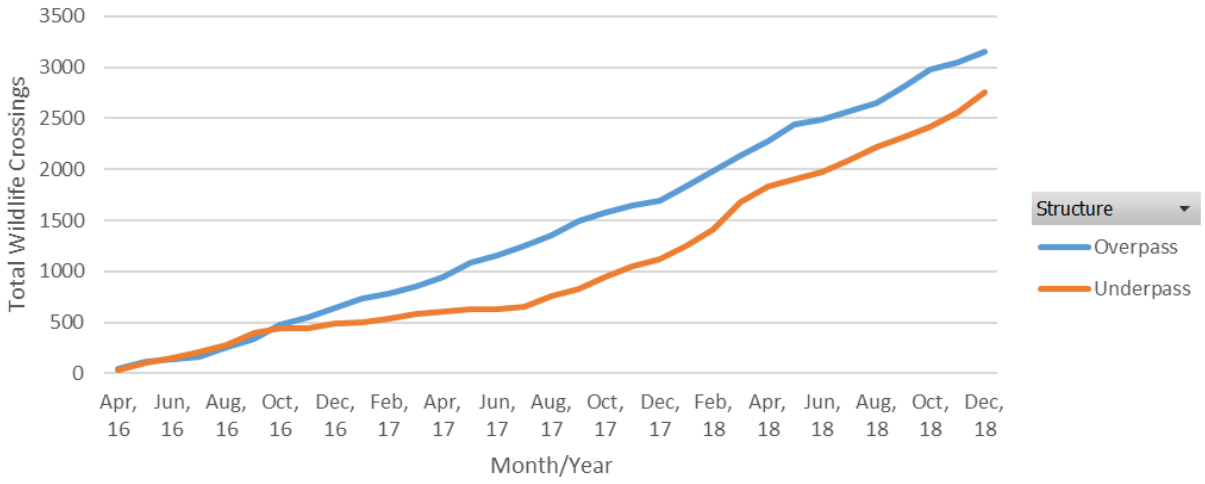

Figure 5. Wildlife use of the overpass and underpass located on SR 77.

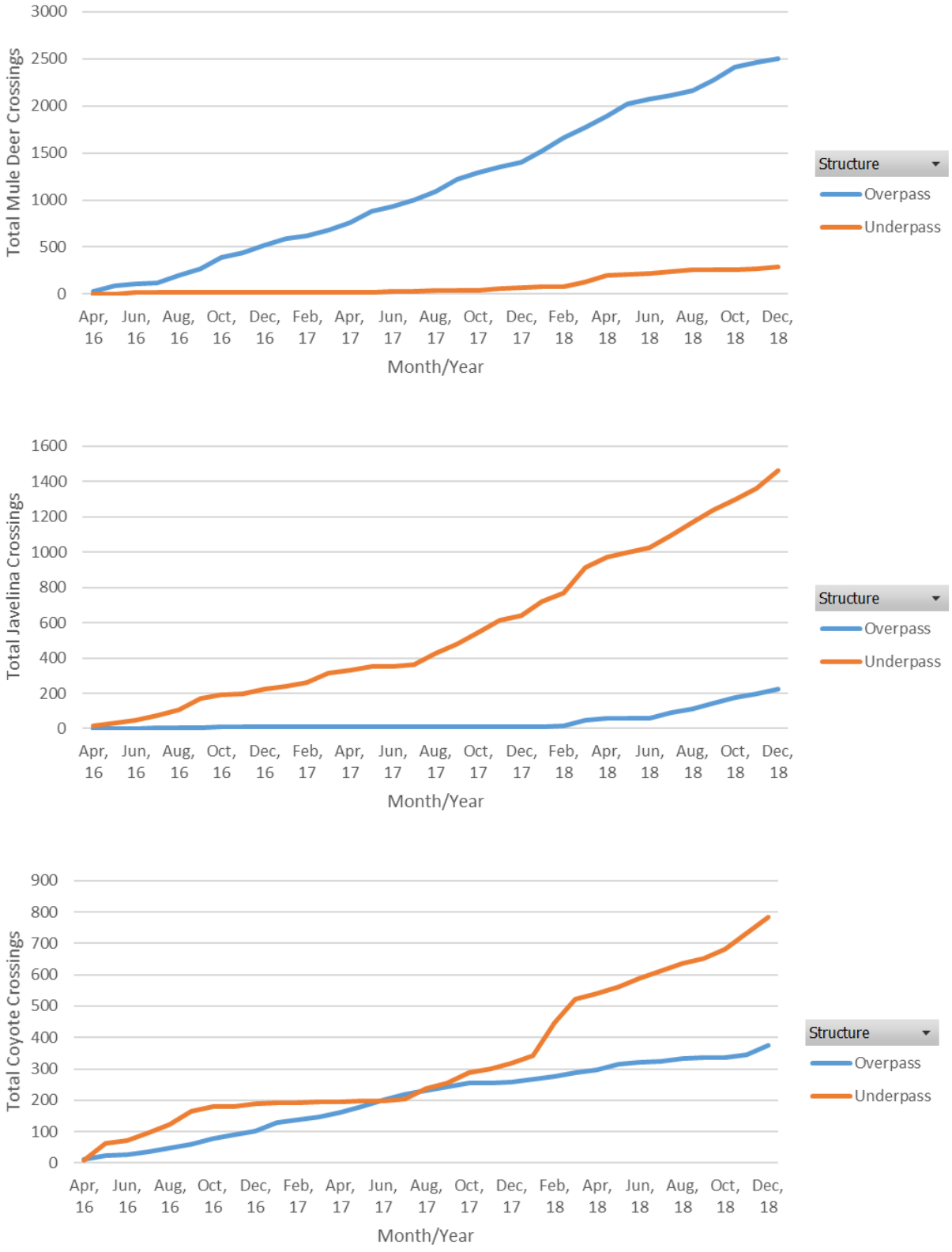

Figure 6. In order from top to bottom; mule deer, javelina, and coyote use of the overpass and underpass located on SR 77.

Figure 7. 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.

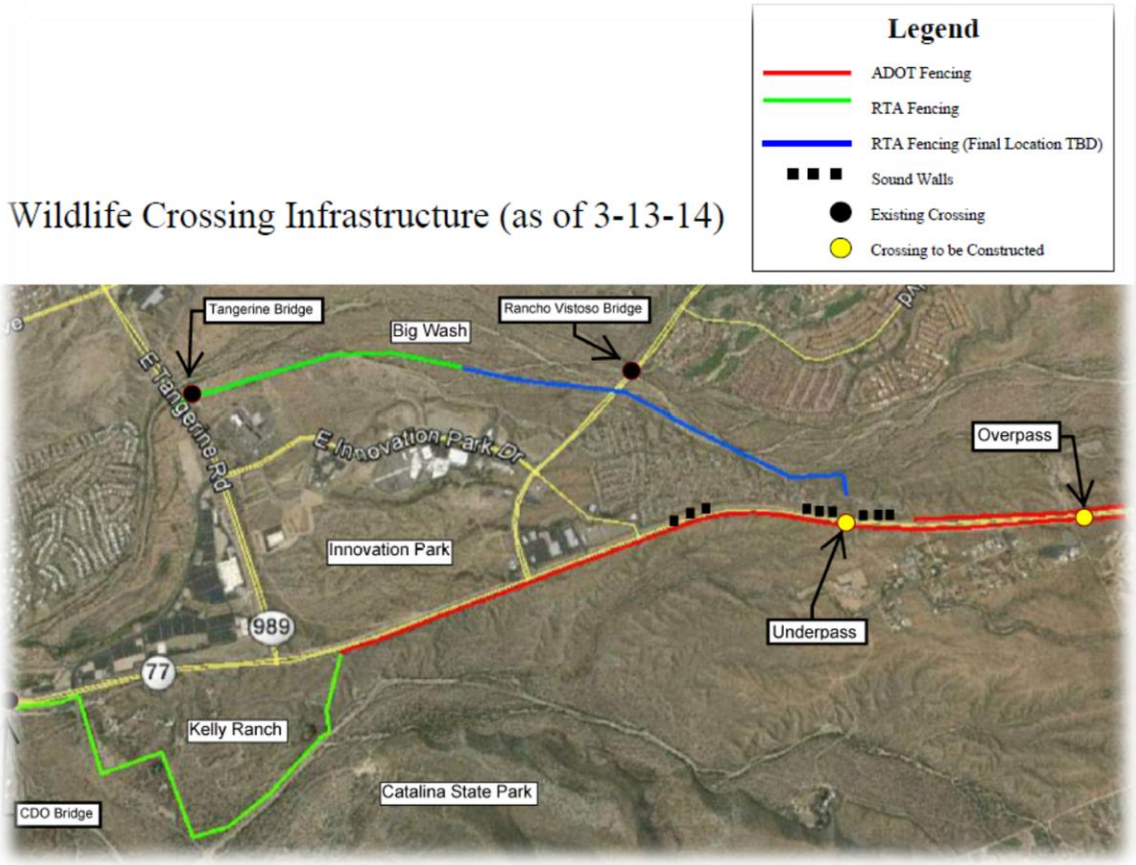

Figure 8. Map showing alignment of wildlife funnel-fencing and the complexities that will need to be accounted for (e.g. fencing distance from road) during road kill analysis. Map courtesy Coalition for Sonoran Desert Protection.

