Final Report

State Comptroller Contract

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prepared by

University of Texas at San Antonio

Biodiversity and Environmental Sustainability Laboratory

Principal Investigator

Janis K. Bush, PhD.

Table of Contents

Table of Tables

Table of Figures

Executive Summary and Recommendations

Roadside Surveys

- Species richness of native milkweed was eight; the most abundant native milkweeds were *Asclepias asperula, A. oenotheroides,* and *A. viridis*.
- There were some variations in milkweed abundance from year to year, however this did not correlate with precipitation; there was a greater abundance of milkweed in the spring than fall.
- *Asclepias asperula* was the most abundant species of native milkweed, occurring in 49% of the sites that had at least one milkweed present (spring sampling); the highest abundance was in the Edward's Plateau Ecoregion.
- *Asclepias viridis* was the second most abundant, with the greatest abundance in east Texas.
- Very little native milkweed was found in the South Texas Plains Ecoregion, south of San Antonio.
- Very few eggs or larvae were found on the milkweed. Additionally, very little of the milkweed showed herbivory damage.
- Only 2% of the quadrats sampled had fire ant mounds.
- More nectaring plants were found in the spring than the fall; the number of blooms varied from year to year.
- We recommend:
    - ✓ a continuation of the north/south and South Texas Ecoregion roadside sampling; three years of sampling does not produce enough variability and sample size in independent variables to determine which of the variables control the abundance of milkweed.
    - ✓ preparing a restoration plan for adding native milkweed in the South Texas Ecoregion, between San Antonio and Laredo.
    - ✓ adding more nectar plants to the landscape for the fall migration.
    - ✓ sampling of cardenolide concentration of milkweeds along roadsides to determine if levels may be restricting monarch egg laying.

Site Specific Surveys

- Abundance of native milkweed in the site specific surveys varied dramatically from year to year; species richness was five.
- The greatest abundance of native milkweed (*A. viridis*) was in the spring of 2016 in the Cross Timbers Ecoregion; the greatest abundance of native milkweed (*A. asperula*) in the fall of occurred in an ecotone between the Post Oak Savannah and the Blackland Prairies.
- We recommend:
  - ✓ Drawing conclusions regarding soil and management effects on milkweed can only be done through site specific sampling because roadsides have disturbance to soil composition, and management along roadsides are similar due to past road construction and similar management.
  - ✓ If funding is available, more site specific samples should be added and monitored over a longer period of time.

Seed Viability and Germination Experiments

- Viabilities of five native Texas milkweeds and one non-native (*A. curassavica*) were greater than 85%.
- Germination of *A. asperula* and *A. tuberosa* was greater than 70% without the use of any treatment to break dormancy. *Asclepias speciosa* dormancy was broken by gibberellic acid and sulfuric acid. *Asclepias viridis* and *A. incarnata* did not respond to treatments and had less than 20% germination.

Greenhouse Experiments

Response to light.

- Native Texas milkweeds *A. asperula, A. incarnata, A. oenotheroides, A. tuberosa*, *A. viridis* had photosynthetic characteristics of heliophytes.
- *Asclepias syriaca* had characteristics more similar to an intermediate between a sciophyte and heliophyte.
- The non-native *A. curassavica* had photosynthetic charactheristics of a heliophyte.

Predatory relationships between red-imported fire ants and monarchs.

- Survival of monarch eggs was 100% when offered to red-imported fire ants.
- During independent trials, no differences were found in survival (12 – 50%) between the survival of first through fifth instars when exposed to red-imported ants.
- Twenty-five percent of monarch chrysalis survived when offered to red-imported fire-ants.
- Fifty-five percent and forty-three percent of crickets and mealworms, respectively, survived.
- When fire-ants were offered a choice between third instar monarch larvae, crickets, and mealworms the fire-ants consumed the crickets first (0% survived), mealworms second (< 1% survived), and then the monarch larvae (48%) survived.
- We recommend:
  - ✓ Bringing together interested parties to determine successful propagation techniques of native Texas milkweeds.
  - ✓ Focusing restoration in high light environments.

