Section 6 (Texas Traditional) Report Review

Form emailed to FWS S6 coordinator (mm/dd/yyyy): 9/11/2017

TPWD signature date on report: 8/31/2017

Project Title: To provide more evidence for the presence/absence of the southern spot-tailed earless lizard (*Holbrookia lacerata subcaudalis*; STEL) in southern Texas.

Final or Interim Report? Final

Grant #: TX-E-165-R

Reviewer Station: Austin ESFO

Lead station concurs with the following comments: NA (reviewer from lead station)

Interim Report (check one):

- ☐ Acceptable (no comments)
- ☐ Needs revision prior to final report (see comments below)
- ☐ Incomplete (see comments below)

Final Report (check one):

- ☒ Acceptable (no comments)
- ☐ Needs revision (see comments below)
- ☐ Incomplete (see comments below)

Comments:

FINAL PERFORMANCE REPORT

As Required by

THE ENDANGERED SPECIES PROGRAM

TEXAS

Grant No. TX E-165-R

(F14AP00824)

Endangered and Threatened Species Conservation

An Inventory of a Subset of Historically Known Populations of the Spot-tailed Earless Lizard (*Holbrookia lacerata*)

Prepared by:

Mike Duran

Carter Smith
Executive Director

Clayton Wolf
Director, Wildlife

31 August 2017

FINAL REPORT

STATE: Texas GRANT NUMBER: TX E-165-R-1

GRANT TITLE: An Inventory of a Subset of Historically Known Populations of the Spot-tailed Earless Lizard (*Holbrookia lacerata*).

REPORTING PERIOD: 1 September 2014 to 31 August 2017

OBJECTIVE(S). To provide more evidence for the presence/absence of the southern spot-tailed earless lizard (*Holbrookia lacerata subcaudalis*; STEL) in southern Texas.

Segment Objectives:

Task 1. March 1 – June 30, 2015 – Spring surveys.
Task 2. September 15 – October 31, 2015 – Fall surveys.
Task 3. March 1 – June 30, 2016 – any additional or make-up surveys if needed.
Task 4. Project Completion – August 31, 2016

Significant Deviations:

None.

Summary Of Progress:

Please see Attachment A.

Location: Ward County, Texas, USA.

Cost: Costs were not available at time of this report, they will be available upon completion of the Final Report and conclusion of the project.

Prepared by: Craig Farquhar Date: 31 August 2017

Approved by: _____ Date: 31 August 2017
C. Craig Farquhar

ATTACHMENT A

A Survey of a Subset of Historically Known Localities of the Spot-tailed Earless Lizard (*Holbrookia lacerata*) 2015-2017

Final Report

to

Texas Parks and Wildlife Department
Contract #45817

and

The US Fish and Wildlife Service
Cooperative Endangered Species Fund Grant TX E-165-R-1
(CFDA# 15.615)

by

Mike Duran, Vertebrate Zoologist
The Nature Conservancy

August 31, 2017

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of the Spot-tailed Earless Lizard (*Holbrookia lacerata*)

Mike Duran, Vertebrate Zoologist
The Nature Conservancy
31 August 2017

Introduction

In 2008-2010 Duran and Axtell (2010, 2011) visited 220 historical localities of the spot-tailed earless lizard (STEL; *Holbrookia lacerata*). We recorded data that described the current ecological conditions and conducted brief surveys at the historical sites. We solicited public participation and coordinated the efforts of volunteers and cooperators. The main objective of that project was to compile a database of historical and recent records of the species. Conducting comprehensive surveys across the range of the species was not an objective of that project. Based on occurrences recorded during that project and in the previous 10 years, we concluded that the northern STEL (*H. l. lacerata*) was extant in 11 Edwards Plateau counties, but we found no recent occurrences of the southern STEL (*H. l. subcaudalis*). Later, I discovered a population of the southern STEL in Val Verde County (Duran 2013; Duran and Yandell 2014). For the current project, I proposed to survey eight sites below the Balcones Escarpment, in Ward County around the site of an odd and possibly erroneous locality, and in the potential area of intergradation in Kinney and/or Val Verde counties. During a one-year extension of this project in 2017, I revisited some the southern Texas sites and the potential intergradation area and added surveys in counties from where the lizard was not previously known in Upton and Mitchell counties. Some general results of another STEL survey project conducted concurrently on the Edwards Plateau are included in this report.

Taxonomy and Distribution

When Cope (1880) described *Holbrookia lacerata*, he did not specify the specimens upon which he based his description or the localities from where they came. These ambiguities and a subsequent redescription by Stejneger (1890) led to seven decades of confusion and disagreement over the distribution, diagnostic characteristics, and taxonomy of the STEL.

Cope's original description:

> "*<u>Holbrookia lacerata</u> Cope, sp. nov. Tail cylindric, slender, a little longer than body; six or eight supraorbital scuta surrounded by minute tubercles; scales of muzzle tubercular. Labials less elongate, 5 oblique, 1 flat; femoral pores 12-13; no blue spots on the sides; transverse blue spots on the inferior side of the tail. Color light brown, with six pairs of transverse dark brown bars between the scapular region and groin, which extend downwards and backwards on the abdomen. Their posterior border is serrate or digitate, and edged with yellowish, producing a variegated pattern. The inner part of the spots is frequently cut entirely off. The spots are continued on the upper side of the tail, and there are six irregular longitudinal brown bars on the neck. A brown band across supraorbital region, and spot on upper surface of muzzle. Limbs brown cross-banded. A pale band on inferior part of side, which is crossed by the ends of the lateral spots. Below this are five*

> *or six small dark spots, sometimes obsolete. Total length .099; to collar, .015; to vent, .056. This is a short-legged species allied to the H. maculata, but with longer tail and very different coloration. As compared with the variety of H. maculata above described, the labial scuta are shorter and less oblique, resembling more nearly those of H. texana. In coloration, it differs from the H. maculata in a point not above mentioned. The dorsal ground color is everywhere the same, a rich yellowish brown. In the H. maculata the median dorsal region is paler, and the sides of the back are of a dark shade, which connects the spots as by a wide band.*"

The following statement from Cope (1880) was a primary source of the confusion that followed:

> "*The most northern locality for Holbrookia lacera [sic] with which I am acquainted is in Erath County, west of the upper Brazos. Mr. Boll found it rather abundantly there and in Comanche County. Southward it has been found by Mr. Marnock on the Guadalupe River in Kendall or Comal County. It thus belongs to the first plateau fauna, and is not widely distributed."*

The time-frame and details of Cope's description and the later designation of a holotype by Stejneger (1890) appear to indicate that the description was based on specimens collected by G. W. Marnock that were deposited in three museums. Three specimens (NMNH 10106, 563713 and 13631) were deposited in the U.S. National Museum (now the National Museum of Natural History, NMNH). Axtell (1956) later designated NMNH 10106 as the lectotype and NMNH 563713 and 13631 as paralectotypes. Three specimens (ANSP 12671-73) were deposited in the Academy of Natural Sciences of Philadelphia, and six specimens (MMC-BU R 04776, R 04777, R 04867, R 04983, R 05107, and R 05108) were deposited in the Strecker Museum at Baylor University (SMBU), now the Mayberry Museum Complex at Baylor University (MMC-BU). The MMC-BU specimens are listed in the museum catalogue as "possible topotypes" and the locality of those specimens is listed as Helotes.

Helotes, Texas, was designated as the locality of all Marnock's specimens; however, that locality contradicts Cope's (1880) ambiguous locality description: "…*on the Guadalupe River in Kendall or Comal County*." Property owned by Marnock along Helotes Creek appears to have been suitable habitat for the STEL, but since no specimens have subsequently come from near Helotes, the specimens upon which the description was based may have come (as Cope said) from near the Guadalupe River, probably in Kendall County.

Cope's most significant error may have been the mention of Erath and Comanche counties, Texas as the most northern localities, stating that "*Mr. Boll found it rather abundantly there*." Jacob Boll supplied Cope with many specimens of numerous species collected from Texas in 1870. All of Boll's *H. lacerata* specimens went (as part of Cope's personal collection) to ANSP. I obtained photographs of the four Boll specimens (ANSP 12666-70; all from unknown localities in Comanche County, Texas) and found that they were the lesser earless lizard (*H. maculata*). Those specimens are still identified in the ANSP catalog as syntypes of *H. lacerata*, though based on Cope's description, they are not syntypes. However, it seems that Cope would have had those specimens on-hand when he did his description of *H. lacerata*—it may just have to remain a mystery why they apparently weren't examined for the description.

Stejneger (1890), attempted to clarify or redescribe Cope's new lizard but exacerbated the problem, referring to the form as "*only a color race of typical H. maculata*," then subsumed it to *H. m. lacerata*. Stejneger identified a specific specimen, "*H. lacerata* (No. 10160 Helotes, Texas; W. G. [sic] Marnock col.)." However, it is clear that Stejneger (1890) was comparing the Marnock specimen to specimens of *H. maculata* further north as he mentioned unspecified specimens from Neosha County, Kansas to dispute Cope's descriptor "*no blue spots on sides*". Strangely, Stejneger ignored the most invariable diagnostic characteristic of *H. lacerata* that Cope's had correctly identified: "*transverse blue spots on the inferior side of the tail*" (though in most specimens those spots are black or dark gray).

To further compound the problem, Yarrow (1882), in one of the first attempts to assign vernacular names to species, named *H. lacerata* "Boll's Spotted Lizard," but it is now clear that Boll never collected any *H. lacerata* specimens, and that if Cope had examined Boll's specimens for the description, he could not have included the description of the spots beneath the tail. Schmidt (1922) noted the subcaudal spots and dorsal markings that distinguished *H. lacerata* from *H. maculata*, but failed to recognize the geographic discontinuity of the subcaudal spots; thus, he considered the markings unreliable for distinguishing between some specimens. Most of the literature that followed Schmidt (1922), most notably Smith's (1946) "Handbook of Lizards," continued to regard *H. lacerata* as a subspecies of *H. maculata*, leaving Schmidt (1953) somewhat alone in continuing to consider it a full species. Ironically, despite all of the decades of confusion, Cope's (1880) original description of *H. lacerata* was essentially correct and describes *H. lacerata* as we know it today.

Cope's and Stejneger's errors were first discovered in 1950 by R. W. Axtell, when he was gathering *Holbrookia* specimens and locality data for his MA degree at the University of Texas (Axtell 1954). He found that all *Holbrookia* specimens south of the Colorado River in Texas had dark (black or gray) subcaudal spots, while all specimens north of that river lacked dark subcaudal spots. After recognizing this important diagnostic feature, Axtell (1956) described the Erath and Comanche county populations, along with numerous other *Holbrookia* populations in north-central Texas, Oklahoma, and Kansas, as a new subspecies of *H. maculata,* (*H. m. perspicua*). He also described a new subspecies of *H. lacerata* (*subcaudalis*) and recognized the southern edge of the Edwards Plateau, the Balcones Escarpment, as the dividing line between those subspecies.

Axtell (1956) described the morphological differences between the *H. l. lacerata* and *H. l. subcaudalis*:

> *"Holbrookia lacerata subcaudalis differs from H. l. lacerata in having a higher average femoral-pore count (15.7 in 62 subcaudalis; 12.8 in 68 lacerata); a high percentage of specimens (85.9) with unfused pairs of blotches on each side of the median dorsal (vertebral) line; a pattern of rounded blotches on the hind legs, not dark bands; and a larger average adult size (SV length 62 mm. in male subcaudalis, 54 mm. in male lacerata)."*

Behavior

In addition to delineating the distribution of the species, Axtell (1956 and 1958) offered the most definitive descriptions of habitat, behavior, and life history published to that date.

Among his findings (from the description of *H. l. subcaudalis*—Axtell, 1956):

- "The extreme wariness of the lizard is paralleled by few other North American lacertilians."

- "Both sexes frequently choose a small pebble, dirt clod, or similar object on which to perch."
- In the laboratory, *H. lacerata* will arch its tail upward from side to side, as do other Sand-Lizards (Smith, 1946). He never observed the tail wagging behavior in *Holbrookia* that do not have subcaudal markings.
- The STEL will quickly bury itself into the substrate by rapidly wiggling its body back and forth. That behavior was previously described as "sand swimming" by Stebbins (1944) in reference to the genus *Uma* and was called "shimmy burial" by Axtell for *H. lacerata*.
- The southern STEL is diurnal and ceases activity when the ground temperature falls below 28° C.
- He suggests a bimodal activity pattern, depending on the season, from around mid-morning to noon and from mid to late afternoon.

Other behavior observed during this project:

- The STEL will often be found on unpaved roads.
- When the STEL feels threatened, it will often find refuge in grass or leaf litter and despite vigorous disturbance of that refugia it will remain there until it is uncovered.
- When ground squirrel burrows are available in abundance, the STEL will seek refuge in those burrows almost exclusively (Duran and Yandell (2014). It seems likely that the STEL will seek refuge in the burrows of other mammals when available (Axtell 1954, 1958).

Reproduction

Axtell (1956)—

Based on examination of nine preserved females of *H. L. subcaudalis*:

- Egg laying apparently takes place twice per year—the first in May/June and the second in July/August.
- Females collected early in the year were found to have two complements of eggs, one group of large ova and one group of smaller ones.
- A female less than one year old will probably lay 4–6 eggs during the first oviposition and 5–7 during the second. Older females will probably lay 7–12 eggs during each oviposition.

Based on observations of two captive *H. l. subcaudalis* females:

- The two captive females deposited nine and 12 eggs on August 23 and June 25, respectively.
- The nine eggs laid in August hatched from October 1 to October 4; the 12 eggs deposited in June hatched from July 31 to August 2.
- The average length of eggs laid in August was 14.6 mm; those laid in June averaged 12.9 mm.
- Mean snout-vent length (SVL) for lizards hatched in October was 21 mm, and for those hatched in July and August, it was 20.4 mm.

Diane Barber, Curator of Ectotherms, Ft. Worth Zoo (2017; pers. comm.)—

Based on examination of five captive *H. l. subcaudalis* clutches and two captive *H. l. lacerata* clutches:

- It is not uncommon for 6-month-olds to lay their first eggs in January.
- On average, both *lacerata* and *subcaudalis* females, that are at least one year old, laid eggs twice per year, in March/April and July/August, and sometimes laid eggs in winter if not put through a brumation cycle; younger females sometimes laid eggs three times per year.
- Females younger than one year, and as early as six months, laid 6–8 eggs (*lacerata and subcaudalis*). *Subcaudalis* females, at least one-year old, averaged 8–9, and up to 12 eggs; *Lacerata* females, at least one year old, averaged 7–8 eggs.
- Eggs hatched in 35–44 days; the shortest incubation period was 35 days at 30–31 ℃ and the longest was 41 days at 28 ℃.
- The average SVL for *subcaudalis* hatchlings was 19.73 mm (range 16.81–24.4 mm) and the average SVL for *lacerata* hatchlings was 19.34 (range 16.03–22.74).

In the field, I and others have observed that gravid females of *H. l. subcaudalis* take on a yellowish hue, particularly around the throat and along the sides; gravid *H. l. lacerata* are even more colorful with combinations of orange and yellow (Figure 1). In some parts of the range, males may also take on a pale yellowish color during mating season, but mostly show little change in their normal coloration.

Figure 1. Gravid female northern spot-tailed earless lizard (*H. l. lacerata*), Tom Green County, June 9, 2009.

Habitat

Based on his personal observations, Axtell (1998) wrote:

> *"Populations occur on substrates varying from the fine sandy loam to clay-loam to non-loamy clay, sometimes over limestone or caliche, but never on pure sands. H. l lacerata has been found in open oak – juniper woodlands, in plowed fields (probably originally grasslands) and in mesquite brushlands, whereas H. l. subcaudalis is found in more xeric mesquite-prickly pear brushlands, coastal and degraded grasslands…"*

Using multiple regression analysis on habitat variables from 220 historical localities, Duran and Axtell (2010, 2011) determined the following (Appendix 1):

- The most predictive variables measured were Ecological Sites (ESs; formerly rangesites) which can generally be thought of as combinations of similar soil types and vegetation classes.
- ES preferences varied significantly between different parts of the species' range, but in all parts of the range the species never occurs on ESs that are composed of mostly deep sands.
- In the northern part of the species' range, it most often occurs on loam, clay-loam and sometimes loamy-clay and clay ESs.
- In the central part of the range, the species most often occurred on the Low Stony Hill ES. The Low Stony Hill ESs are flat plateaus, generally live-oak savannah associations on clayey-loam soils.
- Where the southern STEL occurs in the southern part of the range below the Balcones Escarpment, the habitat is best analyzed by dividing the range into eastern and western sections. In the eastern part of the southern STEL range, the species most often occurs on the Blackland ES, which is mostly composed of fine loamy soils with near equal parts of sand, clay, and silt. In the western part of the southern STEL range, the species usually occurs near drainages on saline clays, clayey loams and sometimes sandy loam ESs. The species is also known to occur on the Low Stony Hill ES in the NW part of Maverick County, which is the only place where that ES occurs south of the Balcones Escarpment.
- In all parts of the range, the species occurs closer to drainages than if they were randomly distributed.
- In all parts of the range the species occurs on ESs that are relatively flat.
- Duran and Axtell (2010, 2011) speculated that the lizard was mostly extirpated from agricultural fields, but recent surveys indicate that the hypothesized negative impact of agricultural fields may not be as severe as previously thought.
- In all parts of the range, the species occurs in areas that could be classified as grasslands or savannahs or would have been grasslands or savannahs historically.