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 8). 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, 14 survey cycles have been completed in total, 7 each in 2017 and 2018 respectively. Each year four survey cycles were completed during the first four weeks of May; the remaining three survey cycles were completed during the first three weeks of August. All collected road mortality data has been compiled.

1849 observations were recorded over the course of the project, of these 1799 related to vertebrate mortalities, representing at least 80 species (Appendix I). Merriam's kangaroo rat, couch's spadefoot, and regal horned lizard were the most commonly recorded species with 257, 187, and 143 records respectively. Notable records include; Sonoran desert tortoise, gila monster, bobcat, javelina, black-necked gartersnake, checkered gartersnake, barn owl, and kit fox.

Table 3. Number of mortalities detected during roadkill surveys by group.

Group	Detections
Small Mammals	**547**
Lizards	**473**
Amphibians	**348**
Snakes	**190**
Birds	**161**
Bats	**11**
Carnivores	**6**
Tortoises	**4**
Ungulates	**1**
Unidentifiable	**58**
Total	**1799**

For the purposes of analysis, records are broken into functional groups along broadly taxonomic lines reflecting the nature of the constituent species' interactions with highways and ROW fences. Three of these groups contribute 76% of documented vertebrate mortalities, these being; small mammals, lizards, and amphibians, with 547, 473, and 348 records respectively (Table 3). Up to an additional 58 records may be attributable to these groups, however, insufficient material was present at time of detection to confirm their group. Of the remaining 373 records, 190 are snakes, 161 are birds, and 11 are bats. Ungulates, carnivores, and Sonoran desert tortoises with one, six, and four records respectively make up the remaining 0.6% of documented vertebrate mortalities.

Table 4. Number of mortalities detected during roadkill surveys by group and year.

Group	Detections	
	2017	2018
Small Mammals	380	167
Lizards	252	221
Amphibians	122	226
Snakes	126	64
Birds	90	71
Bats	3	8
Carnivores	4	2
Tortoises	0	4
Ungulates	0	1
Unidentifiable	30	28
Total	**1007**	**792**

There were 21% fewer vertebrate mortality detections in 2018 versus 2017 (Table 4). The difference is accounted for primarily by a marked reduction in detections during spring 2018 when compared to Spring 2017, with 323 versus 529 detections. Total detections during monsoon surveys were broadly similar across the two years with 478 detections in 2017 versus 469 in 2018. However, while the proportions of constituent groups were largely consistent across both years for detections during spring (Figure 9) this was not true of detections during the monsoon. During 2017 monsoon surveys, small mammals, amphibians, and snakes accounted for 33%, 26%, and 20% of detections respectively. Whereas, during 2018 monsoon surveys, amphibians, lizards, and small mammals accounted for 48%, 20%, and 14% of detections respectively (Figure 10). These results may be at least partially attributable to the prolonged drought conditions experienced between the August 2017 and August 2018 surveys combined with the onset of a wet monsoon shortly prior to the August 2018 surveys.

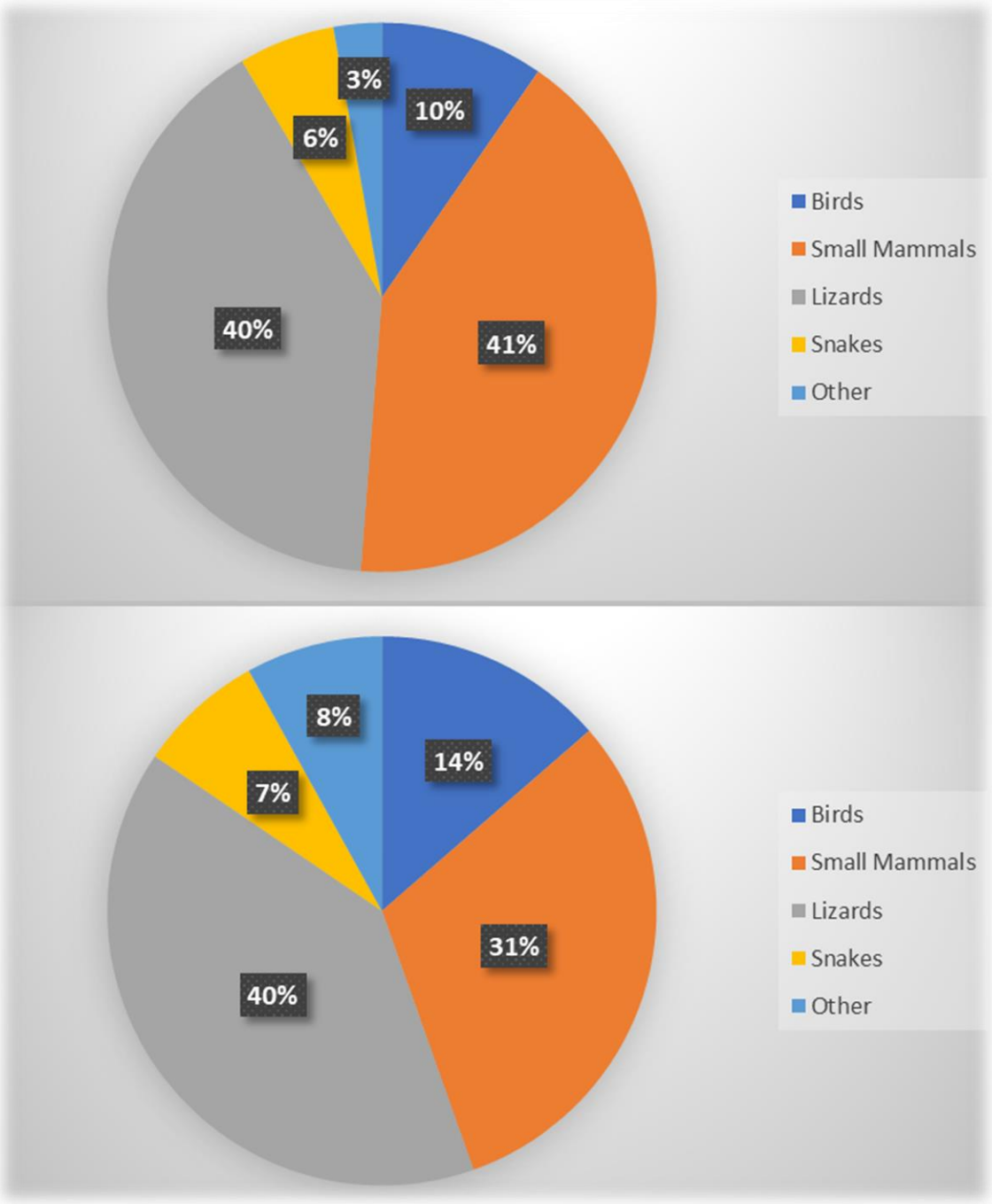

Figure 9. Proportions of detections by group during spring 2017 roadkill surveys (top), and spring 2018 roadkill surveys (bottom).