Field Experiments

Best Management Experiment One

- One year following treatment, more milkweed stems were found in the prescribed burn and grazing treatments, followed by the mowing treatment. The control had the fewest number of stems.
- Twenty months after treatments, there were no effects of the best management practices on the number of milkweed stems.
- No differences were found in the number of eggs or larvae between the various best management practices.

Best Management Experiment Two

- The greatest number of milkweed stems were found six months post treatment when mowing occurred in the winter.

- There were no differences in the number of milkweed stems in the control, summer burn, winter burn, spring mow, summer mow, or fall mow.
- Twelve months after treatments, there were no effects of the best management practices on the number of milkweed stems.

Milkweed Patch Size Dynamics

Milkweed Density

- No differences were found in the number of eggs or any larvae as the density of milkweed increased from one to sixteen/16 m^2.
- The greatest number of eggs were found on March 28.

Milkweed spacing

- No differences were found in the number of eggs or any larval stage as the distance between milkweed plants increased from 0.5 to 2.5 meters.

Nectar Density Experiment One

- Significantly more eggs (6 eggs/plant) were laid on milkweed in a dense stand (53 blooms/0.1 m^2 of *Lupinus texensis* (Texas bluebonnet) than in an open area with one nectar plant (1 egg/plant) or without any nectar plants (1 egg/plant).
- On average, milkweed in the bluebonnet patch produced two 5^{th} instar/plant, while the other two treatments produced less than one instar per plant.

Nectar Density Experiments Two and Three

- No differences were found in egg laying or instar development as a function of nectar density (0.16 to 3 nectar plants/m^2)

- We recommend
  - ✓ Using winter prescribed burns, mowing, or cattle grazing to increase the number of milkweed stems on the landscape; however the cattle should be removed from January – May.
  - ✓ The treatments should be repeated annually.

- ✓ Adding milkweed seeds to seed mixes used by TxDOT. Data suggest that greater reproduction of monarchs will occur in high density of nectaring plants (> 50 blooms/0.1 m^2)

Outreach

- We completed over 60 outreach activities.

Introduction

Based on the population estimates in overwintering sites, monarch butterflies are on the decline (Brower et al., 2012). It has been suggested that forest degradation, loss of breeding habitat in the United States, and extreme weather are leading causes of this decline (see Brower et al., 2012). Of these factors, only loss of breeding habitat can be mitigated in Texas. However, only anecdotal evidence is currently available regarding changes in monarch populations and/or their primary food source (milkweed) within the State of Texas. In order to better manage for monarch butterflies in the State of Texas, more research is needed on both the monarch butterflies and milkweed.

Surveys, greenhouse experiments, and field experiments were used to 1) describe the habitat of milkweed populations and nectar availability in several ecoregions in Texas, 2) determine seed viability, germination, and growth requirements for the native Texas milkweed species, 4) evaluate the predation of red-imported fire ant (*Solenopsis invicta*) on monarch butterflies, 5) examine the effects of milkweed density and spacing on monarch reproduction, 6) determine the role of nectar density on monarch reproduction, and 7) evaluate the effects of best management practices on milkweed and monarch butterfly eggs and larvae. Additionally, we delivered monarch and milkweed curriculum to the greater San Antonio community, although this was not funded by the contract.

Task 1 – Roadside Surveys

Methods

Site Selection.

In order to accurately compare to the only quantitative published work of milkweed abundance in Texas, we choose to re-sample a cross-Texas east to west transect from Pineland (31° 41' N, 93° 58' W) to Ozona (30° 42' N, 101° 12' W) (Calvert, 1999). However, to provide a more comprehensive assessment of the State’s milkweed population three additional transects were included. One transect running 744 km (462 miles) north to south from Wichita Falls (33° 54' N, 98° 29' W) to Alice (27° 45' N, 98° 29' W), a second 360 km (224 miles) from Del Rio (29° 22' N, 100° 47' W) to Alice, and a third 225 km (140 miles) from San Antonio (29° 16' N, 98° 41' W) to Laredo (27° 37' N, 99° 29' W) (Figure 1). These transects followed along a mix of interstates, highways, county, and farm-to-market roads to provide adequate coverage of the State, and a diversity to the types of rights-of-ways sampled.