Many anecdotal and literature accounts describe areas where the lizard has been found as sparsely vegetated with some bare ground; however, considerable observer bias is inherent in those observations since it is difficult to observe the lizard in more densely vegetated areas. While the species clearly uses

sparsely vegetated areas where available, more densely vegetated areas might be important for some unknown aspects of the species' life history.

Methods

Duran and Axtell (2010) observed that roadsides near historical localities in southern Texas are overrun by non-native grasses, mostly Kleberg bluestem (*Dicanthium annulatum*) and buffelgrass (*Pennisetum ciliare*). Those observations prompted the hypothesis that the STEL might still be present near those localities but might only be observed away from roads, where non-native grasses did not create such a dense ground cover. Therefore, for this project I proposed to conduct visual encounter surveys (VES) for STELs by walking transects in suitable habitat away from roads for at least 6 man-hours. Because that methodology proved to be less effective than we had hoped, road cruising was employed more in 2016, and road-cruising was used exclusively in 2017. Two phenomena caused the VES methodology to be less effective than we had hoped:

Effect of Precipitation on Methodology

Rainfall during late winter and early spring 2015 was far above average. No surveys could be performed while it was raining, but more importantly, abundant rain promoted plant growth which created dense ground and shrub layer vegetation that lowered the likelihood of observing STELs during walking surveys. For example, rainfall in Cotulla, Texas, near the center of the range of the southern STEL, for the five months, February-May, 2015, was 12.2 inches, while the average for the previous two years was 3.7 inches per year.

Effect of Access on Methodology

Gaining access to private land was more difficult than anticipated. The reluctance of landowners to grant permission for surveys was largely provoked by the negative media attention that followed the publication of a 90-day finding by USFWS that listing the STEL as federally threatened or endangered may be warranted. The USFWS finding occurred simultaneously with a new oil boom in the US, which led many landowners to believe that a potentially protected species might endanger the income stream they were realizing from oil and gas production. Several landowners who granted permission for surveys in 2009 (Duran and Axtell 2010) denied access in 2015. We were able to gain access to enough properties to fulfill the commitment to survey eight properties near historical localities in southern Texas, but in some cases, we had to settle for sites where habitat was less than ideal. In Ward County, the University of Texas owns all the land near historical localities and leases that land (UT lands) for oil exploration and production. Despite numerous attempts by The Nature Conservancy (TNC) and our UT partners, we were denied access to UT lands, leaving road and roadside surveys as the only option in Ward County. We did not find a landowner who would allow surveys in the hypothetical area of intergradation of the subspecies (*H. l. lacerata and H. l. subcaudalis*) in east-central Val Verde and/or west-central Kinney counties and had to settle for road cruising in that area.

Results

While this project was mostly conducted in southern Texas, TNC staff and collaborators participated concurrently in a project to survey throughout the range of the species. Across the range, there were 227

records before 2012. An additional 197 records have been added since 2012, though the number of unique localities added after 2012 is far fewer than that. Those 424 records are included in the latest version of the distribution map (Figure 2). Duran and Axtell (2010) recorded the STEL in 11 Edwards Plateau counties. In 2015, we observed and collected STELs in four more Edwards Plateau counties: Reagan, Sutton, Coke, and Sterling. Other than a 2010 record from Mason County (Duran et al. 2012), no verifiable observations have been made in counties where the STEL was not previously known.

- Under this grant, from spring 2015 through spring 2017, TNC staff and collaborators performed road and/or walking surveys at 22 sites and road-routes in 13 counties in southern Texas (Table 1). North of the Balcones Escarpment, we surveyed twice in Ward County and once each in Upton and Mitchell counties. We observed and photographed and/or collected STELs in five of the southern Texas counties. We did not observe the lizard in Ward, Upton, or Mitchell counties. We performed walking surveys at 11 sites, but in all cases STELs were found on roads within the property or roads coming to and going from the property.

- In 2016, we surveyed 16 sites/road-routes in 11 counties, which included revisits to nine sites/road-routes surveyed in 2015. We observed the STEL at two sites/road-routes (Nueces and Jim Wells counties) where they had been observed in 2015, but observed fewer lizards at both sites. We made a possible but unverifiable observation in Dimmit County near Catarina. Other than the possible Dimmit County observation, we did not observe the lizard in South Texas in 2016 at any sites where it was not observed in 2015.

- In 2017, we performed road cruising surveys along 11 road-routes in 11 counties. One STEL was observed in Jim Wells County, one in Nueces County, and two in Kinney County in 2017.

- In 2015 our collaborators made 51 observations along Kinney County roads but had no observations along those routes in 2016. TNC staff observed two STELs along Kinney County roads in 2017. Those results and the results from Nueces and Jim Wells counties, may attest to the extreme intermittent nature of STEL activity and to the year-to-year variation in STEL population densities. Other than a 1991 observation at Laughlin Airforce Base Auxiliary Airfield at Spofford, the STEL had not been reported from Kinney County since 1964.

- The 2016 and 2017 surveys in Jim Hogg County were at the site of a 1991 STEL historical record. We did not observe the STEL at that site. Buffelgrass, which had not been present when the species was collected in 1991, now forms a dense ground layer.

- The site surveyed in Dimmit County was about a mile to the east of and on sandier soils than the historical record and probably was not a site we would have chosen to survey if

there had been other options. The dirt road where the lizard had been collected in Dimmit County in the 1950s had been converted to caliche and gravel by the time we cruised them in 2009 and has since been paved. Oil field traffic is extremely heavy on that road, probably greater than one vehicle per minute during peak hours. Due to the new road surface and to the intense vehicular traffic, the likelihood of observing the lizard on that road is now probably near zero. The lizard has not been observed in Dimmit County since 1969.

- The site in McMullen County, the Roberts-Miller Ranch, was the only property where we were granted permission to survey in that county. While it was within a few miles of historical localities, habitat at that site appeared to be only marginally suitable for the species—while the proximity of rivers and streams appears to be an important component of STEL habitat, the Roberts-Miller property lies on a very flat alluvial terrace between widely separated tributaries of the Frio River and there is no moving water on the ranch. The STEL was last observed in McMullen County in 1995.

- The 20 observations in Val Verde County include 16 observations that were made in 2013 that have not been reported except in a note on the relationship between the STEL and ground squirrels at Laughlin Airforce Base (Duran and Yandell 2014). All observations in Val Verde County were on Laughlin Airforce Base. Prior to 2013, the STEL had not been reported south of the Balcones Escarpment for 17 years and had not been reported from Val Verde County since 1968. In 2013, sixteen lizards were observed during a moderately severe drought; in 2015, during a period of much higher rainfall and denser ground layer vegetation, our cooperators observed far fewer lizards per man-hour.

- In 2015, TNC staff observed four STELs on flooded private property and one on a public road in Nueces County near Banquette; our collaborators later observed 23 STELs on roads in the southeastern part of the county, which included the dirt road near where the type specimen for *H. l. subcaudalis* had been collected in 1955. Prior to 2015, the lizard had not been reported from Nueces County since 1980 and had been presumed extirpated (Axtell 1998; Duran and Axtell 2010). Far fewer lizards were observed per man-hour in 2016 and 2017.

- The 2015 observations in Jim Wells County and some of the observations in Nueces County were on roads surrounded by plowed and flooded fields. Initially, TNC staff observed four STELs on a county road east of Alice and collected two. Our collaborators later observed eight STELs near that location. The lizard had not been reported from Jim Wells County since 1984.

- Surveys required by the Texas Railroad Commission were conducted at the Eagle Pass Lignite Mine in Maverick County for the Dos Republicas Resources Company in 2014,

2015, and 2016. The STEL was observed in 2014, but not in 2015 or 2016 (Dos Republicas Resources Co. 2014, 2015, 2016). Those observations were the first in that county since 1972.

- No STELs were observed during road and walking surveys near historical localities in Atascosa, Karnes, Kleberg, Jim Hogg, LaSalle, Live Oak, McMullen, San Patricio, Starr, and Webb counties. No surveys were conducted in Refugio, Goliad, Bee, or Duval counties.

Table 1. STEL survey sites, methods, and results, 2015–2017 (also see Figure 3).

Sites Surveyed	Date(s) Surveyed	Type of survey	Obs 2015*	Obs 2016	Obs 2017	Man Hours	LAT (dd) ~Centroid	LONG (dd) ~Centroid
Laughlin AFB (Val Verde County; Figure 4,5)	3/18/13; 4/15--16/13; 5/21/13	VES, Road	18	NA	NA	24	29.3564	-100.7827
Falcon State Park and Starr County Roads (Figure 6)	3/3/15	VES, Road	0	NA	0	8	26.5756	-99.138
Star Cactus Ranch (Starr Co.; Figure 7)	3/18/15; 3/15/16	VES, Road	0	0	NA	9	26.5248	-98.9042
TNC Las Estrellas Preserve (Starr Co.; Figure 8)	3/19/15; 3/14/16; 3/15/17	VES	0	0	0	8	26.4757	-98.8763
Jim Wells County Roads (Figure 9,10)	3/24: 4/3/15; 3/23/16; 6/17/17	Road	4	2	2	10	27.8169	-97.9895
La Copita Ranch (Jim Wells Co.; Figure 11)	3/24/15: 5/5/16	VES, Road	0	0	NA	8	27.6502	-98.2025
LaSalle County Private Ranch; Figure 12)	3/25/15; 04/27/16	VES	0	0	NA	9	28.2909	-99.1585
Chaparral WMA (LaSalle Co.; Figure 13)	4/2/15; 4/19/15	VES, Road	0	NA	NA	12	28.3238	-99.4001
Ward County Roads (Figure 14)	4/16/15; 6/11/16	Road	0	0	NA	10	31.5321	-103.1349
Laughlin AFB at Spofford (Kinney Co.; Figure 15,16)	6/3/2015	VES, Road	2	NA	NA	10	29.1193	-100.4758
Wright Ranch (Nueces County; Figure 17,18)	6/4: 6/5/15: 6/23/16	VES, Road	5	1	NA	12	27.7911	-97.8225
Nueces County Roads (Figure 19)	6/4/15; 6/22/16; 6/17/17	Road	4	1	1	~12	27.7491	-97.8624
Maverick Co., Eagle Pass Lignite Mine** (Figure 20, 21)	2014 (3 observed in 2014)	unk	0	0	NA	unk	~28.818	(~)-100.4393
Atascosa/Live Oak/Karnes County Roads (Figure 22)	10/16/15; 6/23/16; 06/13/17	Road	0	0	0	12	28.6394	-98.094
McMullen County Roads (Figure 23)	10/18/15: 3/23/16	Road	0	0	NA	6	28.2389	-98.49
San Patricio County Roads (Figure 24)	10/28/15	Road	0	NA	NA	6	28.01	-97.6288
Jim Hogg / Starr Co. Roads (Figure 25)	3/13/16: 3/22/16; 3/16/17	Road	0	0	0	6	26.6413	-98.924

Roberts/Miller Ranch (McMullen Co.) (Figure 26)	04/06/16: 06/26/16	VES, Road	NA	0	NA	12	28.507	-98.785
La Salle County Roads (La Salle Co.; Figure 27)	3/25/15; 04/26-27/16/3/17/17	Road	0	0	0	9	28.3275	-99.1366
Dimmit/Webb Co. Roads/Catarina (Figure 28)	4/28/16: 5/12/16: 3/17/17	Road	NA	1?	0	8	28.4588	-99.7303
Maverick/Webb Co Roads (Eagle Pass to Laredo Rd; Figure 29)	4/29/16	Roads	NA	0	NA	10	28.1368	-100.0303
Shape Ranch and W. Dimmit Co Roads (Dimmit Co.; Figure 30)	5/10/16	VES, Road	NA	0	NA	12	28.3128	-100.0264
Kinney County Roads (Figure 31)	2015 (var); 2016 (var); 5/3-4/17	Road	20+	2	2	~20	29.2996	-100.5137
Mitchell and Howard Counties (Figure 32)	6/8-9/16	Road	NA	0	0	11	32.2046	-101.1252
Upton and some Midland, Glasscock, Reagan (Figure 33, 34)	6/9-10/16	Road	NA	0	0	10	31.5548	-101.9187
Kleberg County Roads and Ballard Ranch (Figure 35)	03/28/17; 06/17-18/17	Road	NA	NA	0	9	27.3671	-97.7713

*includes 2013 records from Laughlin AFB; **Dos Republicas Resource Co. (2014).

Summary and Discussion

This project was rather narrowly focused on gathering more data on the distribution of the southern subspecies of the spot-tailed earless lizard (*H. l. subcaudalis*) through transect and road-cruising surveys. We found the lizard in some places where it was thought to have been extirpated, but found no evidence that it is extant over most of its range in southern Texas. TNC staff, collaborators, and volunteers found the species in five South Texas counties, but there have still been no observations for decades in 16 of the 21 counties (Goliad and Uvalde records are questionable) where the species was known historically. To put these findings into perspective, if we were to speculate that each recent unique locality record represents a population that occupies 20 square miles and that the species was present historically in only 10% of each county from where it was known, then the species would be present in about 6.5% of the area it previously occupied. But absence is a difficult hypothesis to support. A failure to observe an STEL in one or two visits to historical localities provides little evidence of absence. Additionally, because access and public roads are so limited in South Texas, it is impossible to say with any certainty that the lack of recent observations is an indication of rarity or extirpation.

Boom and Bust Cycles in the STEL

Axtell (1958, 1998) observed boom and bust cycles in STEL populations. The year 2015 was apparently a boom year across most of the range. We found STELs in places where they had not been seen in up to 50 years and in some cases found them abundantly in 2015, but not at all in 2016 or 2017. For example, in Kinney County, where the lizard had not been recorded outside of Laughlin AFB at Spofford for 50 years, I compiled 54 observations from various sources in 2015, but only one observation in 2016 and two in 2017. Likewise, in Nueces County the species had not been reported in 31 years but in 2015 it was found by TNC staff and collaborators to be relatively abundant in several parts of the county, including the site of the collection of the holotype for *H. l. subcaudalis*. Ralph Axtell and I had road-cruised that area more than a dozen times over the past 15 years without observing an STEL and had assumed that the species was extirpated (Axtell 1998; Duran and Axtell 2010, 2011). The Kinney and Nueces County results were duplicated in surveys across the range of the species. The boom might be partially explained by the extraordinary rainfall in 2015 that resulted in dense ground-layer vegetation. Ironically, the same factors that may have contributed to the boom also made it nearly impossible to observe lizards away from roads. The boom/bust phenomenon provides one explanation for the extreme intermittent nature of STEL observations.

Flooded Fields and Road Cruising Success

Standing water in fields and pastures in rural areas of Nueces and Jim Wells counties may have also contributed to the abundance of 2015 observations. As previously discussed, bare ground appears to be an important component of STEL habitat, and when the fields were flooded, the only

bare ground available was roads. In 2016 and 2017, those fields were not flooded during surveys, and there were no observations of STELs.

Threats

While there are insufficient data to quantify the effects of any threats, the STEL appears to be threatened mainly by: 1) urbanization and roads: About 84% (329 of 390) of new and historical records came from roads or roadsides; Duran and Axtell (2011) provided an extensive literature review to support the hypothesis that STEL populations might be impacted by road mortality; 2) invasive species—mostly red imported fire ants and exotic grasses; and 3) conversion of grasslands to agriculture and other uses. All those potential threats might be characterized as habitat loss.

Without more research, it is impossible to speculate with any confidence about the overall effects of oil and gas exploration and production on STEL populations—while some clearing might be beneficial, it seems likely that STEL populations are negatively impacted by heavily trafficked roads through prime habitat.

The 2015 rediscoveries in Nueces and Jim Wells counties were particularly significant because most of them occurred on roads surrounded by row crops. Duran and Axtell (2010) hypothesized that row-cropping was a major threat to the STEL based on the absence of records from farmland after 1971. The results of surveys under this grant and another grant appear to indicate that row-cropping may not be as serious a threat as we had presumed, i.e., that it has not lead to extirpation in all cases, but further analysis may provide evidence that the STEL is threatened by certain agricultural practices—the literature on the negative effects of pesticides on reptiles and other vertebrates is extensive. The species was present in the grasslands that were converted to agricultural fields and, in some cases, the species has persisted in those fields, but the STEL's relationship with agriculture continues to be an uncertain one.