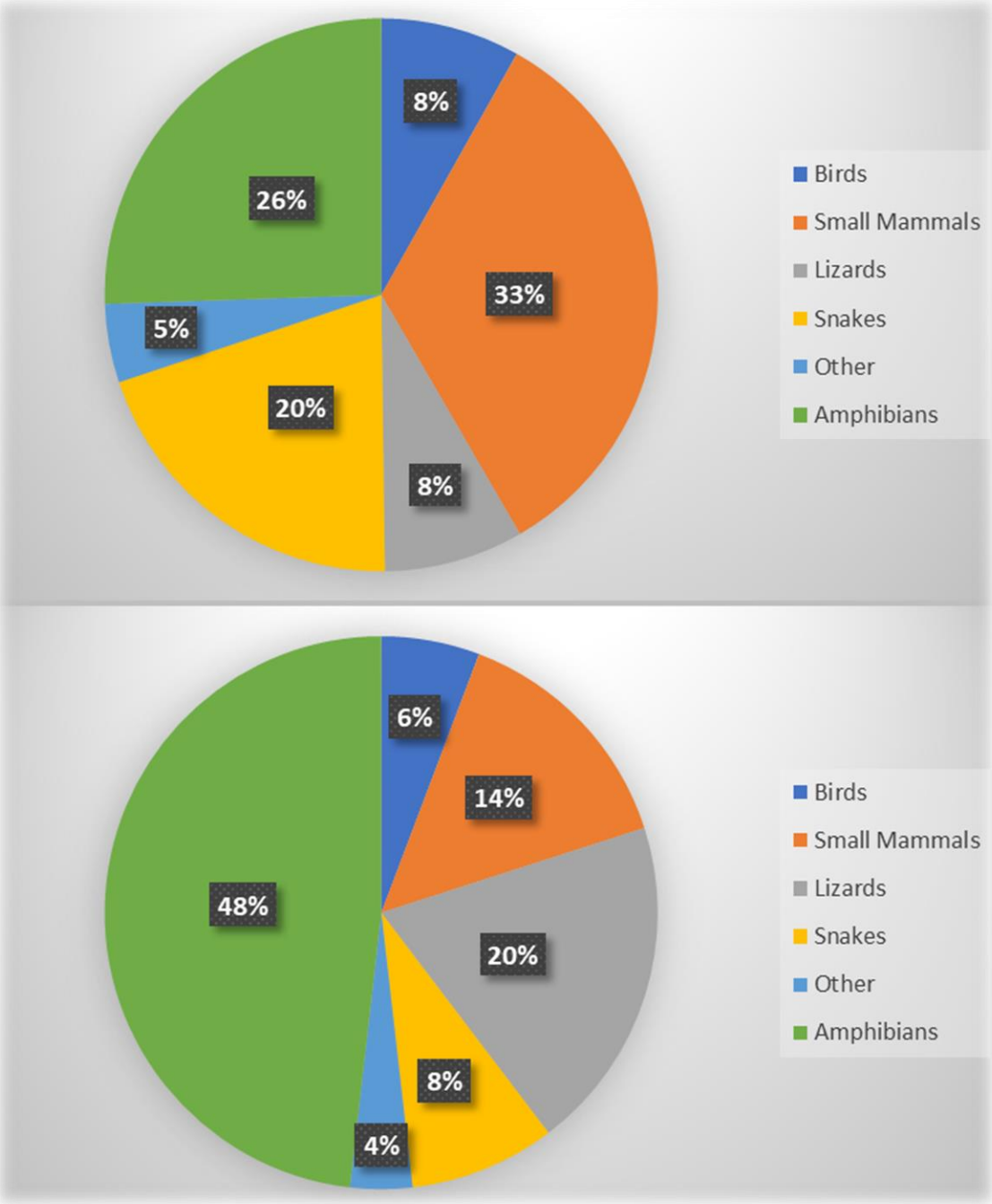

Figure 10. Proportions of detections by group during monsoon 2017 roadkill surveys (top), and monsoon 2018 roadkill surveys (bottom).

The status of installed wildlife fencing along the surveyed extent of SR77 allows us to compare the effectiveness of wildlife fencing in several configurations with respect to the ROW. There is evidence to suggest that installed wildlife fencing is proving effective throughout the surveyed extent. A single ungulate mortality has been recorded and very few carnivores were detected within the ROW. Overall, vertebrate mortality hotspots were most significant where ROW

fencing directly fronted the highway on one side but was retracted or absent on the opposing side (Figure 11). This was most pronounced between mile markers 82 and 83 where land adjacent to the unfenced frontage is less developed. Equally, the most significant vertebrate mortality cold spots were detected where development adjacent to the ROW was heavier and/or where ROW fencing was in situ along both frontages.

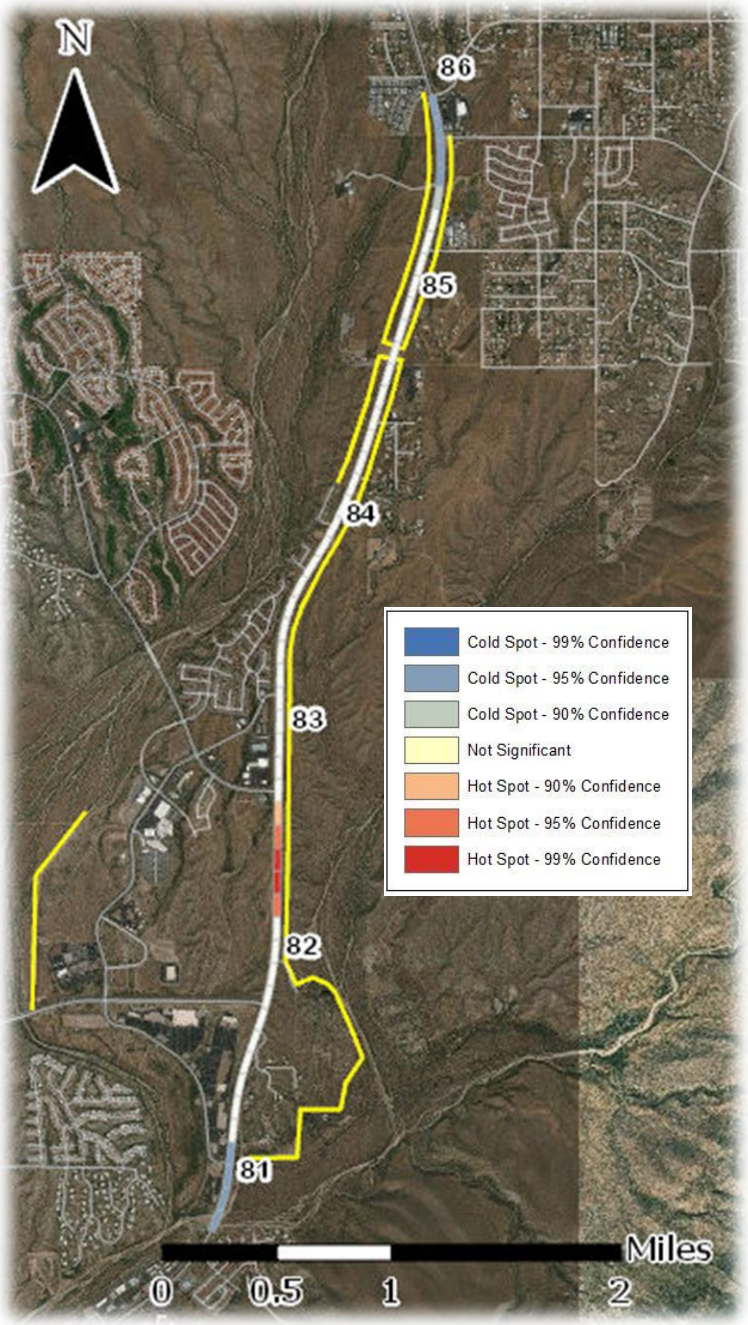

Figure 11. Optimized Hot Spot Analysis for all vertebrate mortalities across all roadkill survey sessions with mileposts and installed wildlife fencing (yellow lines).

Four groups accounted for sufficient detections to allow in depth hot spot analyses to be conducted, these being; amphibians, small mammals, lizards, and snakes. Of these, only lizards and snakes were found to show significant hot and cold spots (Figure 12). The distribution of both hot and cold spots for these groups broadly aligns with the overall trends observed in Figure 11. This serves to highlight the efficacy of the installed wildlife fencing for reducing reptile mortalities while also demonstrating the issues encountered when one frontage is fenced but not the other. It can also be seen that snake mortalities peaked slightly further north within the stretch between MM 82 and 83 than did lizard mortalities.