Sampling stops or “sites” were identified every 16 km (10 miles) whether milkweed was observed or not; however, when large urban areas or regions of significant road construction were encountered they were bypassed due to the disturbance. The order and timing in which transects were surveyed during both the fall and spring migration was based on Journey North reports of the monarch’s peak migration in Texas and conducted in the fall of 2015, 2016, and 2017 between October 10 and November 21 and in the spring of 2016, 2017, and 2018 from March 24 and April 24. During the fall migration we started in the north and moved southward, and during the spring migration we started in south and move northward, following the migrations.

Survey Design.

For each roadside site, we sampled a transect 25 m long using contiguous 1 m^2 quadrats. The sample size (n = 25) was determined by initial sample adequacy curves. Upon arrival at each site, the start of each transect was placed in the center of the roadside between the fence line and the road. The transect line was established 25 m from a random starting point parallel to the road. In each quadrat we recorded the number of milkweed individuals and stems, the species of each milkweed plant, the number of monarch eggs, number of and stage of monarch larvae. Global Positioning System (GPS) coordinates of each site were also recorded along with sightings of adult monarchs. We also recorded the presence or absence of red-imported fire ant (*Solenopsis invicta*) mounds, estimated the percent cover of herbaceous and other ground cover variables (i.e. rock, soil, and litter), and counted the number of blooms of nectaring plants.

Two additional 25 m transects were established from each distal end of the 25 1 m^2 quadrats and sampled using a line-point transect to provide additional information on site characteristics. Each sampling point along these two transects were spaced 1 m apart and sampled for presence of milkweed. Finally, the area between the road, fence line (width restricted to 10 m), and the ends of the full transect (75 m) were also sampled to determine the total number of milkweed individuals and stems, number of milkweed species, number of monarch eggs, and the number and stage of monarch larvae present at the site.

For this report, we only present the number of monarch eggs, number and stage of monarch larvae because of the low number observed. For milkweed information, we present the following:

$$\textit{Average Total number of milkweed stems per year for a given species} = \frac{\textit{Total number of stems for a given species}}{\textit{3 years}}$$

$$\textit{Mean number of sites where a milkweed species was found over the three years} = \frac{\sum_{i=1}^{T} \textit{Number of sites where a species was present for i year}}{\textit{3 years}}$$

$$\textit{Mean frequency for a given milkweed species over the three years} = \sum_{i=1}^{T} \frac{\textit{Number of sites where a given species was present for i year}}{\textit{Number of sites for that year}} \; x\ 100 \Big/ \textit{3 years}$$

$$\textit{Mean relative frequency for a given milkweed species over the three years} = \frac{\textit{Individual species frequency}}{\textit{Sum of individual species frequencies}} \; x\ 100 \Big/ \textit{3 years}$$

$$\boldsymbol{Mean\ Stem\ Density}\ (\#/\boldsymbol{m^2})\boldsymbol{over\ the\ three\ years} = \sum_{i=1}^{T} \frac{\#\ of\ stems\ of\ given\ species\ for\ i\ year}{total\ number\ of\ 1\ m^2\ quadrats\ with\ the\ given\ species\ for\ i\ year} / 3\ years$$

where T = the total number of years (3)

i = the number in a given year.

For each species of milkweed, we describe the average cover (percents of soil, rock, litter, grass, and herbaceous); and the average soil depth. We also a qualitative measure disturbance of the site ranging from 1 (no disturbance) to 5 (complete disturbance). We also measured herbivory damage to milkweed ranging from 1 (no damage) to 5 (no leaves remaining).