STEL habitat = Grasslands

On the central and southern Edwards Plateau, the STEL will often be found on the Low Stony Hill Ecological Site—flat live-oak/juniper plateaus with dark fertile soils. In the southern and northern parts of the range, it is more often found in low grassy clay flats near drainages. Those habitats are not as different as they may seem at a glance because they can all be broadly identified as grasslands—sometimes mesquite savannahs, sometimes coastal prairies, sometimes flat stony plateaus or live oak savannas, sometimes agricultural fields—but always historical grasslands.

Conservation

While many details of STEL ecology are still lacking, it is clear the species occurred exclusively in grasslands historically and it appears to be a diet generalist on an insect/arthropod guild that occurs in those grasslands (Travis LaDuc, Curator of Herpetology, Texas Natural History Collection at the University of Texas, pers. comm.); therefore, conservation actions which encourage native grasslands, efforts to eradicate exotic species (particularly red imported fire ants and non-native grasses) and avoidance of pesticides which significantly impacts lizards and native

invertebrate populations, would undoubtedly benefit the STEL. It is also clear that the species uses sparsely vegetated and bare areas when those are available, though populations apparently persist over periods of years when vegetation is lush. Over much of the range, periodic drought will naturally devegetate the landscape; so, sparsely vegetated areas are probably not something that would need to be artificially provided. The species may do well where parts, but not all, of its home range are artificially devegetated by grazing. While heavily trafficked roads might have an adverse impact on STEL populations, small unimproved and lightly used roads within ranchland might be beneficial to the species.

Literature Cited

Axtell, R.W. 1954. The Systematic Relationships of Certain Lizards in the Genus *Holbrookia*. Master of Science Thesis. University of Texas. 75 pp.

_____. 1956. A solution to the Long Neglected *Holbrookia lacerata* Problem, and the Description of Two New Subspecies of *Holbrookia*. Bulletin of the Chicago Academy of Sciences. 19 pp.

_____. 1958. A monographic revision of the Iguanid genus *Holbrookia*. Ph.D. dissertation, University of Texas. 222 pp.

_____. 1998. *Holbrookia lacerata* Cope. in The Interpretive Atlas of Texas Lizards. Self-published. Account #29, 12 pp.

Dos Republicas Resource Co. 2014, 2015, 2016. Eagle Pass Lignite Mine Permit 42B. Predisturbance survey for threatened and endangered species. Prepared for the Texas Railroad Commission. 24 pp.

Cope, E.D. 1880. On the zoological position of Texas. Bulletin of the United States National Museum, Number 17.

Duran. C.M. 2013. The discovery of the southern spot-tailed earless lizard at Laughlin Air Force Base, Val Verde County, Texas. Report to Laughlin AFB. 8 pp.

_____ and D.L. Yandell. 2014. *Holbrookia lacerata subcaudalis* (Southern Spot-tailed Earless Lizard). Refugia and Commensalism. Herpetological Review 45 (3): 501-502.

_____, W.M. Anderson, and G. Perry. 2012. Holbrookia lacerata lacerata (Northern Spot-tailed Earless Lizard). USA: Texas: Mason Co. Geographic Distribution. Herpetological Review 43(2), 2012, 305-306.

_____ and R.W. Axtell. 2010. A rangewide inventory and habitat model for the spot-tailed earless lizard (*Holbrookia lacerata*). Report to Texas Parks and Wildlife, 37 pp.

_____ and R.W. Axtell. 2011. The status of and a predictive habitat model for *Holbrookia lacerata* (the spot-tailed earless lizard): Response to a request for information from the Department of the Interior, US Fish and Wildlife Service. 54 pp.

Schmidt, K.P. 1922. A review of the North American genus of lizards *Holbrookia*. Bulletin of the American Museum of Natural History, vol. 46, p. 709-725, pl. 58-60.

_____. 1953. A checklist of North American amphibians and reptiles. American Society of Ichthyologists and Herpetologists, 6th Edition, p. i-viii + 280.

Smith, H.M. 1946. Handbook of lizards. Comstock Publishing Co., Ithaca, N.Y., p. i-xxi + 557

Stejneger, L.H. 1890. Annotated list of reptiles and batrachians collected by Dr. C. Hart Merriam and Vernon Bailey on the San Francisco Mountain Plateau and the desert of the Little Colorado, Arizona, with descriptions of new species. North American Fauna, no. 3, pt.5, p. 103-118, pl. 12, 13.

Yarrow, H.C. 1883. Checklist of North American Reptilia and Batrachia, with catalogue of specimens in the U.S. National Museum. Bulletin of the U.S. National Museum. Government Printing Office, Washington D.C. No. 24 p. 9.

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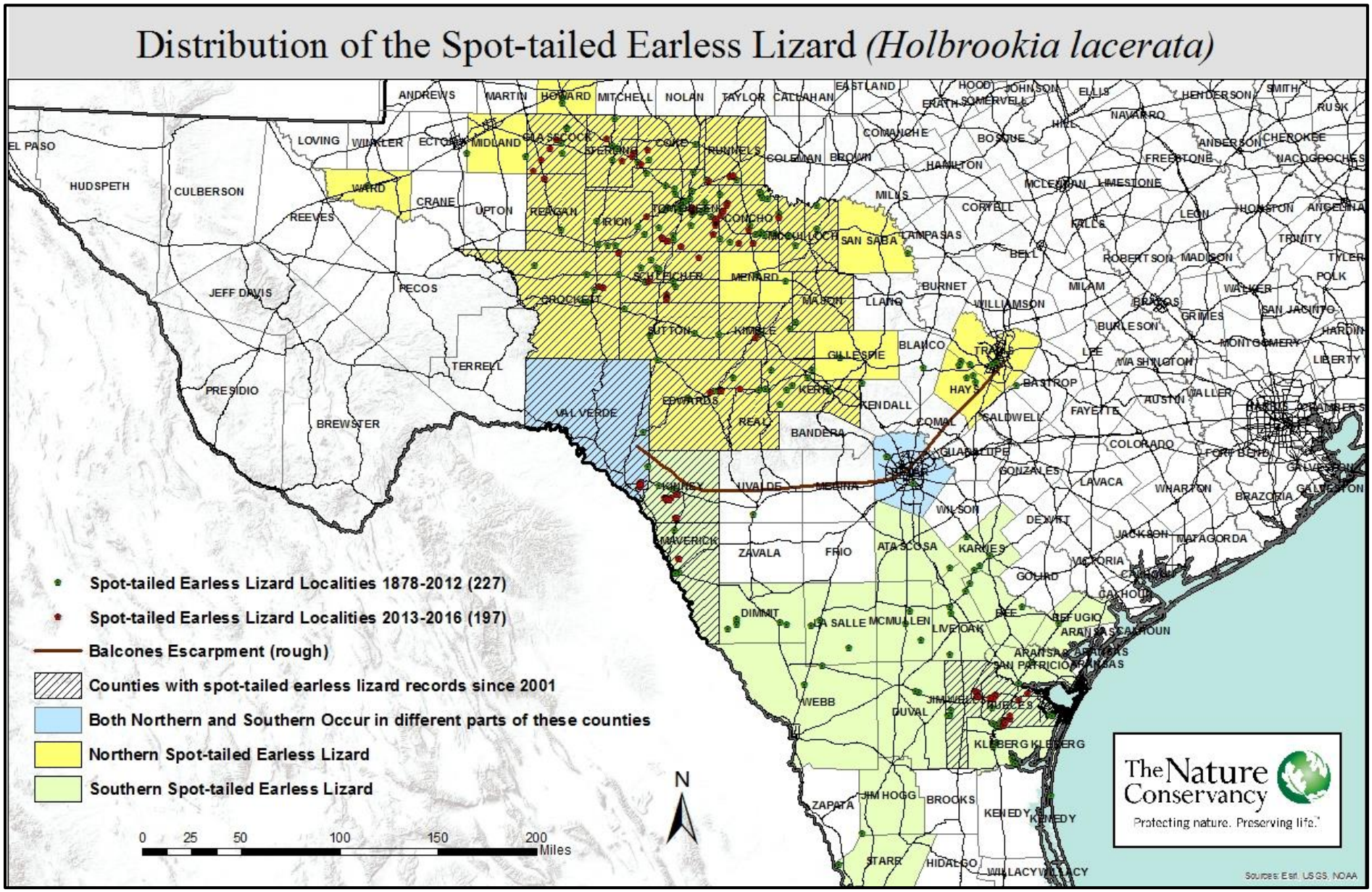
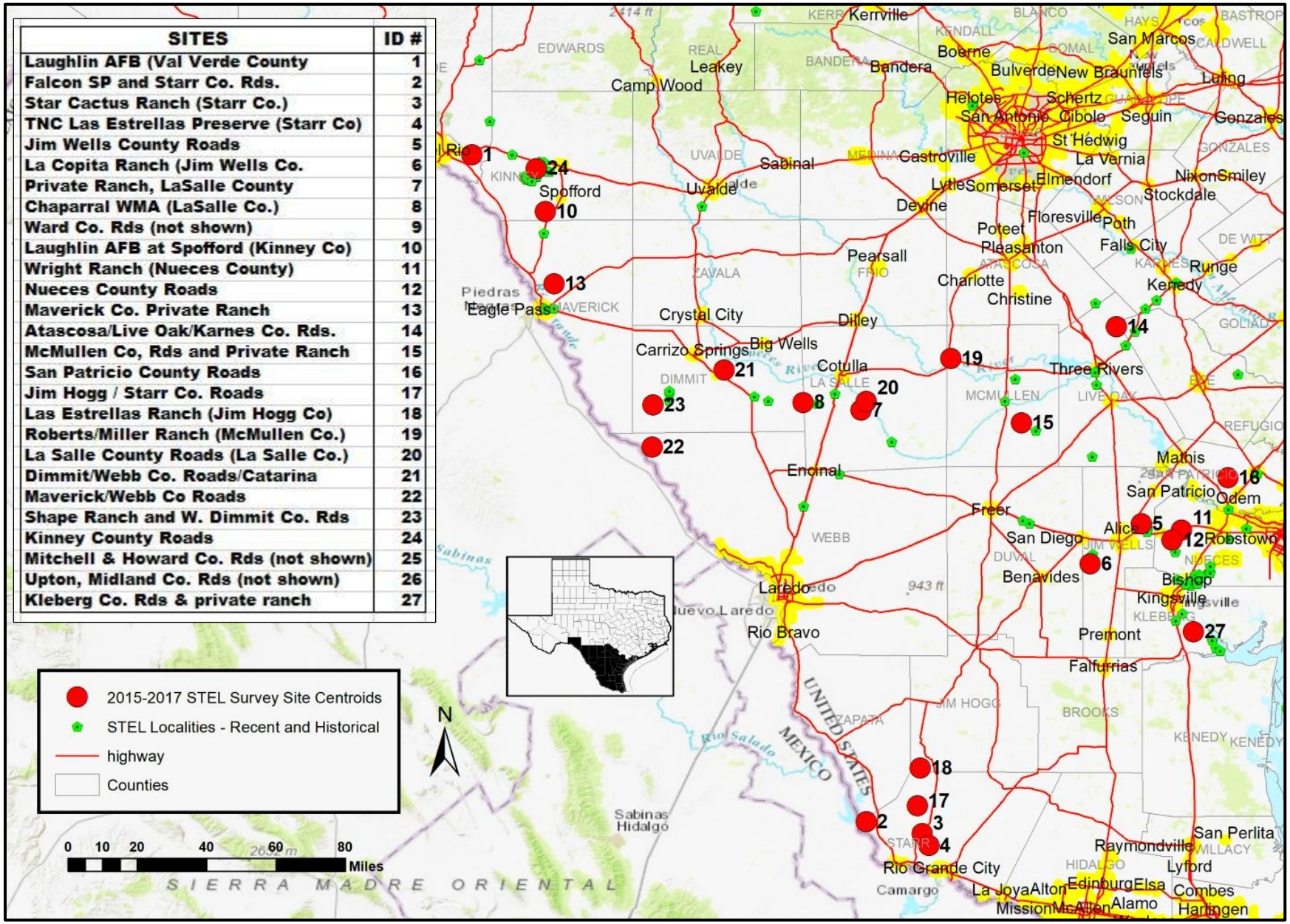
FIGURES

Figure 2. Known Recent Distribution of the Spot-tailed Earless Lizard – August 31, 2017



Questionable records in Goliad and Uvalde Counties

Figure 3. Survey site centroids for Section 6 Project: Surveys of a Subset of Historical Spot-tailed Earless Lizard Localities – 2015-2017


SITES | ID #
Laughlin AFB (Val Verde County | 1
Falcon SP and Starr Co. Rds. | 2
Star Cactus Ranch (Starr Co.) | 3
TNC Las Estrellas Preserve (Starr Co) | 4
Jim Wells County Roads | 5
La Copita Ranch (Jim Wells Co. | 6
Private Ranch, LaSalle County | 7
Chaparral WMA (LaSalle Co.) | 8
Ward Co. Rds (not shown) | 9
Laughlin AFB at Spofford (Kinney Co) | 10
Wright Ranch (Nueces County) | 11
Nueces County Roads | 12
Maverick Co. Private Ranch | 13
Atascosa/Live Oak/Karnes Co. Rds. | 14
McMullen Co, Rds and Private Ranch | 15
San Patricio County Roads | 16
Jim Hogg / Starr Co. Roads | 17
Las Estrellas Ranch (Jim Hogg Co) | 18
Roberts/Miller Ranch (McMullen Co.) | 19
La Salle County Roads (La Salle Co.) | 20
Dimmit/Webb Co. Roads/Catarina | 21
Maverick/Webb Co Roads | 22
Shape Ranch and W. Dimmit Co. Rds | 23
Kinney County Roads | 24
Mitchell & Howard Co. Rds (not shown) | 25
Upton, Midland Co. Rds (not shown) | 26
Kleberg Co. Rds & private ranch | 27
2015-2017 STEL Survey Site Centroids
STEL Localities - Recent and Historical
highway
Counties
0 10 20 40 60 80
Miles
N
Kerrville
Leakey
Camp Wood
Bandera
Boerne
Bulverde
New Braunfels
San Marcos
Luling
Seguin
Gonzales
Helotes
Schertz
San Antonio
Cibolo
St Hedwig
La Vernia
Castroville
Sabinal
Uvalde
Lytle
Somerset
Elmendorf
Nixon
Smiley
Stockdale
Devine
Floresville
Poth
Poteet
Pleasanton
Falls City
Pearsall
Charlotte
Christine
Runge
Kenedy
Crystal City
Dilley
Carrizo Springs
Big Wells
Cotulla
Three Rivers
Eagle Pass
Piedras Negras
Encinal
Mathis
San Patricio
Odem
Freer
Alice
San Diego
Robstown
Benavides
Bishop
Kingsville
Laredo
Nuevo Laredo
Rio Bravo
Premont
Falfurrias
Sabinas Hidalgo
Rio Grande City
Raymondville
San Perlita
Lyford
Edinburg
Elsa
Combes
La Joya
Alton
Mission
McAllen
Alamo
Harlingen
Camargo
SIERRA MADRE ORIENTAL
UNITED STATES
MEXICO

Midland, Upton, Howard, Mitchell, Ward counties not shown – see figures 14, 30, and 31.