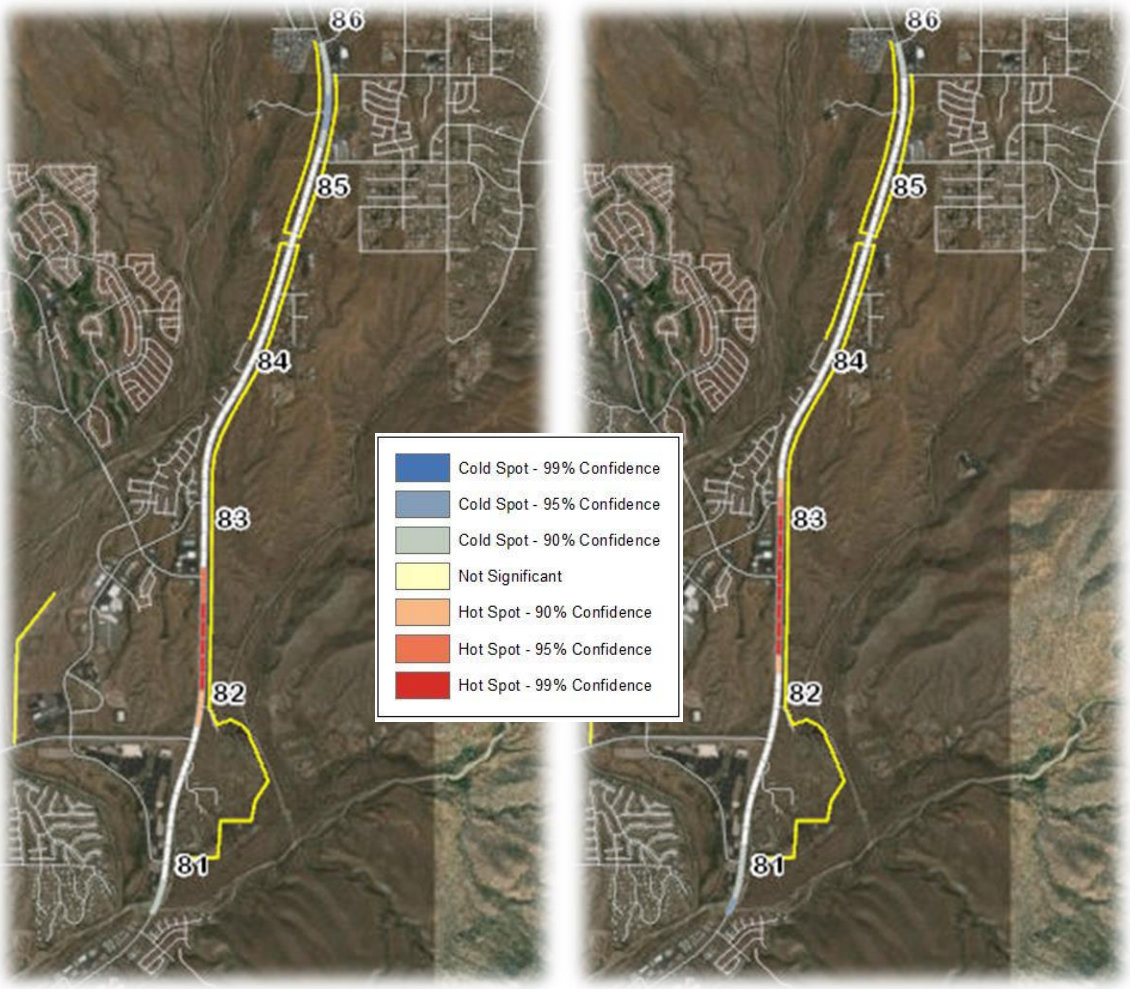

Figure 12. Optimized Hot Spot Analyses for lizard mortalities (left), and snake mortalities (right) detected during SR77 roadkill surveys.

No significant hot spots were observed when analyzing 2018 detections only, whereas, observed hot spot patterns from 2017 data were reflective of those seen in the overall dataset (Figure 13). These patterns held across all groups analyzed and may be attributable to environmental conditions or could reflect a depletion of small vertebrate populations within the ROW fencing by the time

of the 2018 surveys which would further attest to the effectiveness of installed wildlife fencing.

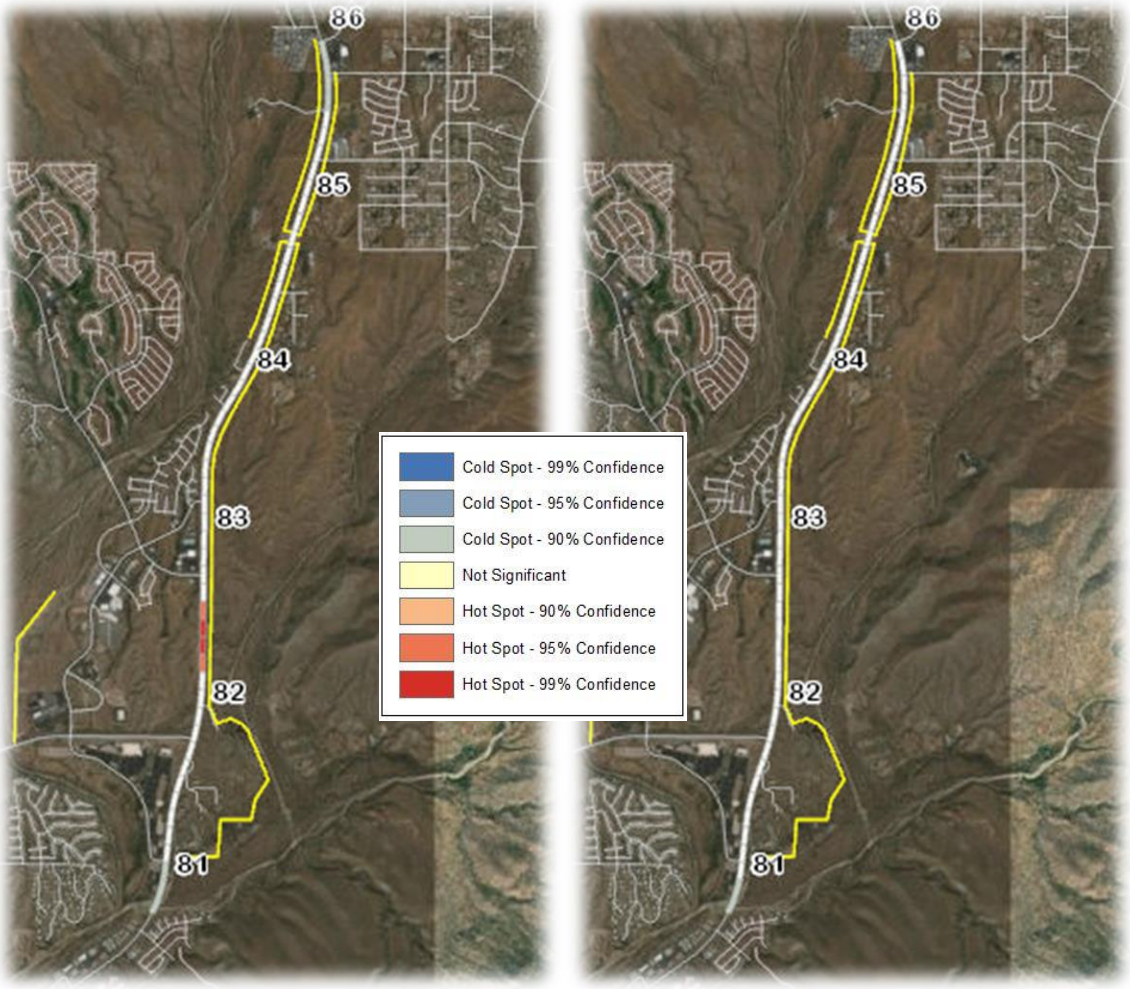

Figure 13. Optimized Hot Spot Analyses for all vertebrate mortalities detected during 2017 roadkill surveys (left), and 2018 roadkill surveys (right).

When analyzing spring and monsoon datasets separately for all vertebrate mortalities it was observed that detected hot spots were broader but less strongly significant in both seasons than when analyzing the full dataset (Figure 14). Cold spots were similarly broad and significant in comparison to the overall dataset in the spring but less pronounced during the monsoon. Given that all amphibian detections occurred during monsoon surveys and no significant hot or cold spots were observed for amphibians it is likely that amphibian records served to mask potential hotspots when analyzing the overall monsoon dataset.