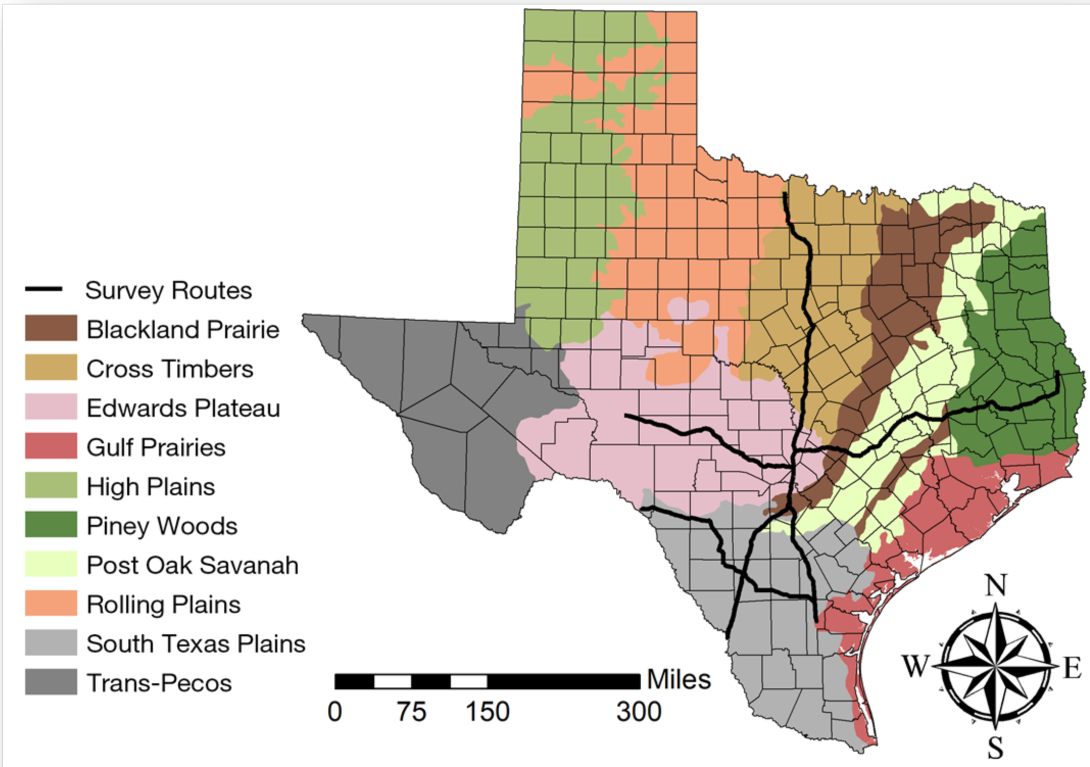

Figure 1. Maps of roadside surveys.

Results

Table 1. Total number of sites and percent of sites sampled by Texas ecoregion during the spring of 2016, 2017, and 2018, as well as the mean and standard deviation of percent of sites with at least one species of *Asclepias* averaged over the three years.

Spring 16 - 18 Texas Ecoregions	# of sites sampled	% of sites sampled	% of sites with *Asclepias* (milkweed)
Blackland Prairies	3	1	33 ± 58
Cross Timbers	73	22	51 ± 15
Edwards Plateau	87	26	60 ± 16
Piney Woods	38	12	66 ± 25
Post Oak Savannah	30	9	36 ± 12
Rolling Plains	3	1	33 ± 58
South Texas Plains	104	31	25 ± 24

Table 2. Mean and standard errors of total number of milkweed stems, number of sites where present, frequency of sites, relative frequency, and the mean stem density averaged over year by species along all cross-Texas transects during the spring of 2016, 2017, and 2018.

Asclepias (milkweed) Species	# of milkweed stems	# of sites where present	Frequency (% of sites where present)	Relative Frequency (% occurrence in sites with at least one milkweed plant)	Milkweed stem density when present(stems/m^2)
A. asperula	2,705 ± 428	30 ± 2	27 ± 0*	49 ± 8	0.1200 ± 0.0259
A. emoryii	6 ± 6	1 ± 1	1 ± 1	2 ± 2	0.0020 ± 0.0020
A. latifolia	3 ± 3	1 ± 1	1 ± 1	1 ± 1	0.0013 ± 0.0013
A. linearis	3 ± 2	1 ± 1	1 ± 1	1 ± 1	0.0115 ± 0.0017
A. oenotheroides	102 ± 31	13 ± 5	11 ± 4	19 ± 6	0.0013 ± 0.0015
A. verticillata	2 ± 2	1 ± 1	1 ± 1	1 ± 1	0.0026 ± 0.0013
A. viridiflora	7 ± 4	2 ± 1	2 ± 1	3 ± 2	0.0067 ± 0.0014
A. viridis	291 ± 50	15 ± 3	13 ± 2	23 ± 3	0.0269 ± 0.0036