Figure 4. (Site ID # 1) STEL Survey Routes at Laughlin AFB, Del Rio, TX - 03/18/13, 04/15-16/13, 05/21/2013

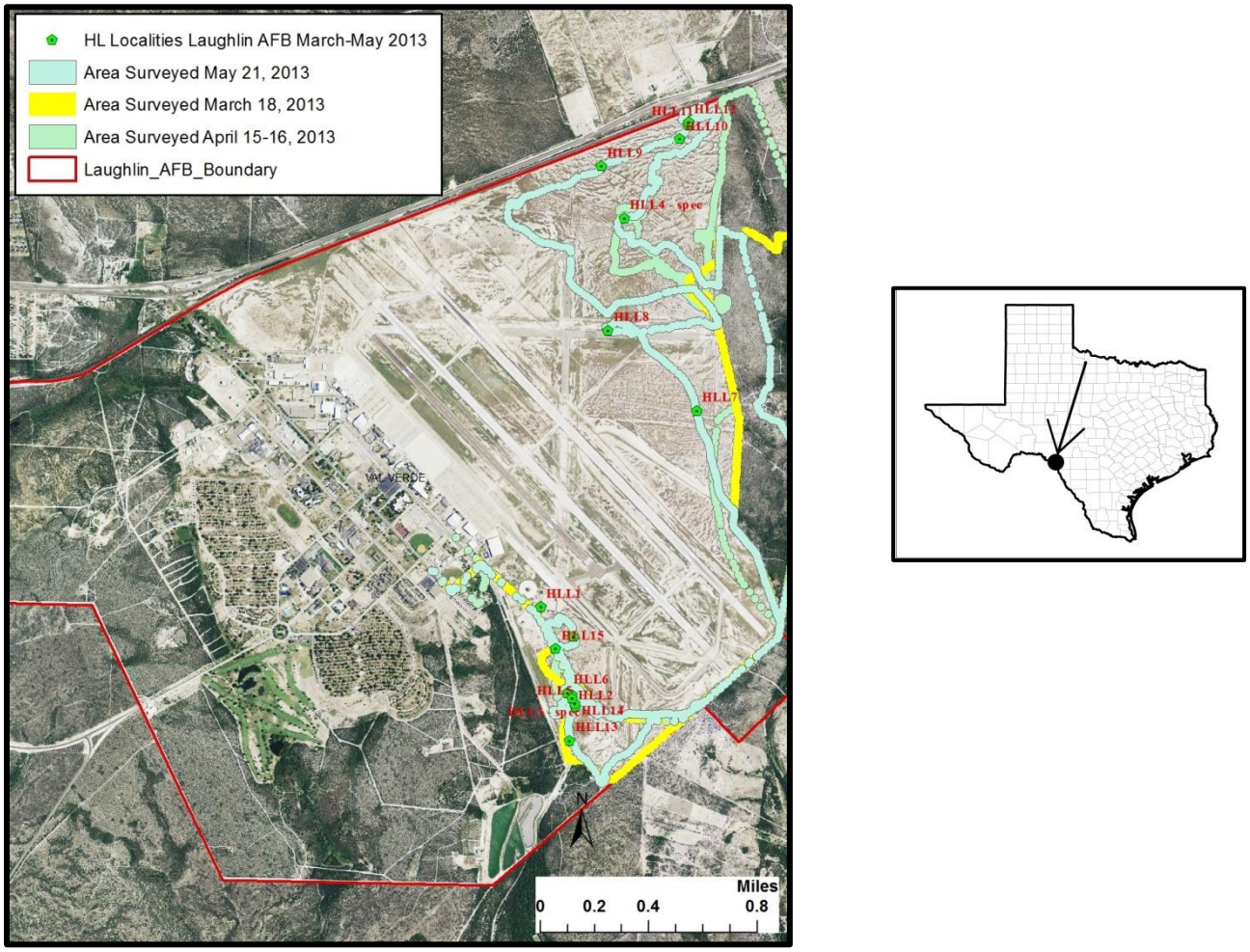
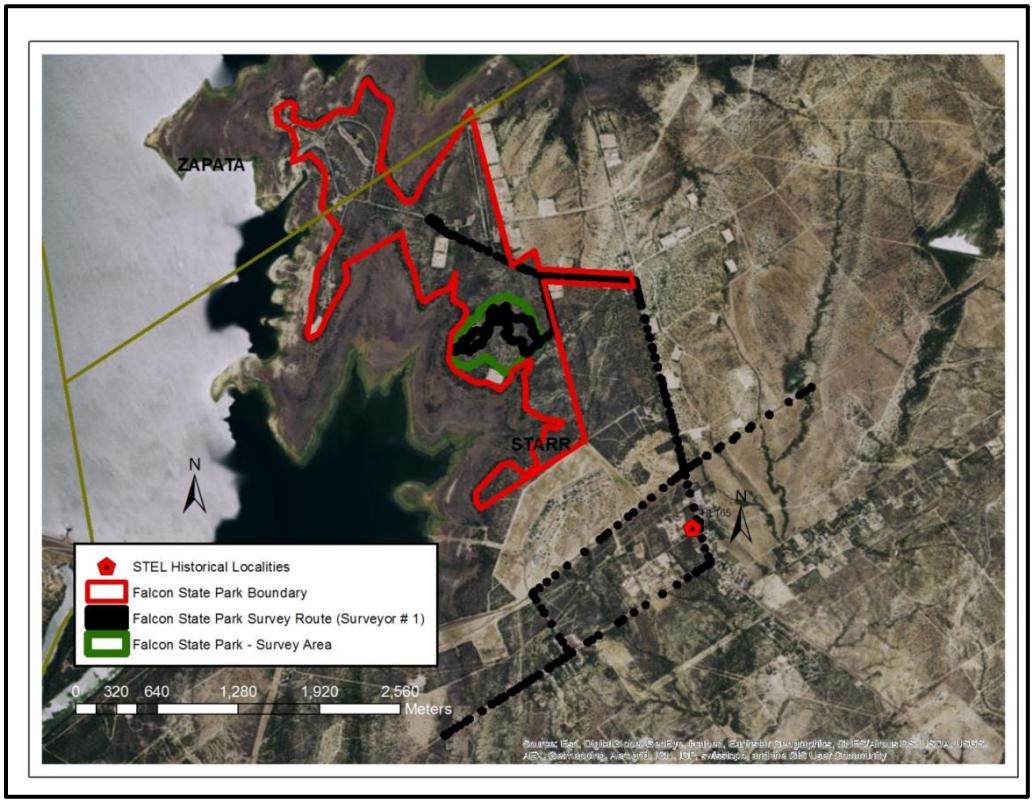


Figure 5. (Site ID # 1). Spot-tailed earless lizard at Laughlin AFB, Del Rio, Texas – 04/16/13

Figure 6. (Site ID # 2). Falcon State Park and vicinity STEL survey map – 03/03/15



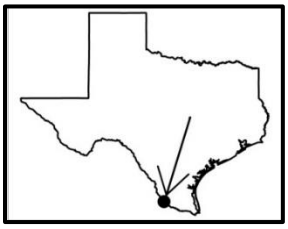
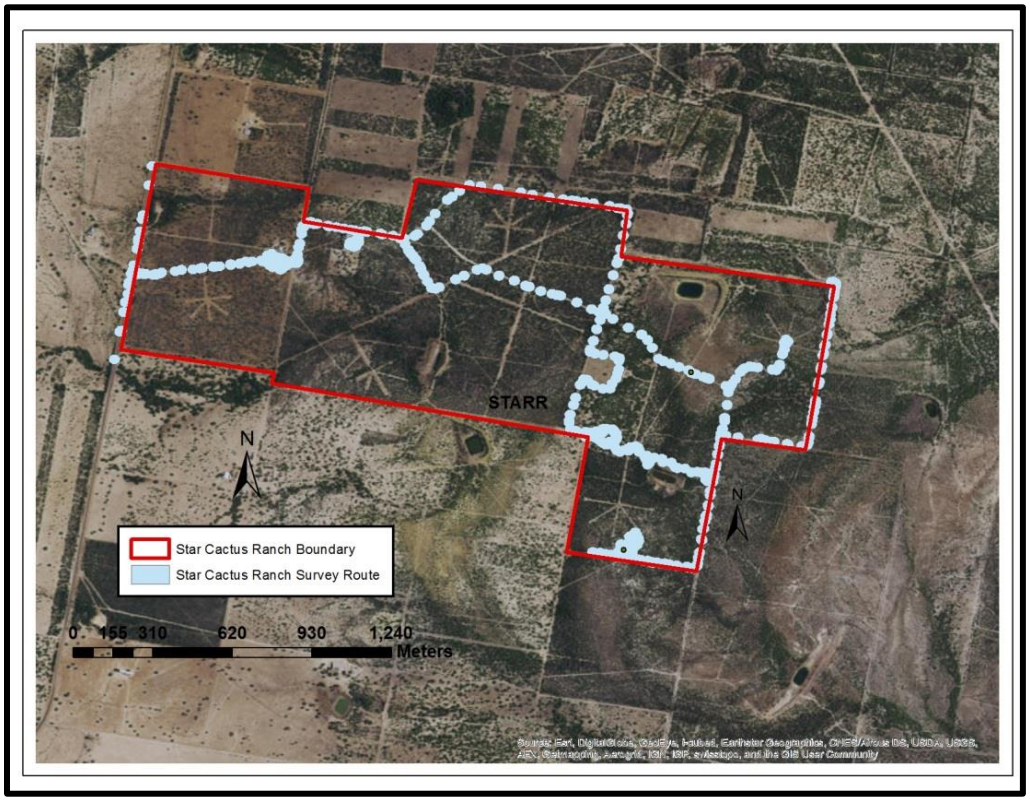


Figure 7. (Site ID # 3). Star Cactus Ranch STEL survey map - 03/15/15 and 03/18/16



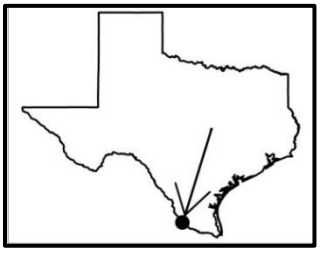


Figure 8. (Site ID # 4). TNC Las Estrellas Preserve STEL survey map - 03/19/15 and 03/14/16

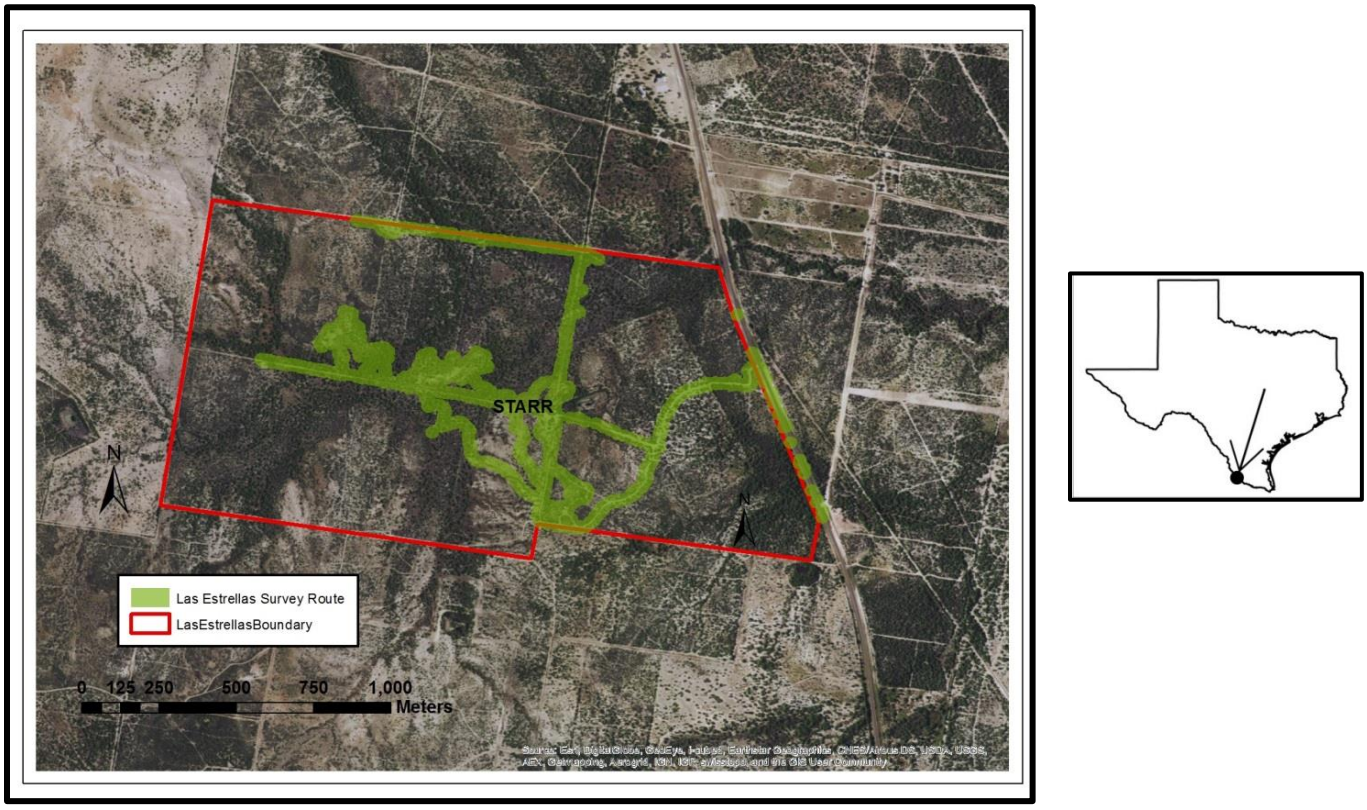


Figure 9. (Site ID # 5). Jim Wells Co roads surveyed for STEL - 03/03/15, 04/03/15, 03/03/15, 05/05/16, 06/22/16, 06/18/17

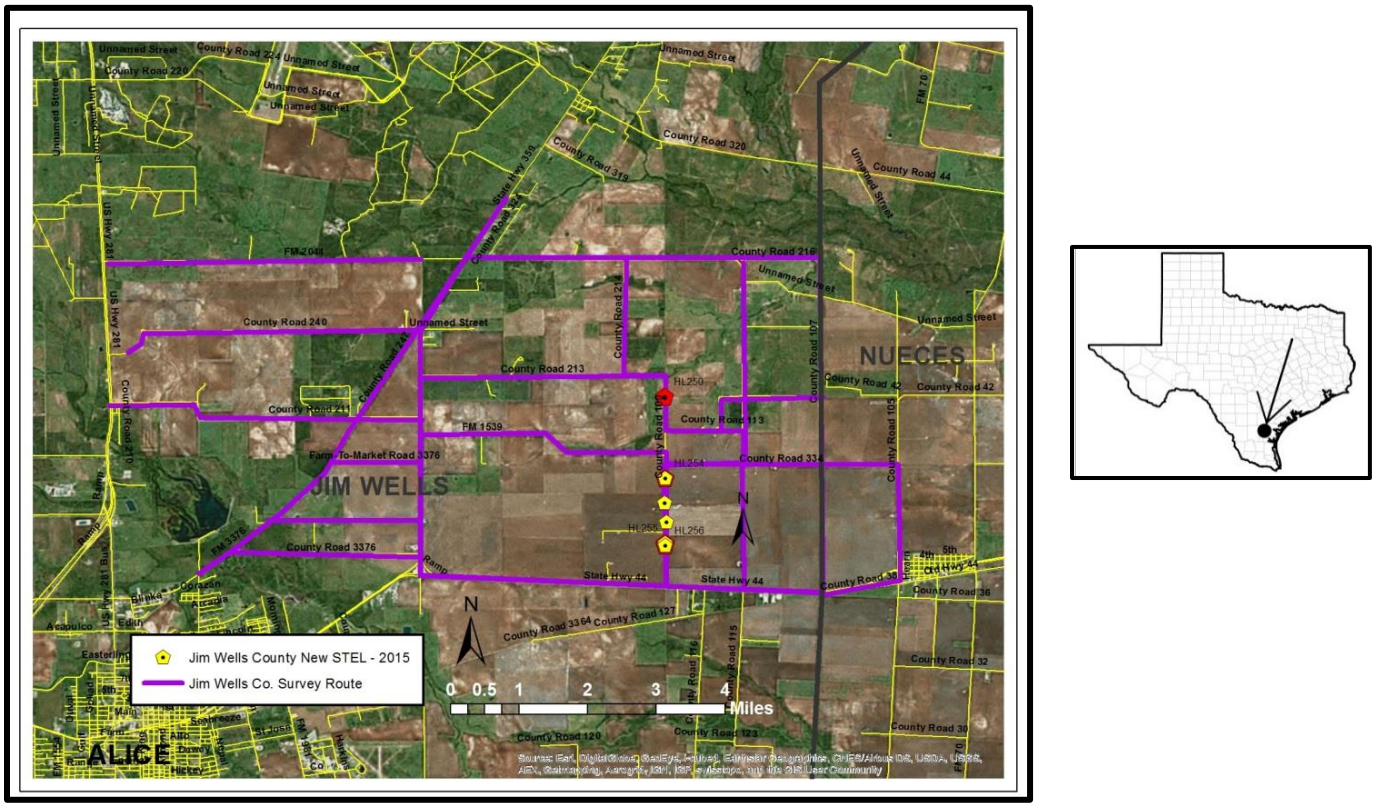


Figure 10. (Site ID # 5). A spot-tailed earless lizard found in NW Jim Wells County – 03/24/15