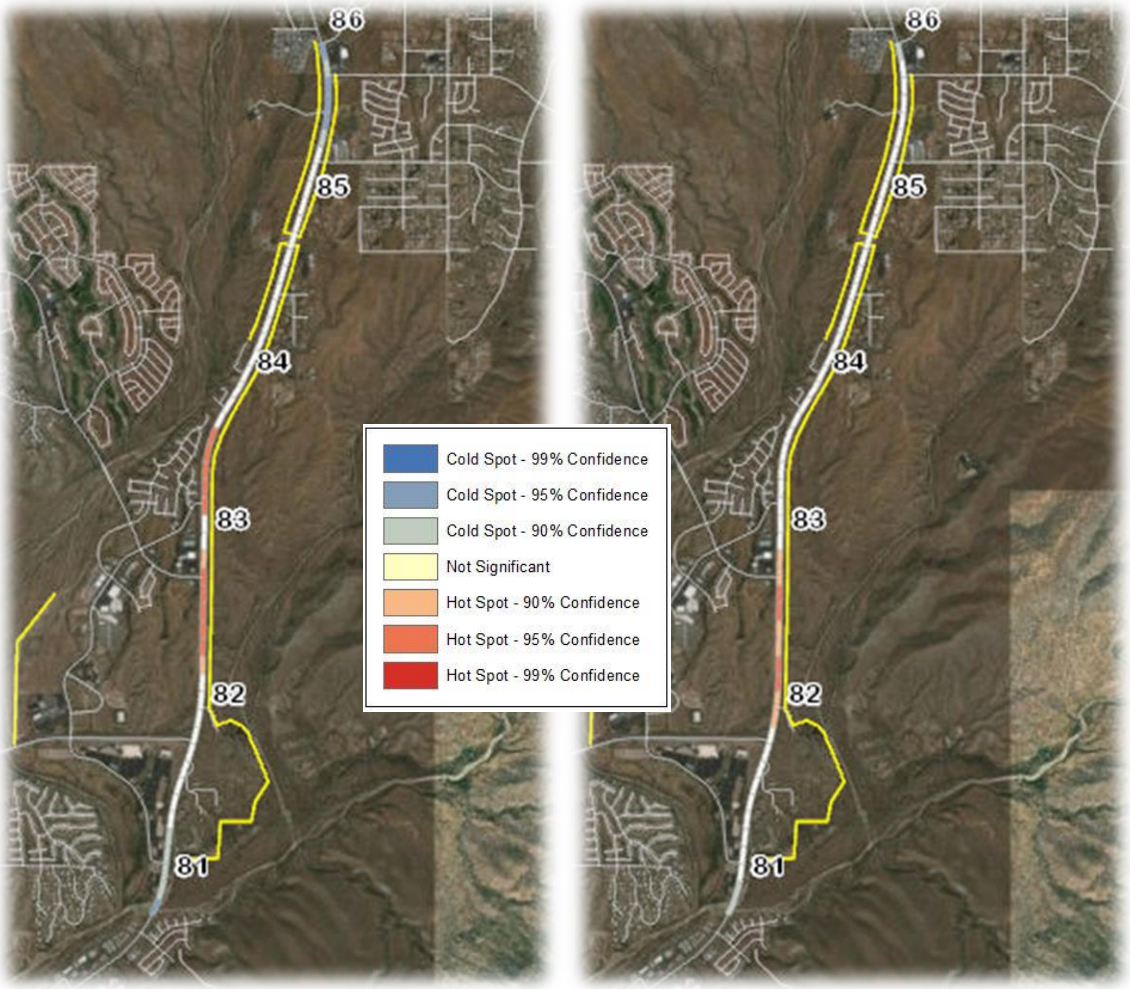

Figure 14. Optimized Hot Spot Analyses for all vertebrate mortalities detected during spring roadkill surveys (left), and monsoon roadkill surveys (right).

A southward shift in the focus of hotspots can be seen in the monsoon data when compared to spring data (Figure 14). This shift was driven by lizard and snake detections as can be seen from the patterns of hot and cold spots in Figures 15 & 16. It should also be noted that hotspots for both groups were considerably broader and more strongly significant for monsoon detections than for spring detections. Nonetheless, hotspots for both groups during both seasons were spatially associated with sections of highway where one or both sides were unfenced. Likewise, cold spots coincided with fully fenced and/or more heavily developed sections.

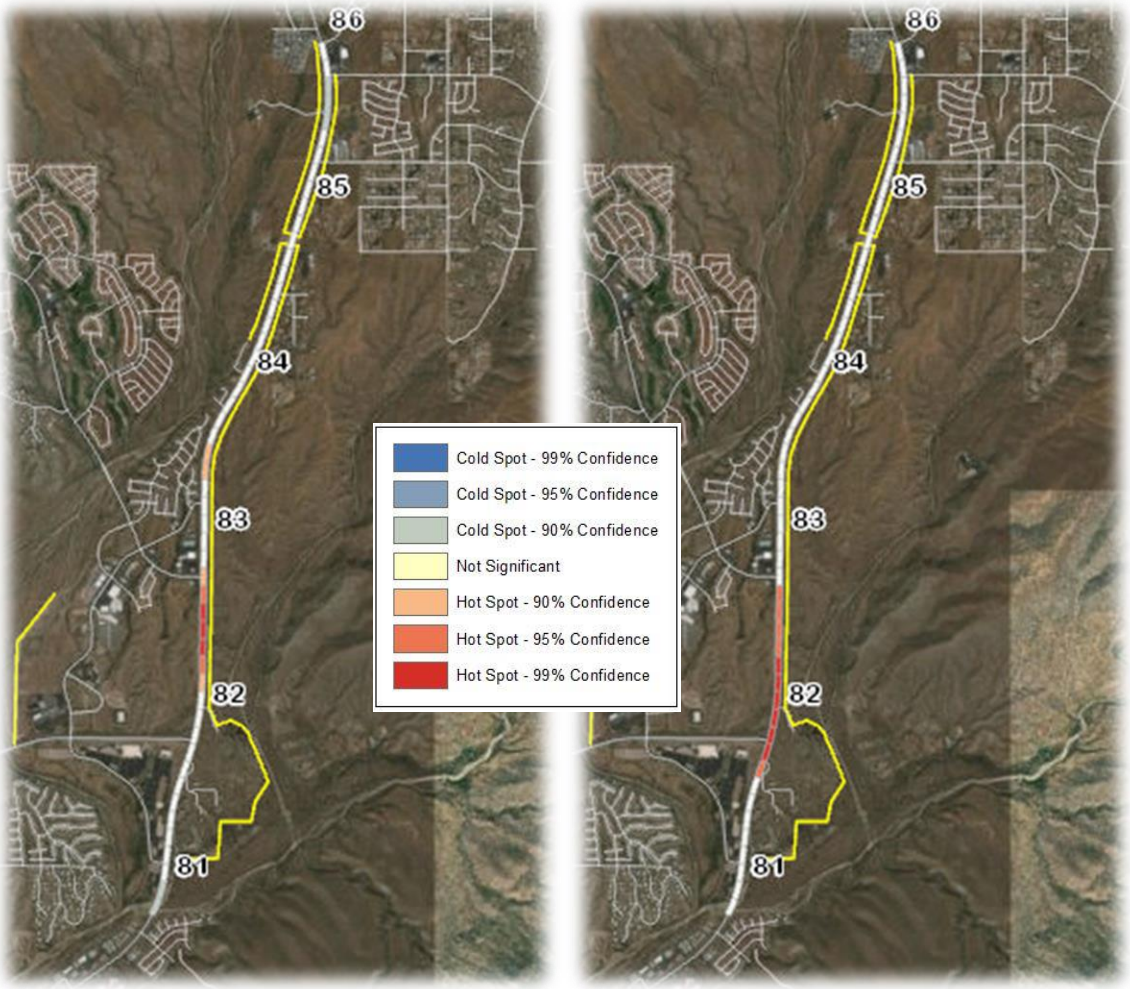

Figure 15. Optimized Hot Spot Analyses for lizard mortalities detected during spring roadkill surveys (left), and monsoon roadkill surveys (right).

As installation of wildlife fencing is completed and development within the fenced areas occurs it is expected that detections will normalize across the redeveloped stretch of SR77 and the currently observed hotspots will disappear.