Figure 11. (Site ID # 6) La Copita Ranch STEL survey map – 03/24/15 and 05/05/16

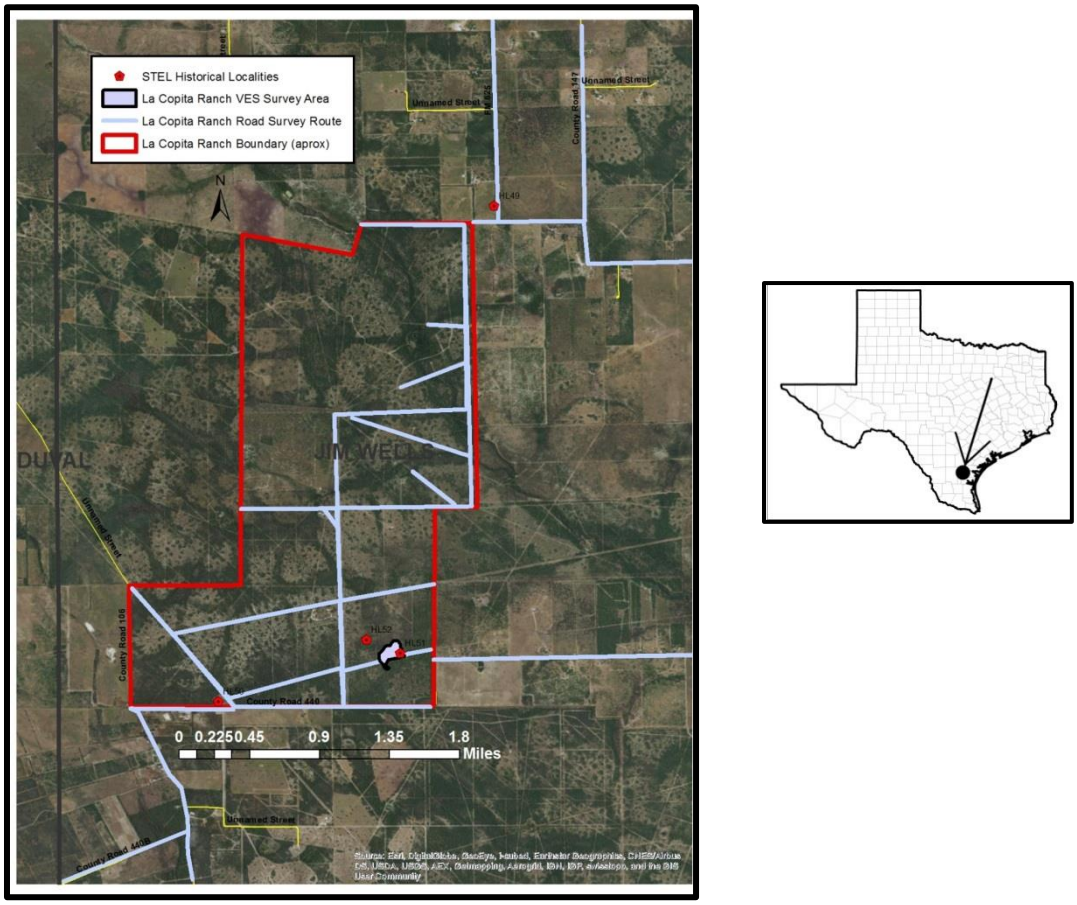


Figure 12. (Site ID # 7). LaSalle County Private Ranch STEL survey – 03/25/15 and 04/27/16

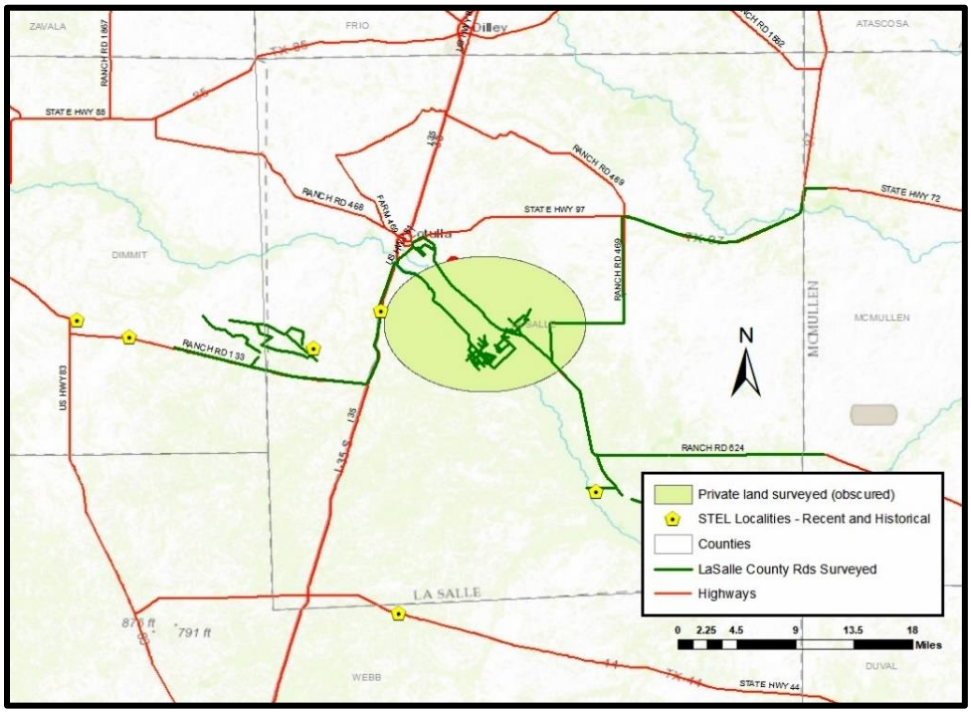
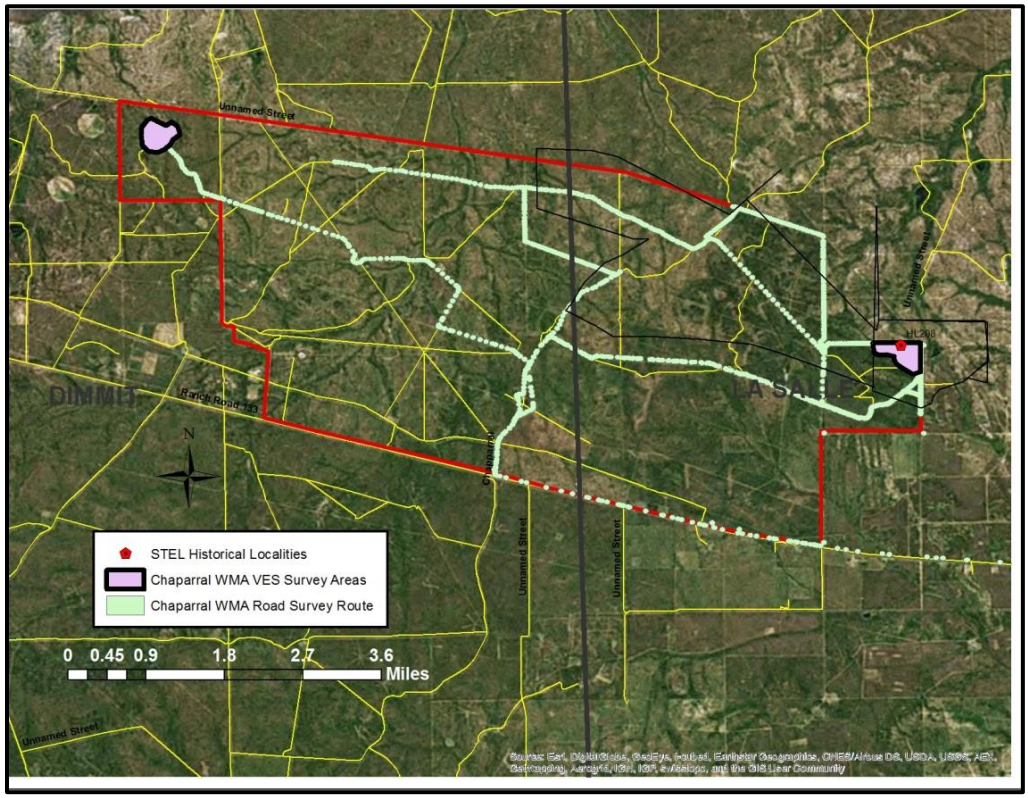


Figure 13. (Site ID # 8). Chaparral WMA STEL survey map – 04/02 and 05/01/15



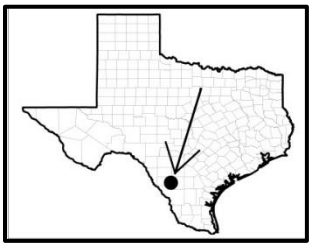
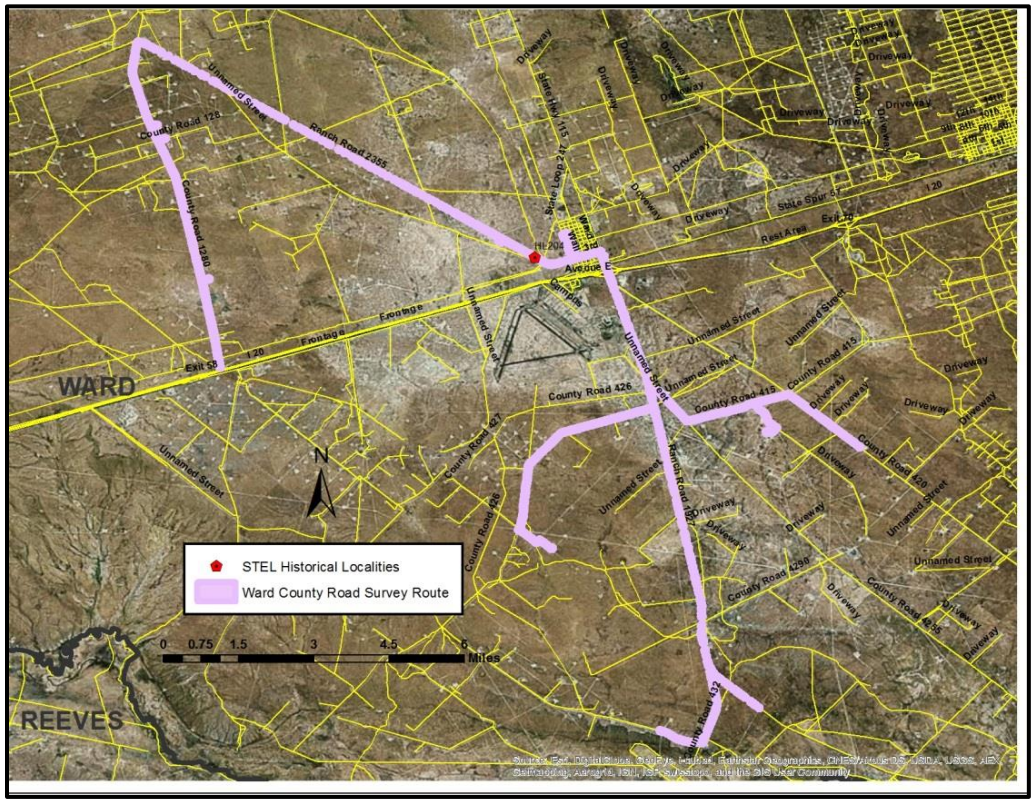


Figure 14. (Site ID # 9). Ward County STEL survey map – 04/16/15 and 05/11/16



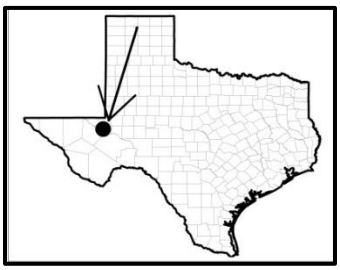
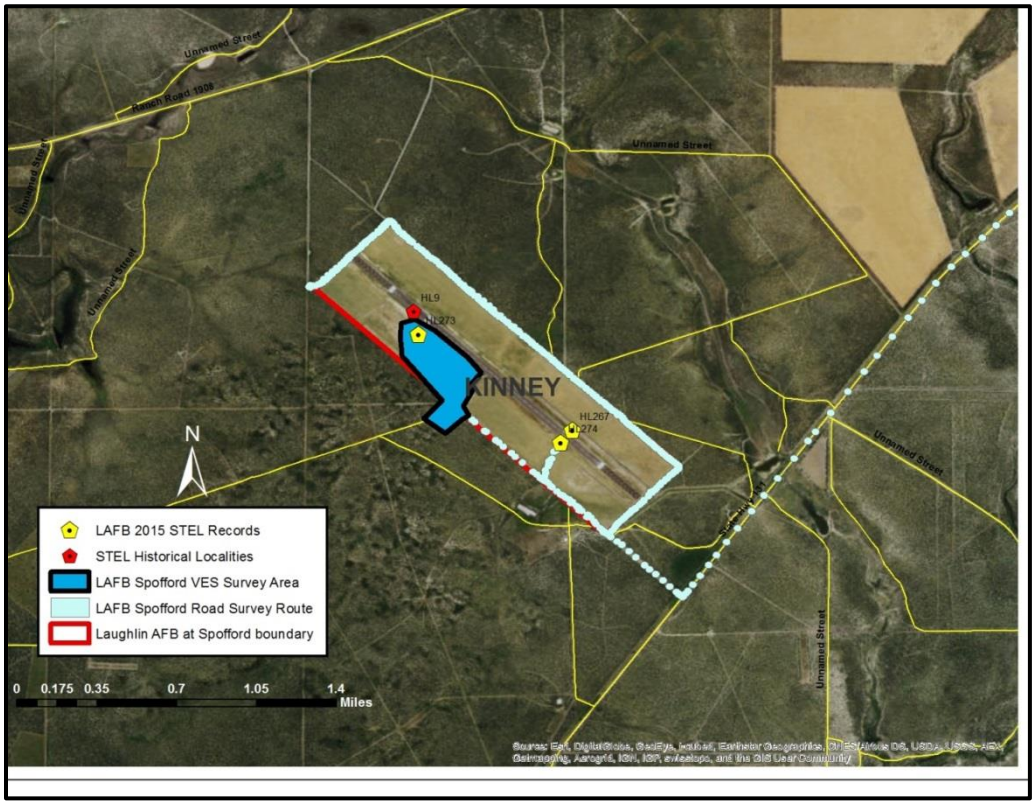


Figure 15. (Site ID #10) Laughlin AFB at Spofford STEL survey map – 06/03/15



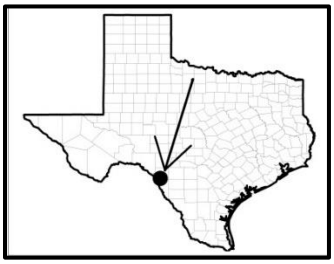


Figure 16. (Site ID # 10). Spot-tailed earless lizard, Laughlin AFB, Spofford - 06/03/15

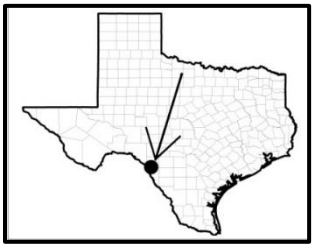


Figure 17. (Site ID # 11). Wright Ranch, Nueces Co., STEL survey map - 06/4-5/15 and 06/23/16

Figure 18. (Site ID # 11). Spot-tailed earless lizards from Wright Ranch, Nueces Co. – 06/05/15

Figure 19. (Site ID # 12). Nueces County road survey map – 04/09/15, 03/06/15, 06/22/16

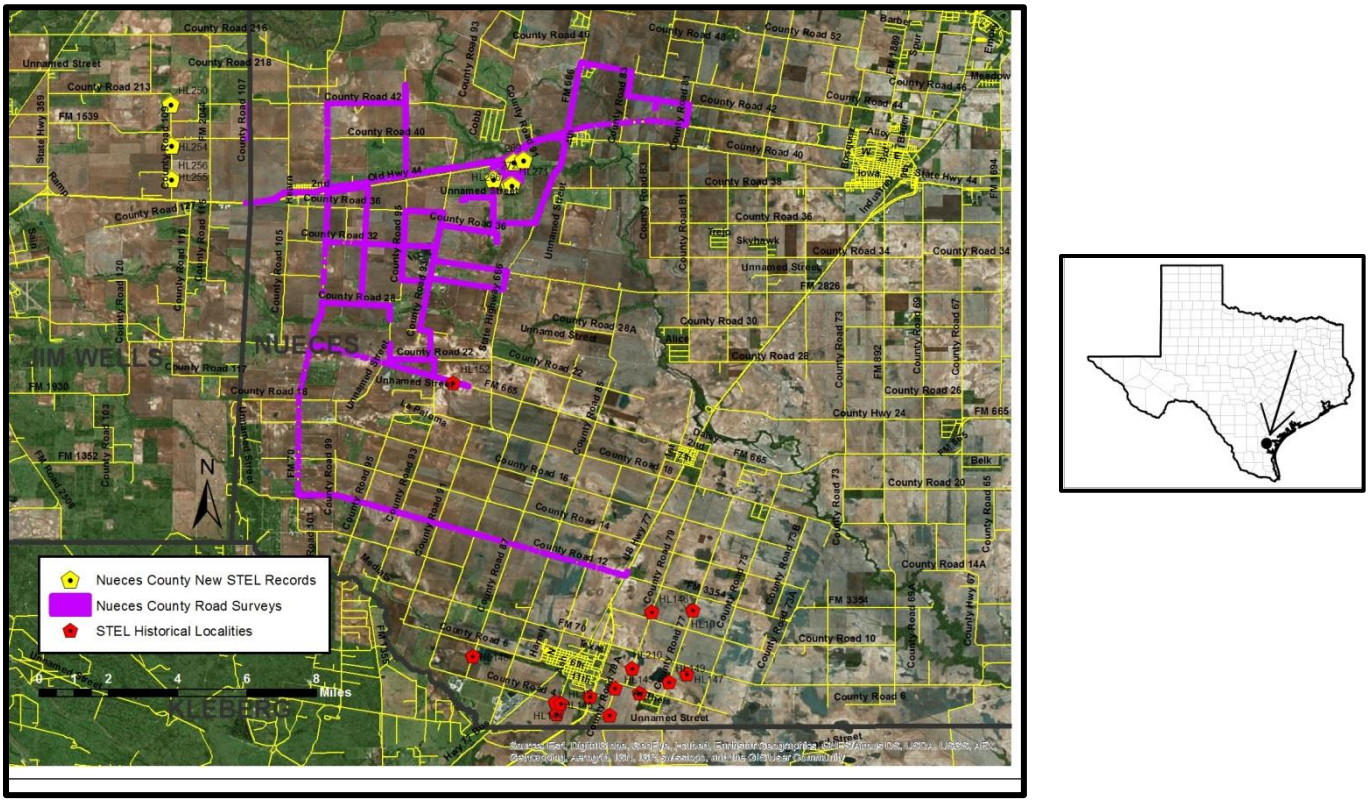


Figure 20. (Site ID # 13). Eagle Pass Lignite Mine Maverick County (Dos Republicas Resources Co. 2014)