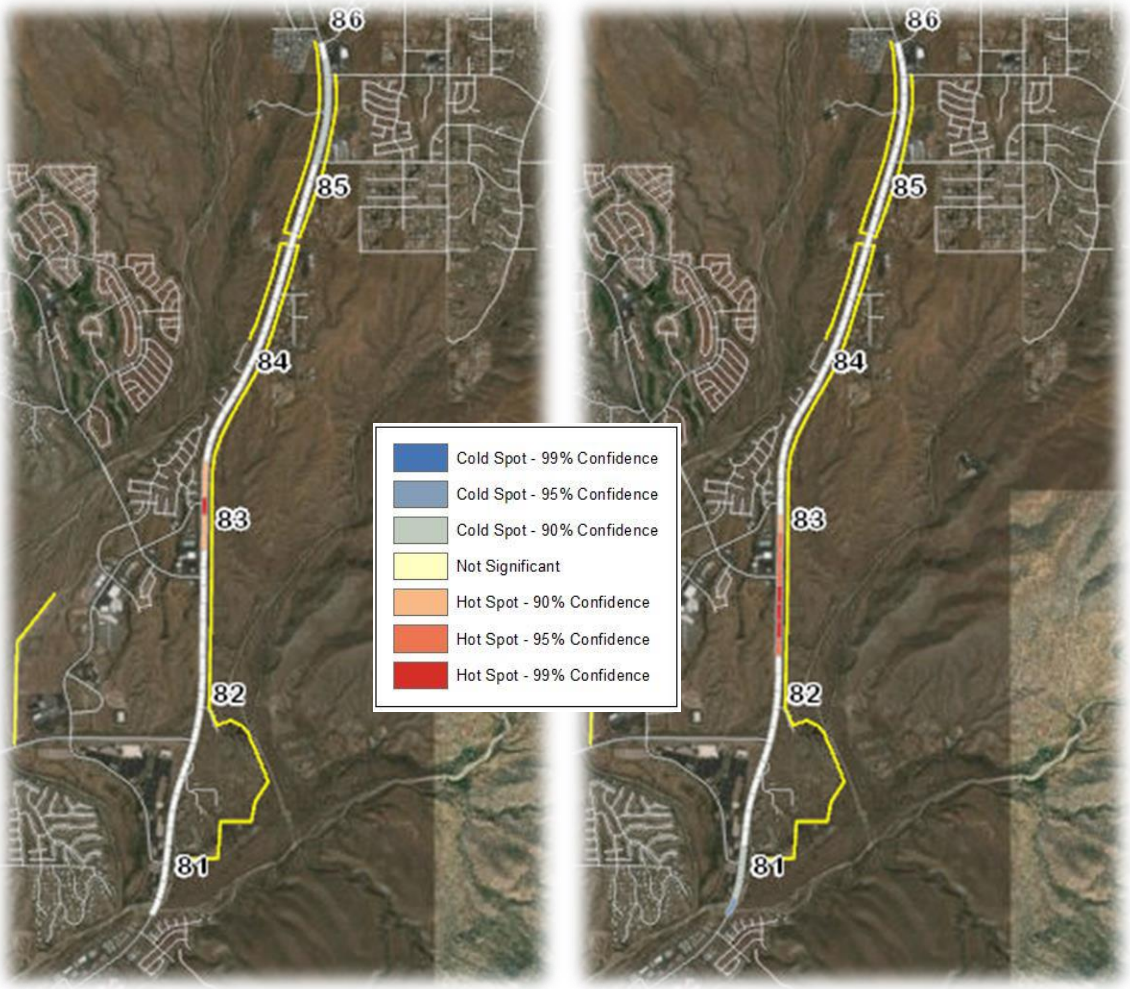

Figure 16. Optimized Hot Spot Analyses for snake mortalities detected during spring roadkill surveys (left), and monsoon roadkill surveys (right).

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 17).

Figure 17. 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.

Figure 18. Sonoran desert tortoise tracks documented at the SR77 wildlife underpass during September of 2018.

- **In September 2018 SDT tracks were documented entering and leaving the underpass from the west (Figure 18), the individual did not appear to have completed a crossing.**
- **Third party reports have placed SDT's at the unguarded intersection of N Big Wash Overlook Pl with SR77.**
- **35 individuals detected of which 22 individuals have been outfitted with transmitters, 12 east of 77, and 10 west (Figure 19).**
- **4 confirmed mortalities of outfitted individuals have been recorded (2 east and 2 west).**

- **4 additional animals have either ceased to transmit or moved beyond tracking range over the course of the project.**
- **14 individuals are currently being actively monitored.**
- **GPS transmitters were pulled for the 2018 season in October.**
- **GPS transmitters will be redeployed for the 2019 season in March and April.**
- **No GPS outfitted tortoises have been observed to cross SR77 since project inception (Figure 20).**
- **7 GPS outfitted individuals have been documented within 0.5 miles of the wildlife underpass (Figure 21).**
- **2 GPS outfitted individuals have been documented within 0.5 miles of the wildlife overpass (Figure 21).**

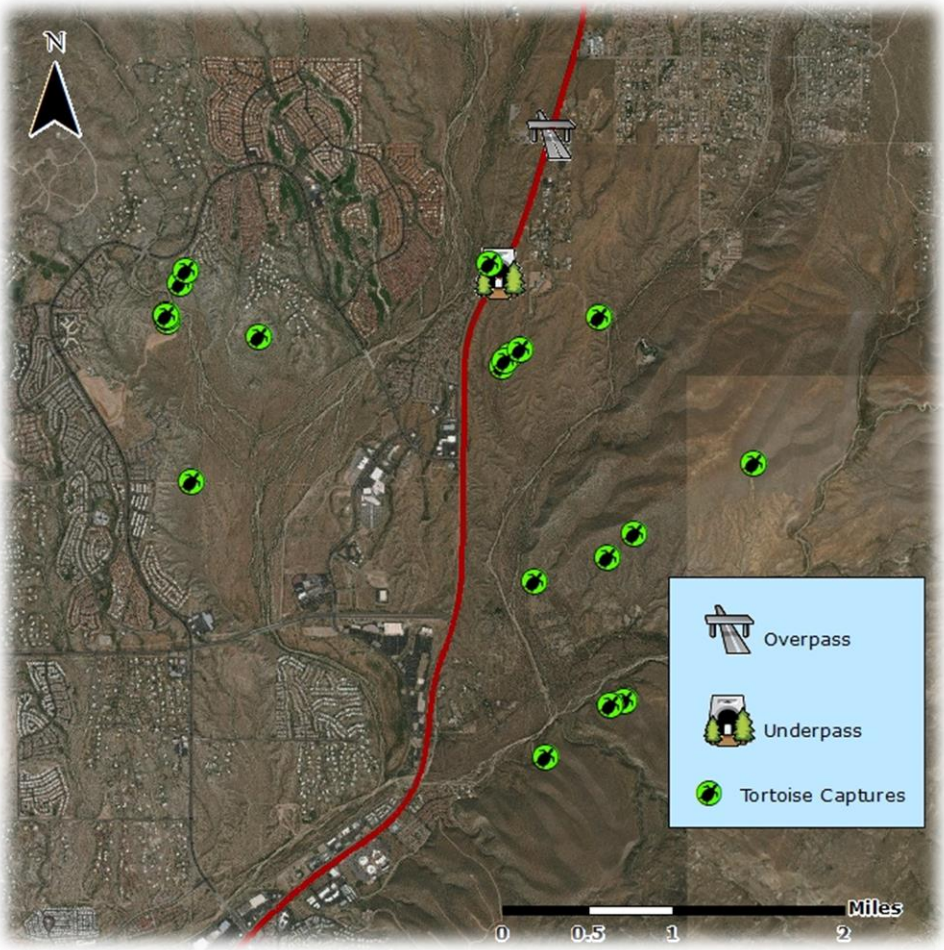

Figure 19. Distribution of Sonoran desert tortoise VHF and GPS transmitter deployments.