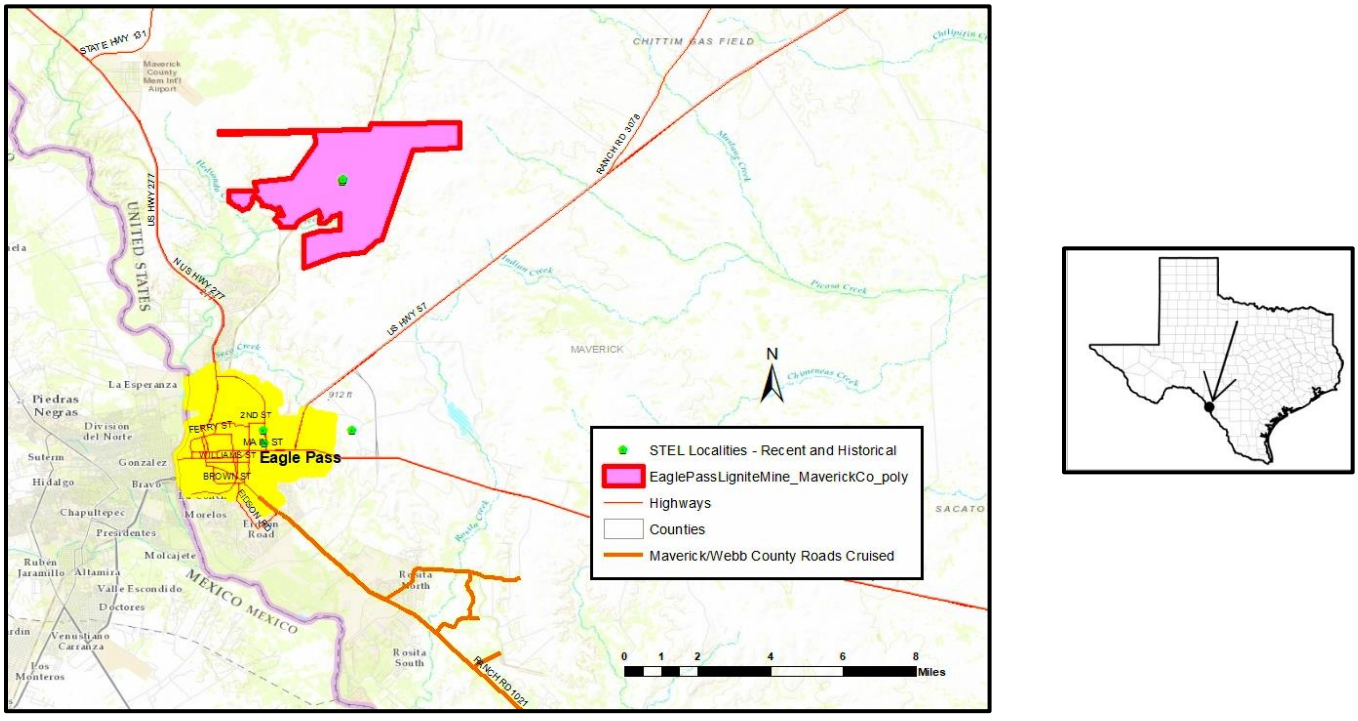


Figure 21. (Site ID # 13). Spot-tailed earless lizard – Eagle Pass Lignite Mine – photo by Jeremiah McKinney (Dos Republicas Resources Co. 2014)

Figure 22. (Site ID # 14) Atascosa, Bee, Karnes, Live Oak, STEL road survey (10/16/15) with STEL historical localities.

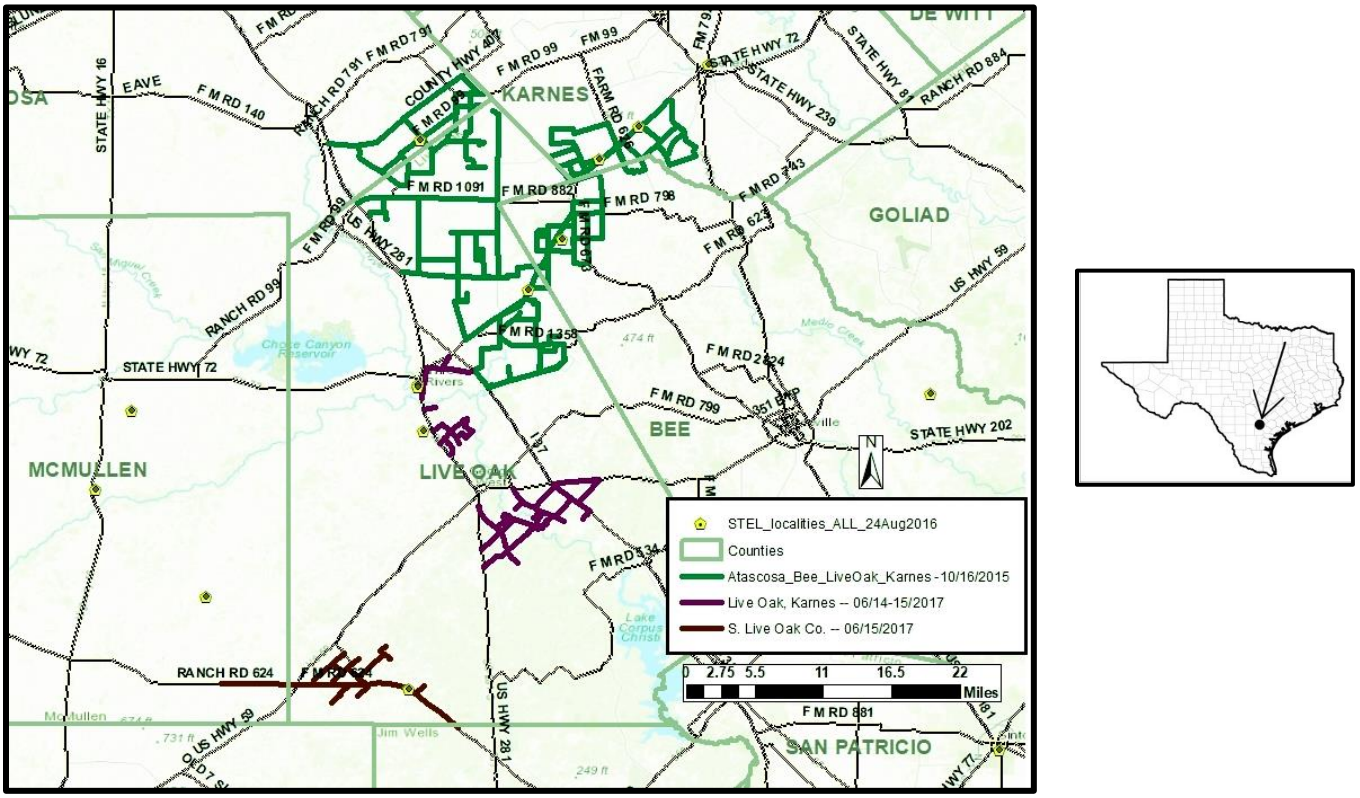
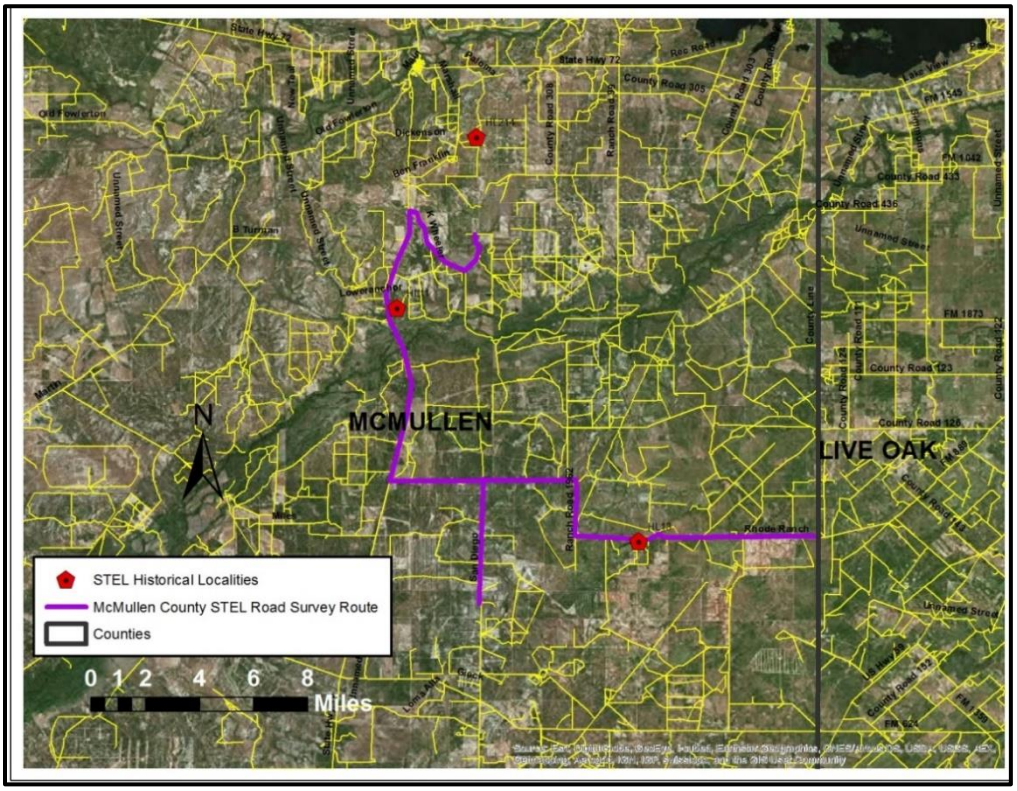


Figure 23. (Site ID # 15). McMullen County STEL road survey map – 10/18/15 and 03/23/16



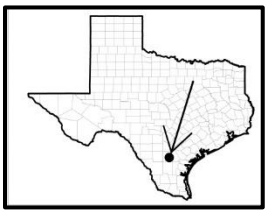
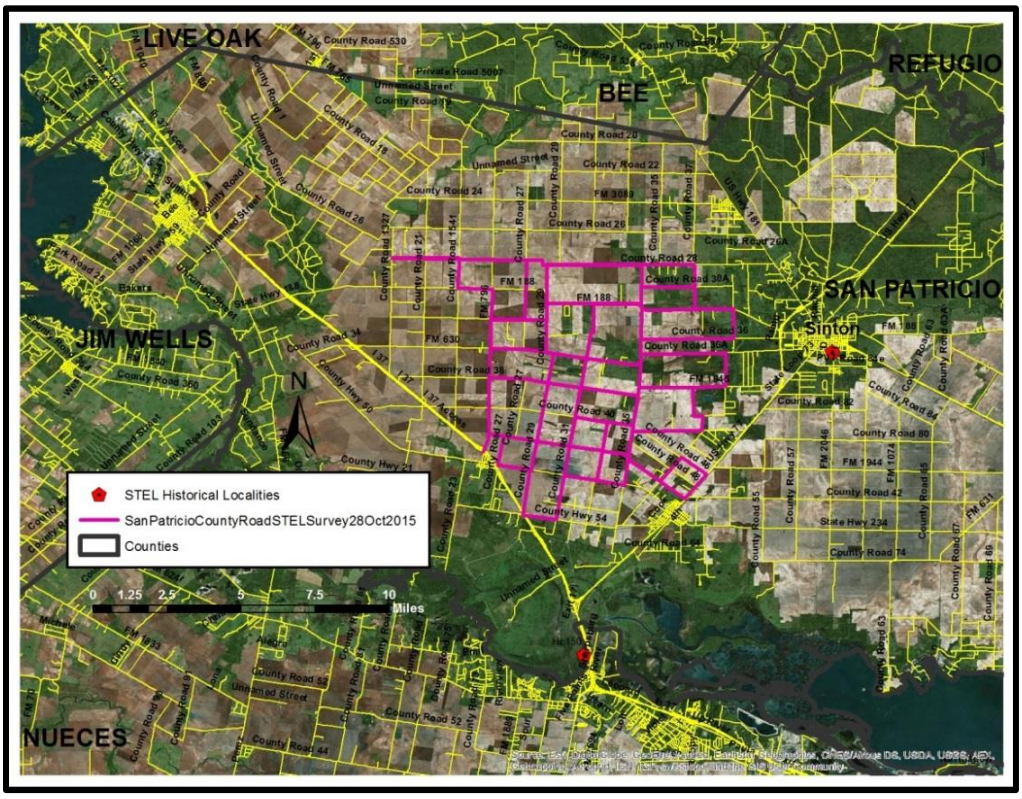


Figure 24. (Site ID # 16). San Patricio County STEL road survey map – 10/28/15



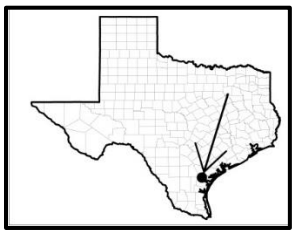


Figure 25. (Site ID # 17, 18). Jim Hogg and Starr Co. STEL roads surveyed (3/19/15) with historical STEL localities

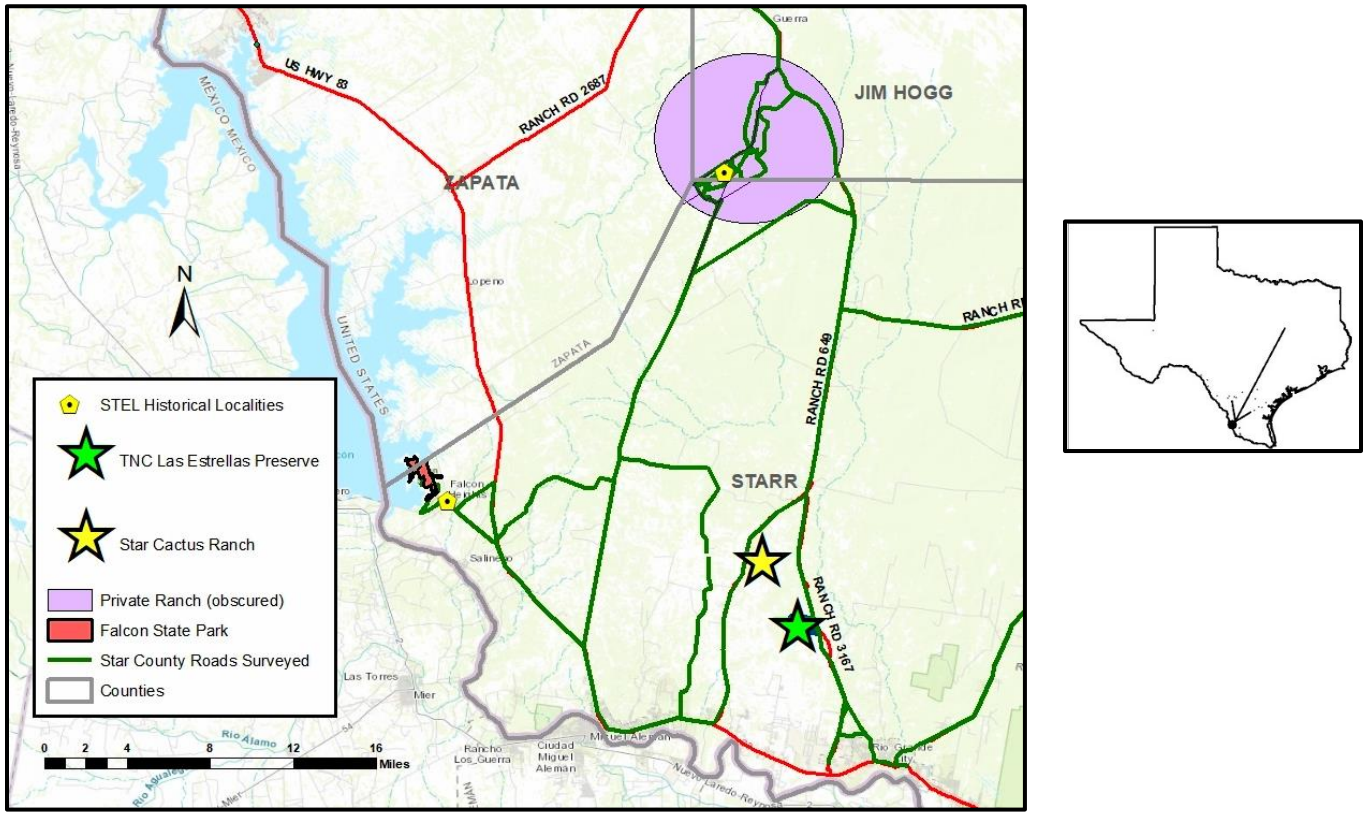


Figure 26. (Site ID # 19). Jim Roberts-Miller Ranch, McMullen Co., STEL survey map - 04/06/16 and 06/26/16

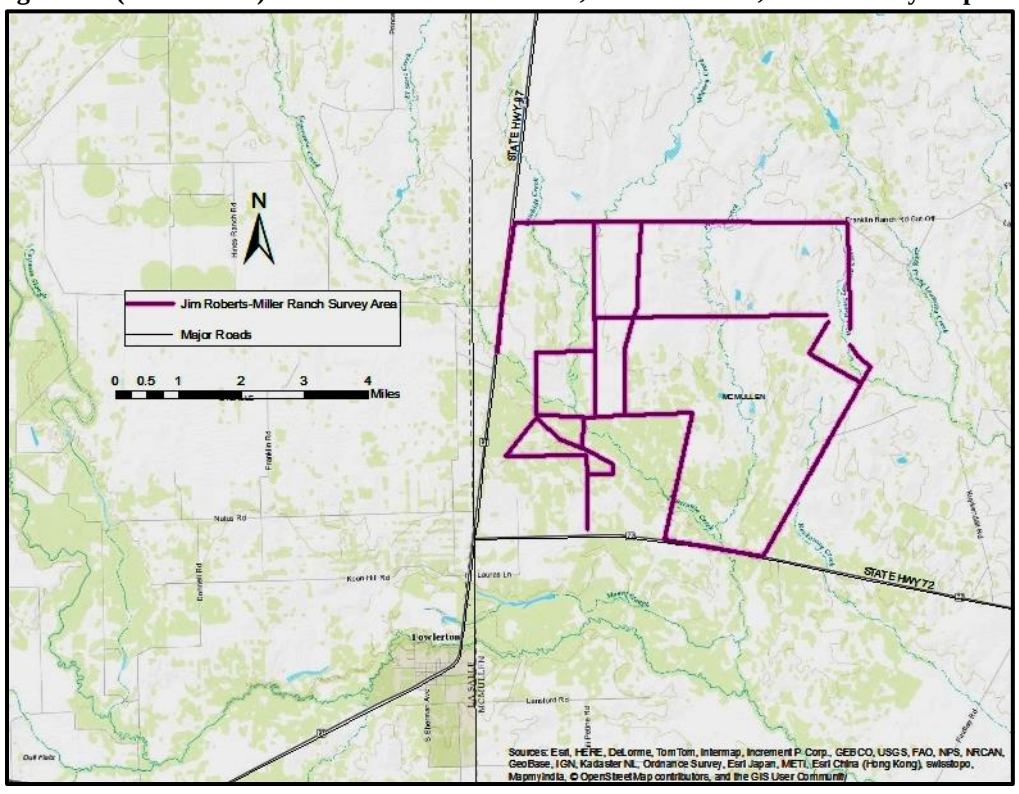


Figure 27. (Site ID # 20). La Salle County Roads Cruised for STEL – 3/25/15; 04/26-27/16/3/17/17

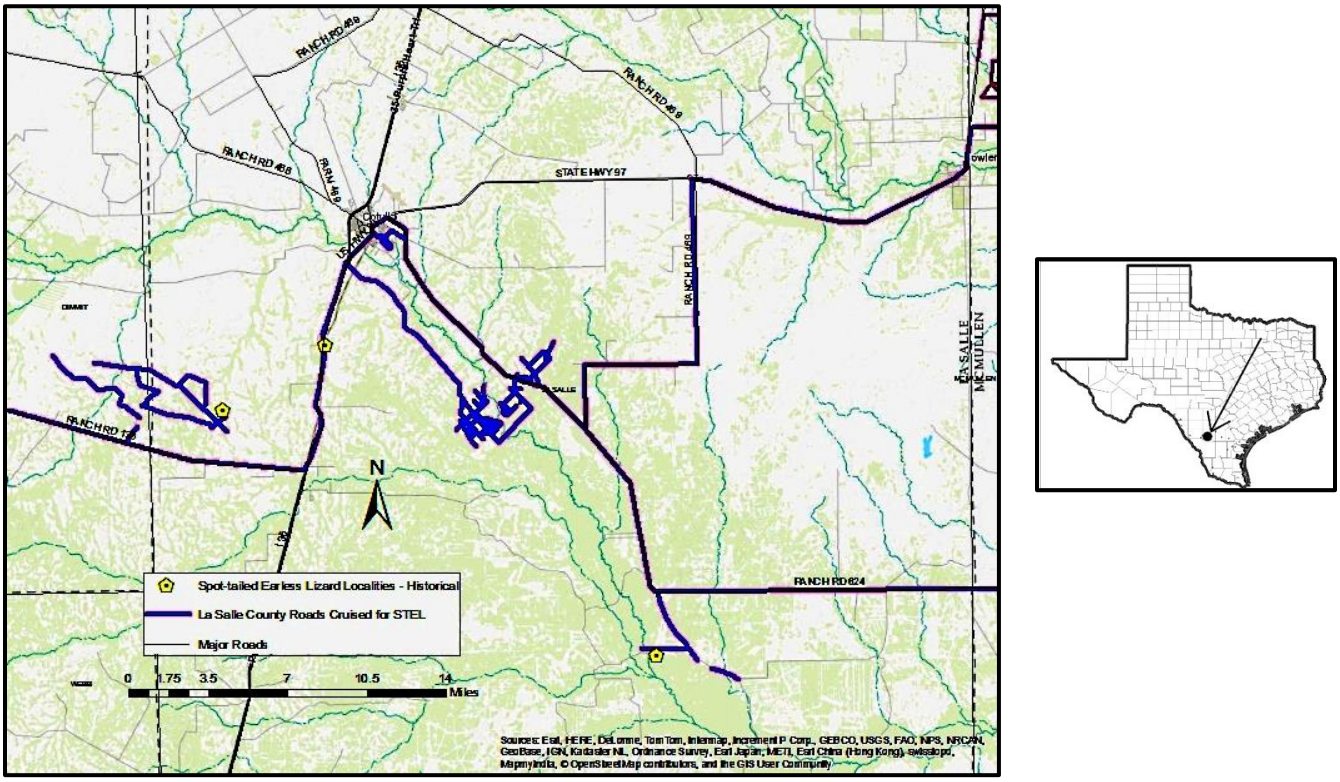


Figure 28. (Site ID # 21) Dimmit and Webb Road Surveys (4/28/16; 5/12/16; 3/17/17) with historical STEL localities.

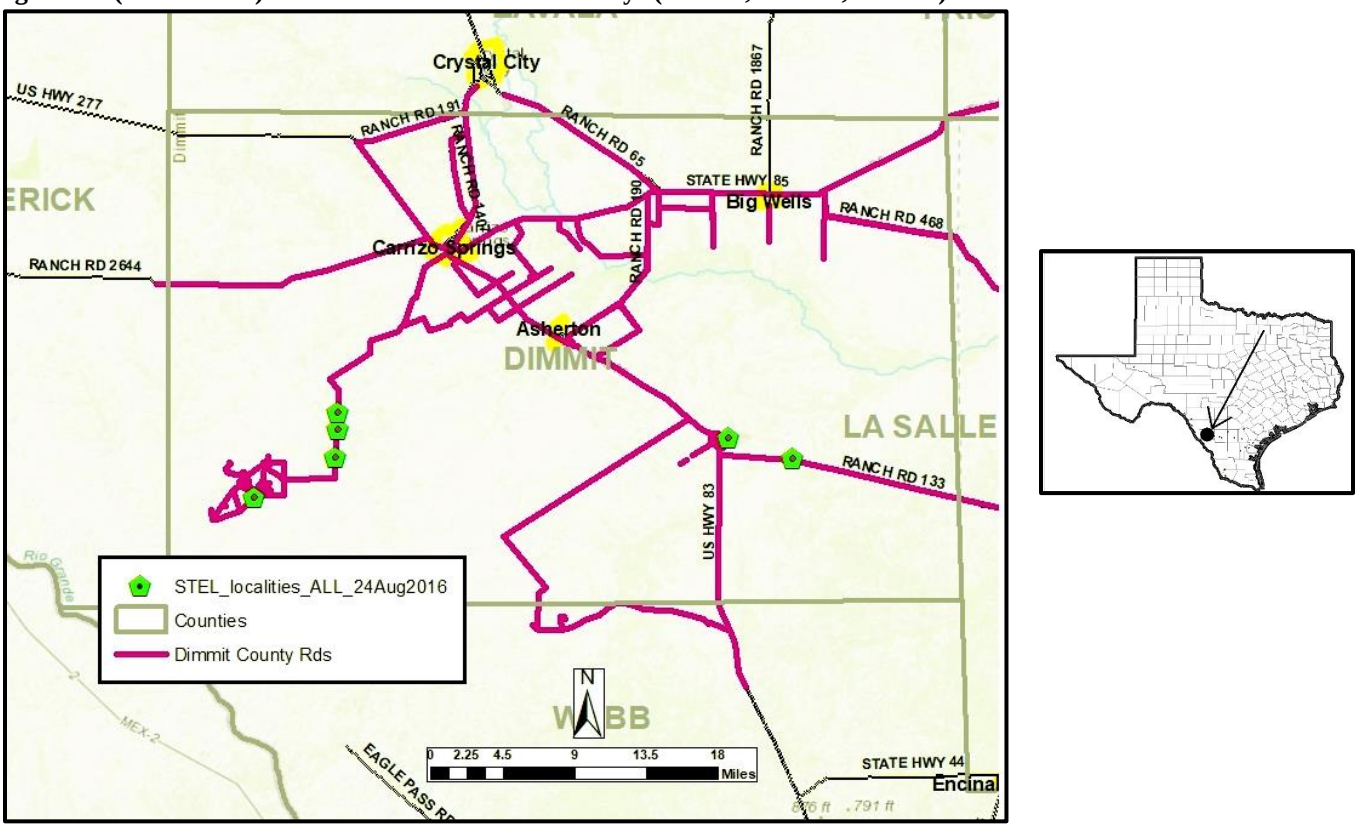


Figure 29. (Site ID # 22). Road from Eagle Pass to Laredo surveyed - 04/29/2016.

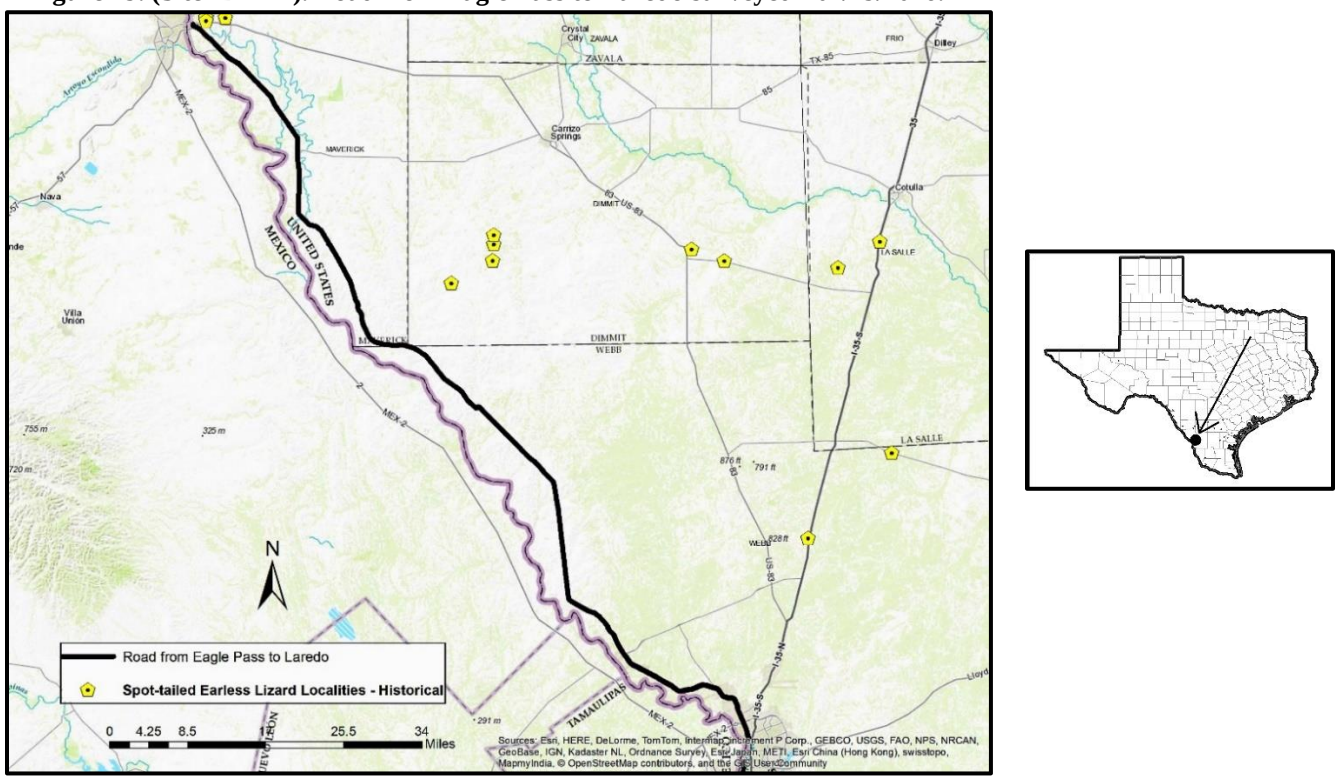
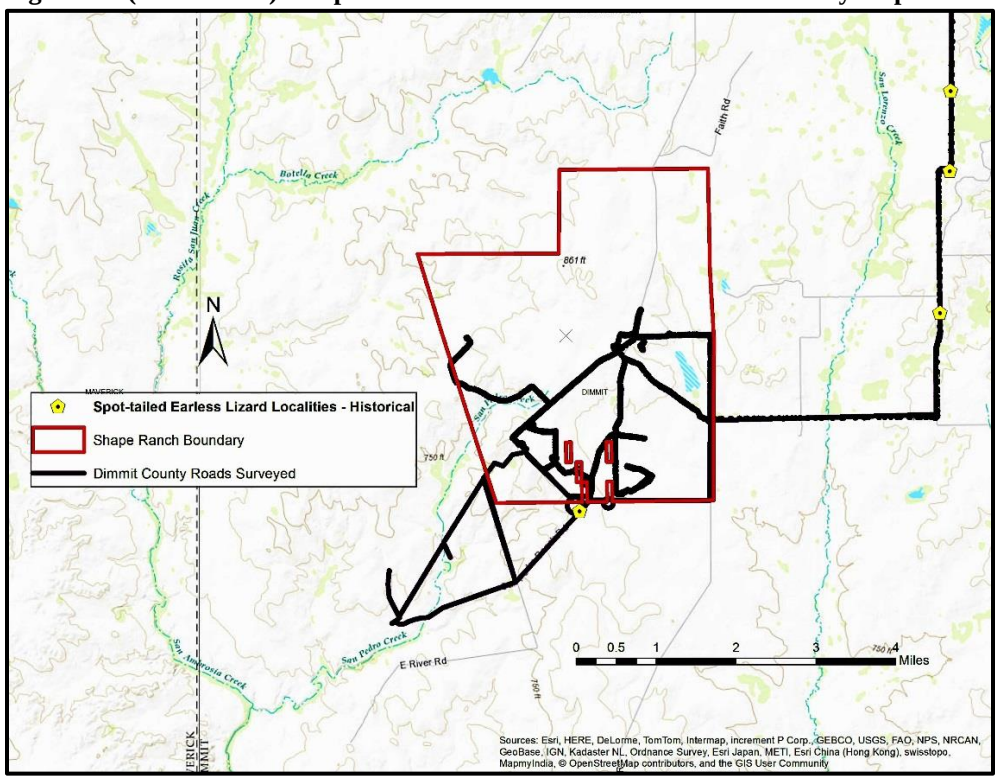


Figure 30. (Site ID # 23). Shape Ranch and W. Dimmit roads STEL survey map – 05/10/16



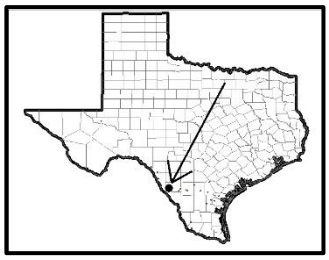


Figure 31. (Site ID # 24). Kinney County STEL road surveys (various dates - 2016, 2017) with historical and recent STEL localities