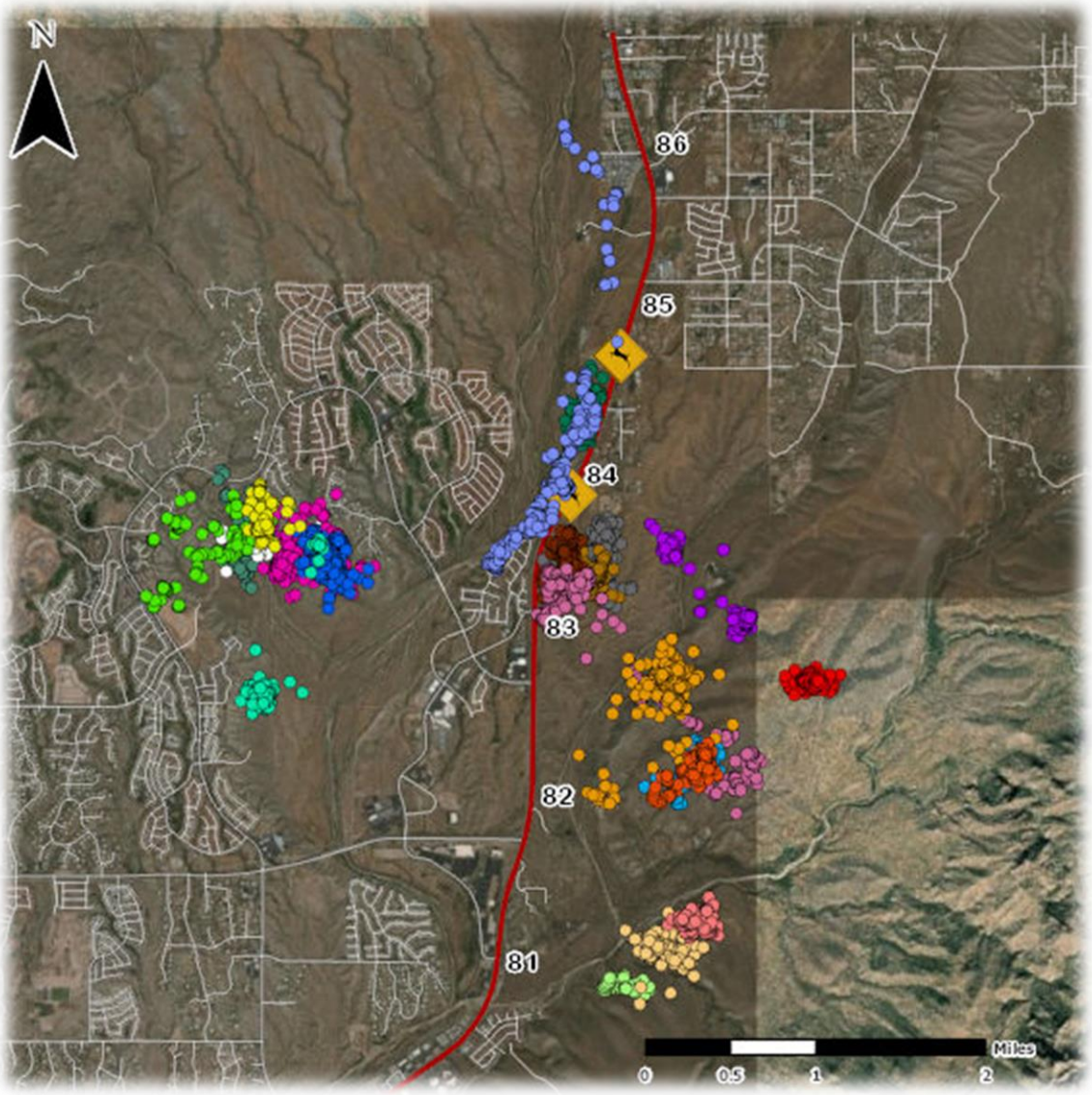

Figure 20. GPS locations from tracked tortoises from inception through the 2018 deployment season, each color represents a distinct individual.

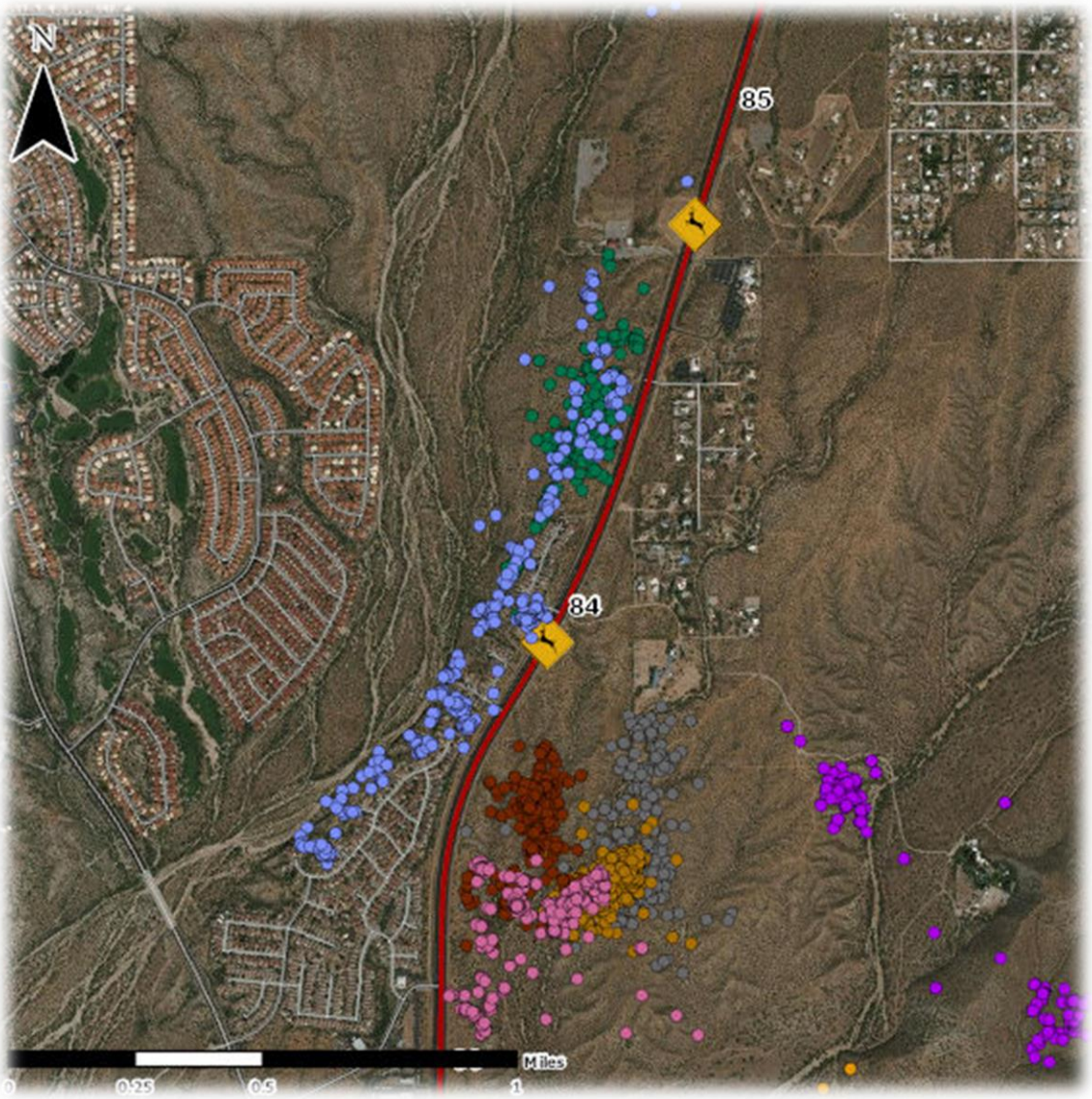

Figure 21. GPS locations from tracked tortoises around the wildlife overpass and underpass from inception through the 2018 deployment season, each color represents a distinct individual.

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 22. First recorded image of a collared mule deer 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.

- **Initial collar deployments were completed on February 26th, 2019.**
- **The first image of a collared deer crossing SR77 was recorded at 0625 the following morning (Figure 22).**
- **Two mule deer bucks completed crossings of the overpass from east to west and back again within 48 hours of collar deployment (Figure 23).**

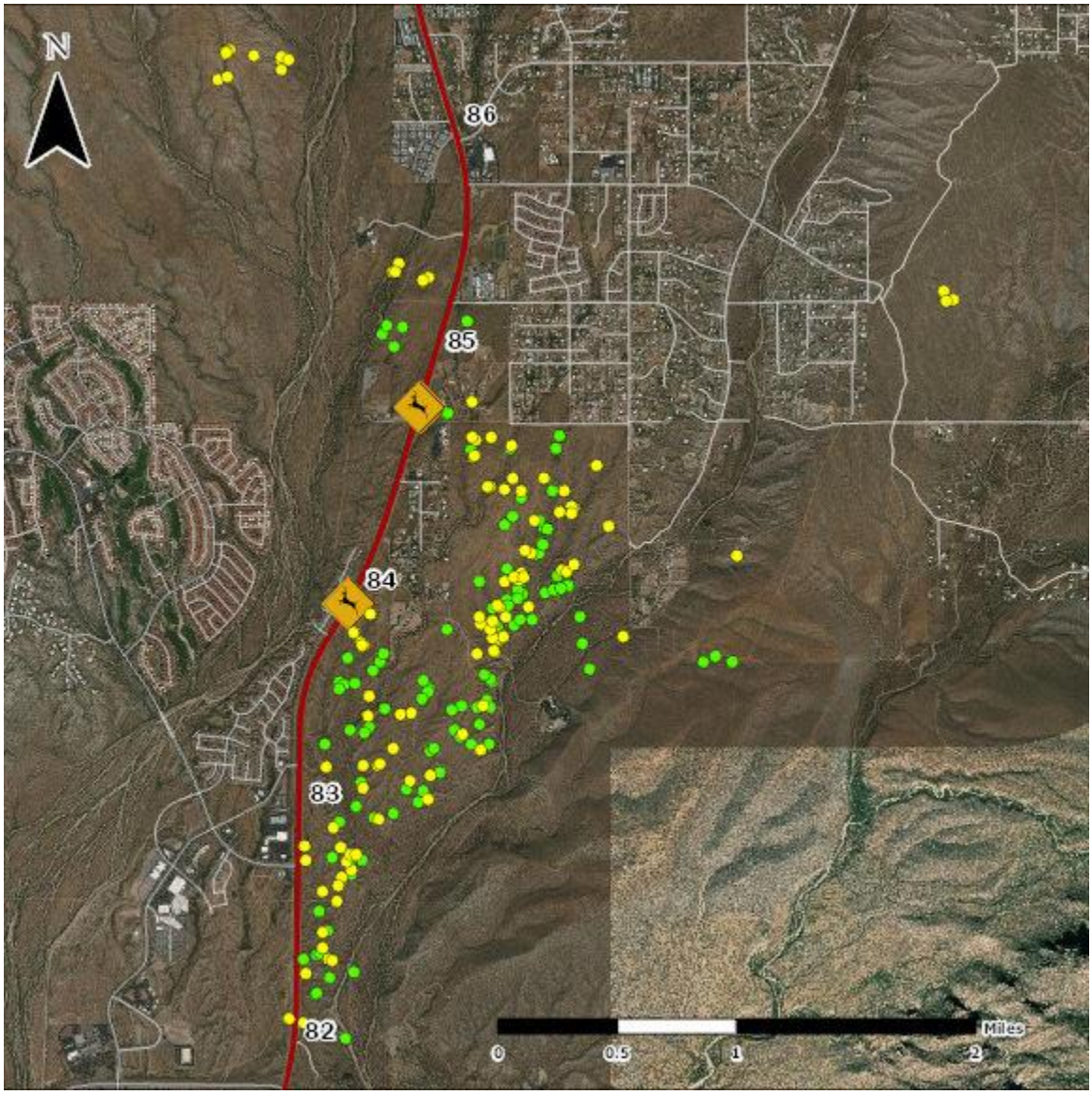

Figure 23. GPS tracking locations of two mule deer bucks from collar deployment to March 14th, 2019. Individuals distinguishable by symbol color.