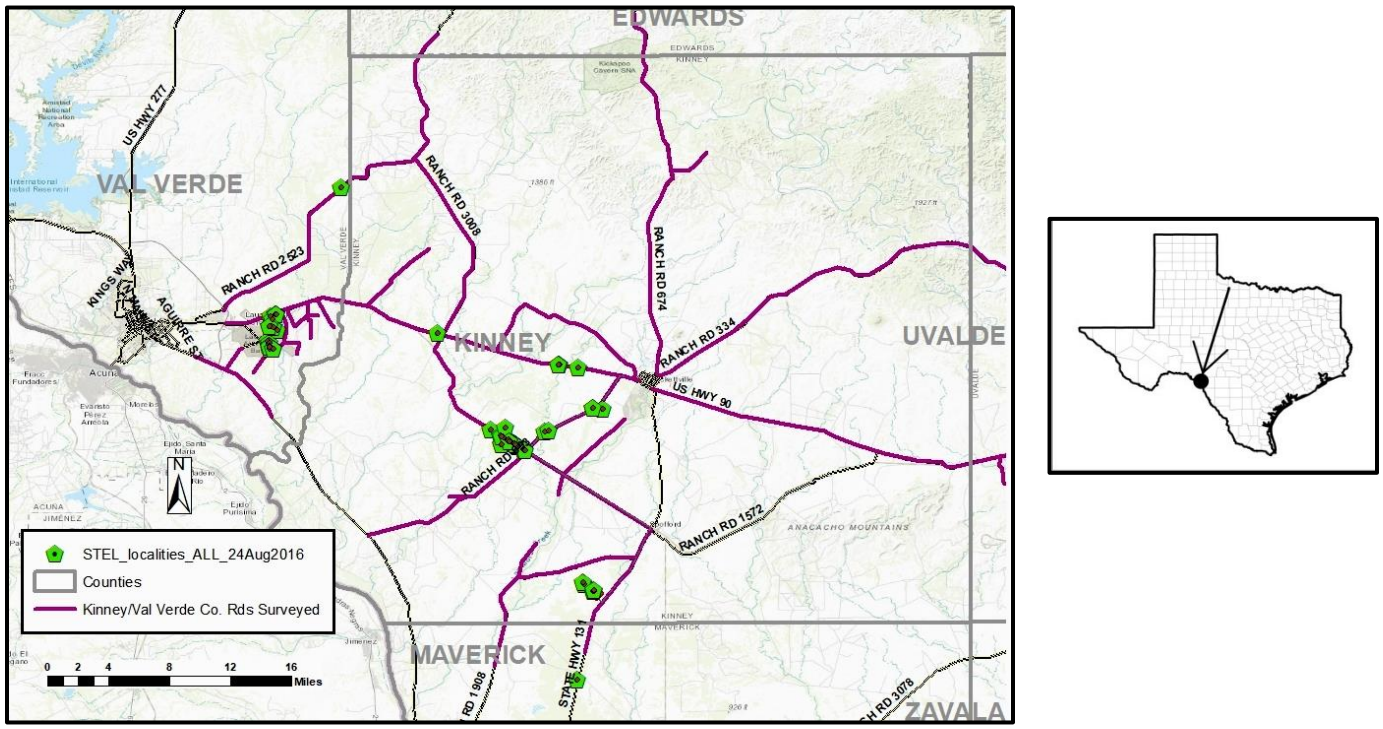


Figure 32. (Site ID # 25). Mitchell and Howard Co STEL road surveys (6/8-9/16) with historical STEL localities.

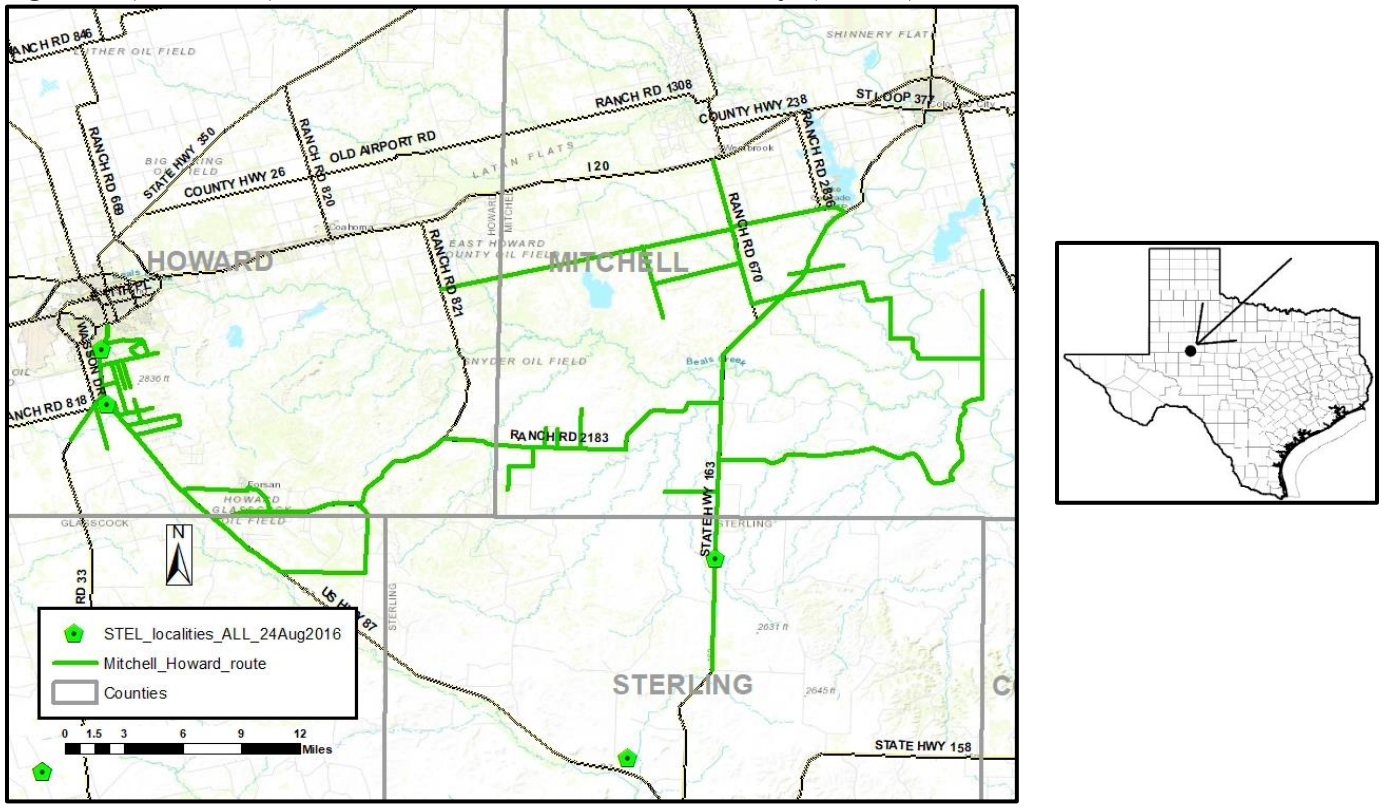


Figure 33. (Site ID # 26). Upton, Midland, Reagan, Glasscock Co. road surveys (6/9-10/16) with historical and current STEL localities

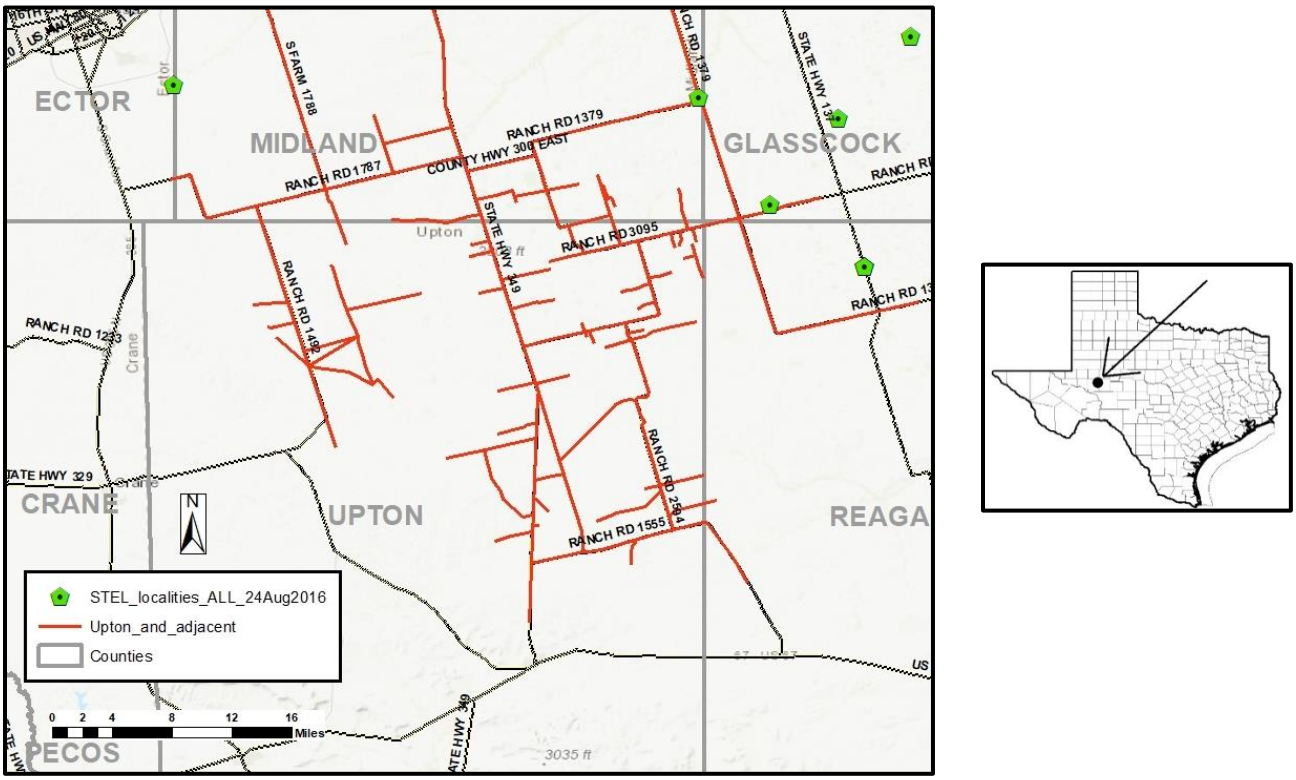


Figure 34. (Site ID # 26). Spot-tailed Earless Lizard – Observed in Glasscock Co. during road cruising - 06/10/2016

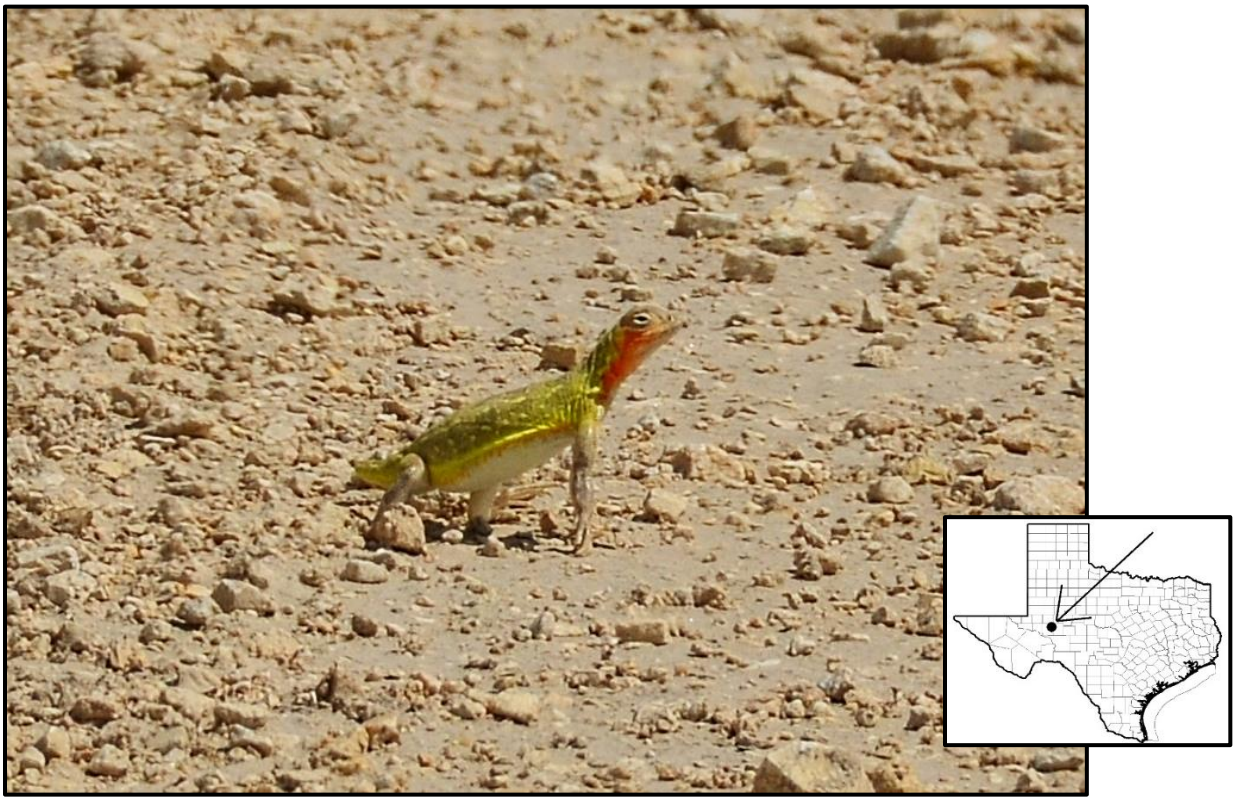
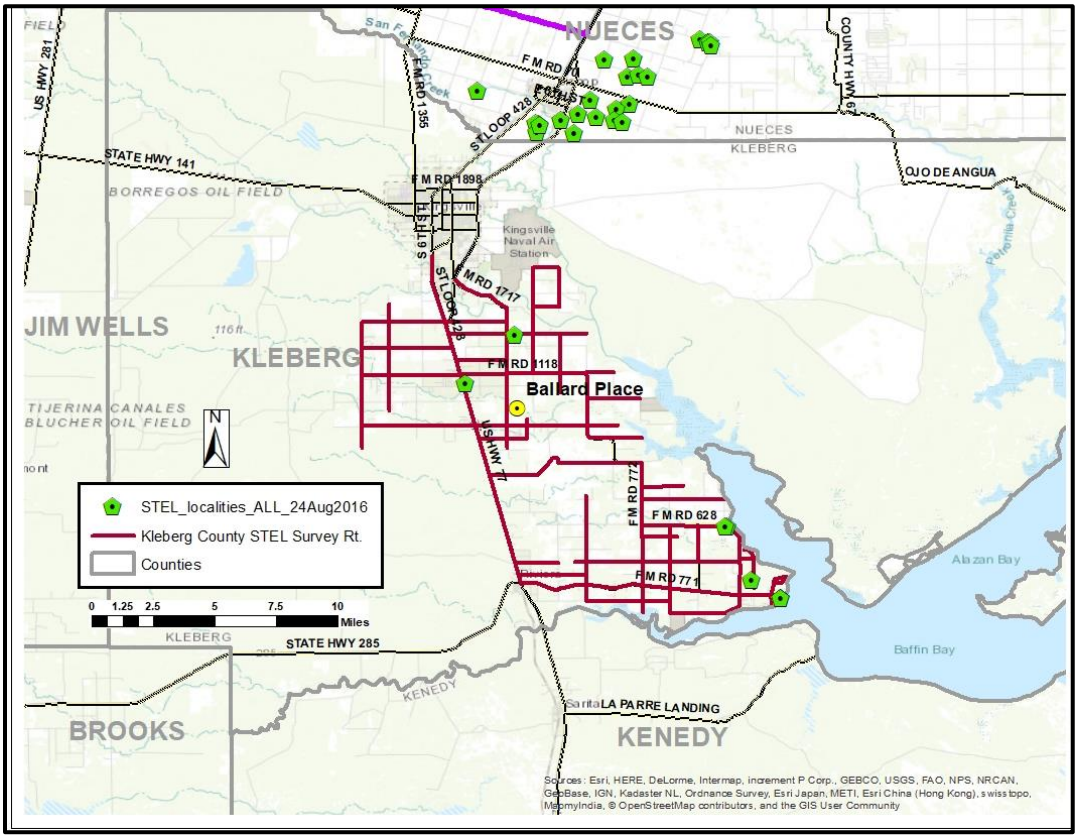
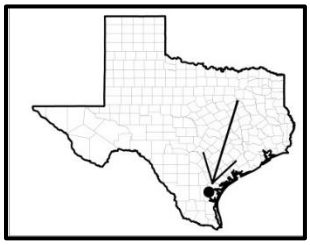


Figure 35. (Site ID # 27). Kleberg Co. STEL road surveys (3/28/17, 06/18-19/17) with recent and historical STEL localities.





APPENDICES

Appendix 1. Example of graphic representation of predictive habitat model from Duran and Axtell (2010)