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. It is estimated that this project will be initiated in May 2016 and will not exceed 4 years to final report completion followed by 6 months of reviews and revisions.

Project Deliverable	**Completion date(s)**
Project status reports	Twice per year
Final Project Report	NTE 4 years following completion of construct.
Scientific journal manuscripts	Various during and after the project
Professional/scientific symposia presentations	Various during and after the project

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Arizona Game and Fish Department will oversee implementation of mitigation monitoring with the following team members:

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APPENDIX I – Full SR77 Road Mortality Species List with Detection Counts

Mammals		**609**
Bats		11
Big Brown Bat	*Eptesicus fuscus*	1
Unidentifiable Bat	*Unidentifiable Bat*	10
Carnivores		6
Bobcat	*Lynx rufus*	1
Kit Fox	*Vulpes macrotis*	1
Coyote	*Canis latrans*	2
Unidentifiable Carnivore	*Unidentifiable Carnivore*	2
Ungulates		1
Javelina	*Pecari tajacu*	1
Small Mammals		547
Desert Cottontail	*Sylvilagus auduboni*	32
Antelope Jackrabbit	*Lepus alleni*	3
Black-tailed Jackrabbit	*Lepus californicus*	6
Unidentifiable Rabbit	*Unidentifiable Lagomorph*	1
Harris's Antelope Squirrel	*Ammospermophilus harrisii*	5
Round-tailed Ground Squirrel	*Xerospermophilus tereticaudus*	43
Rock Squirrel	*Spermophilus variegatus*	1
Botta's Pocket Gopher	*Thomomys bottae*	1
Brown Rat	*Rattus norvegicus*	1
White-throated Woodrat	*Neotoma albigula*	41
Merriam's Kangaroo Rat	*Dipodomys merriami*	257
Bailey's Pocket Mouse	*Chaetodipus baileyi*	1
Desert Pocket Mouse	*Chaetodipus penicillatus*	6
Unidentifiable Spiny Pocket Mouse	*Chaetodipus sp*	9
Arizona Pocket Mouse	*Perognathus amplus*	2
Silky Pocket Mouse	*Perognathus flavus*	3
Unidentifiable Silky Pocket Mouse	*Unidentifiable Perognathus*	10
Unidentifiable Deer Mouse	*Unidentifiable Peromyscus*	4
Unidentifiable Rodent	*Unidentifiable Rodent*	80
Unidentifiable Small Mammal	*Unidentifiable Small Mammal*	41
Unidentifiable		44
Unidentifiable Mammal	*Unidentifiable Mammal*	44

Birds		**161**
Songbirds		86
House Sparrow	*Passer domesticus*	17
House Finch	*Carpodacus mexicanus*	7
Lesser Goldfinch	*Spinus psaltria*	3
Verdin	*Auriparus flaviceps*	1
Lucy's Warbler	*Oreothlypis luciae*	1
Yellow-rumped Warbler	*Setophaga coronata*	3
Unidentifiable Warbler	*Unidentifiable Warbler*	1
Blue-gray Gnatcatcher	*Polioptila caerulea*	1
Cactus Wren	*Campylorhynchus brunneicapillus*	1
Curve-billed Thrasher	*Toxostoma curvirostre*	6
Northern Mockingbird	*Mimus polyglottos*	2
Common Starling	*Sturnus vulgaris*	2
Great-tailed Grackle	*Quiscalus mexicanus*	1
Barn Swallow	*Hirundo rustica*	1
Unidentifiable Songbird	*Unidentifiable Songbird*	39
Woodpeckers		3
Northern Flicker	*Colaptes auratus*	1
Gila Woodpecker	*Melanerpes uropygialis*	2
Pigeons & Doves		31
Rock Dove	*Columba livia*	4
White-winged Dove	*Zenaida asiatica*	1
Mourning Dove	*Zenaida macroura*	23
Unidentifiable Dove	*Unidentifiable Dove*	3
Cuculids		2
Greater Roadrunner	*Geococcyx californicus*	2
Caprimulgids		3
Common Nighthawk	*Chordeiles minor*	3
Game Birds		5
Gambel's Quail	*Callipepla gambelii*	5
Owls & Raptors		8
Barn Owl	*Tyto alba*	2
Great Horned Owl	*Bubo virginianus*	1
Red-tailed Hawk	*Buteo jamaicensis*	3
Unidentifiable Raptor	*Unidentifiable Raptor*	2
Unidentifiable		23
Unidentifiable Bird	*Unidentifiable Bird*	23

Reptiles		**677**
Lizards		473
Gila Monster	*Heloderma suspectum*	8
Western Banded Gecko	*Coleonyx variegatus*	94
Desert Horned Lizard	*Phrynosoma platyrhinos*	2
Regal Horned Lizard	*Phrynosoma solare*	143
Desert Iguana	*Dipsosaurus dorsalis*	1
Tiger Whiptail	*Aspidoscelis tigris*	5
Zebra-tailed Lizard	*Callisaurus draconoides*	15
Greater Earless Lizard	*Cophosaurus texanus*	8
Lesser Earless Lizard	*Holbrookia maculata*	21
Clark's Spiny Lizard	*Sceloporus clarkii*	1
Desert Spiny Lizard	*Sceloporus magister*	35
Ornate Tree Lizard	*Urosaurus ornatus*	2
Common Side-blotched Lizard	*Uta stansburiana*	39
Unidentifiable Lizard	*Unidentifiable Lizard*	99
Snakes		190
Western Diamondback Rattlesnake	*Crotalus atrox*	28
Mojave Rattlesnake	*Crotalus scutulatus*	1
Unidentifiable Rattlesnake	*Unidentifiable Crotalus*	4
Sonoran Coralsnake	*Micruroides euryxanthus*	2
Black-necked Gartersnake	*Thamnophis cyrtopsis*	2
Checkered Gartersnake	*Thamnophis marcianus*	2
Western Lyre Snake	*Trimorphodon biscutatus*	1
Coachwhip	*Masticophis flagellum*	3
Common Kingsnake	*Lampropeltis getula*	32
Long-nosed Snake	*Rhinocheilus lecontei*	63
Glossy Snake	*Arizona elegans*	2
Gopher Snake	*Pituophis catenifer*	14
Desert Nightsnake	*Hypsiglena chlorophaea*	3
Western Patch-nosed Snake	*Salvadora hexalepis*	2
Saddled Leaf-nosed Snake	*Phyllorhynchus browni*	2
Variable Sandsnake	*Chilomeniscus stramineus*	3
Western Shovel-nosed Snake	*Chionactis occipitalis*	1
Western Threadsnake	*Leptotyphlops humilis*	16
Unidentifiable Snake	*Unidentifiable Snake*	9
Tortoises		4
Sonoran Desert Tortoise	*Gopherus morafkai*	4
Unidentifiable		10
Unidentifiable Reptile	*Unidentifiable Reptile*	10

Amphibians		**348**
Spadefoots		208
Couch's Spadefoot	*Scaphiopus couchii*	187
Mexican Spadefoot	*Spea multiplicata*	9
Unidentifiable Spadefoot	*Unidentifiable Spadefoot*	12
Toads		131
Sonoran Desert Toad	*Bufo alvarius*	46
Great Plains Toad	*Bufo cognatus*	8
Red-spotted Toad	*Bufo punctatus*	58
Unidentifiable Toad	*Unidentifiable Toad*	19
Unidentifiable		9
Unidentifiable Amphibian	*Unidentifiable Amphibian*	9
Unidentifiable		**4**
Unidentifiable		4
Unidentifiable Vertebrate	*Unidentifiable Vertebrate*	4
Grand Total		**1799**