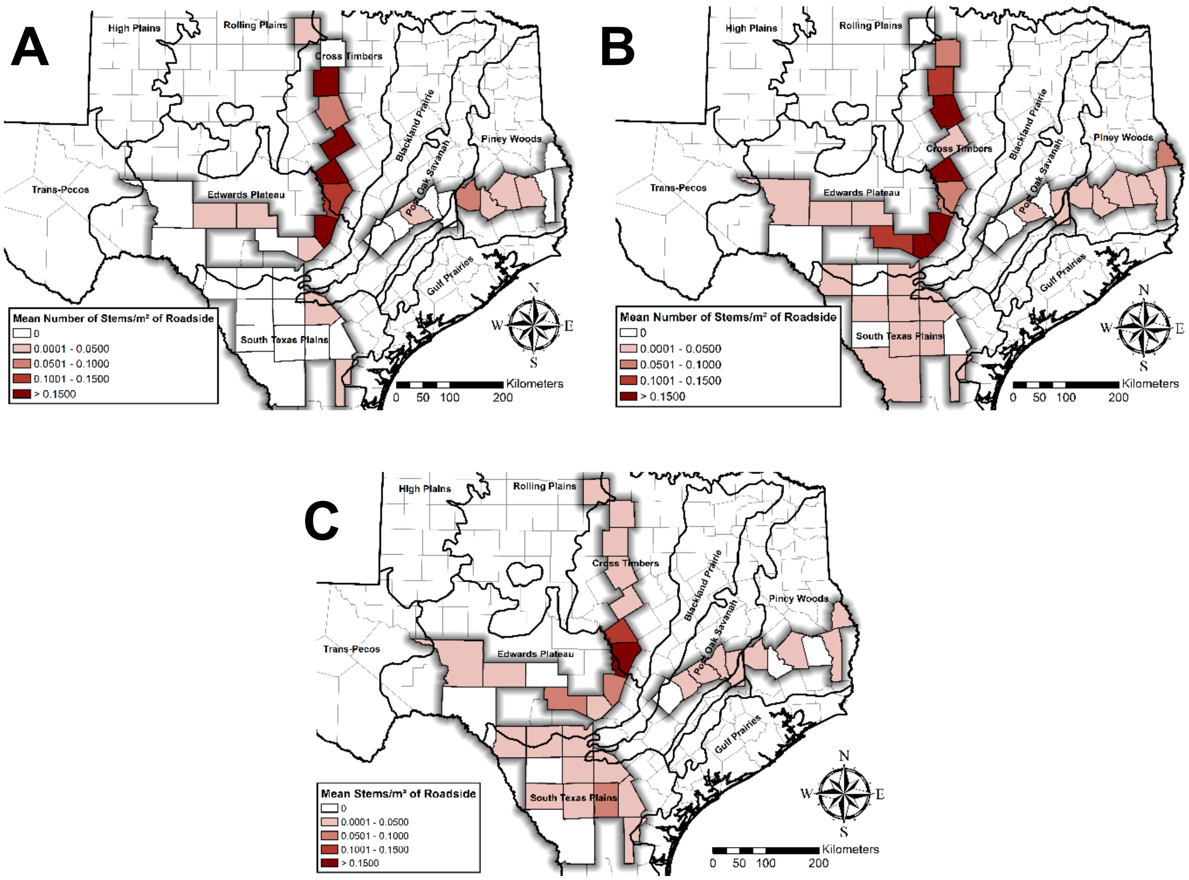

Figure 2. Density (stems/m^2) of *Asclepias* species in the spring of A) 2016, B) 2017, and C) 2018 from east to west (Pineland to Ozona, Texas) and from north to south (Wichita Falls to Alice, Texas), and in areas of south Texas between San Antonio and Laredo, Texas. Counties sampled have shaded outlines.

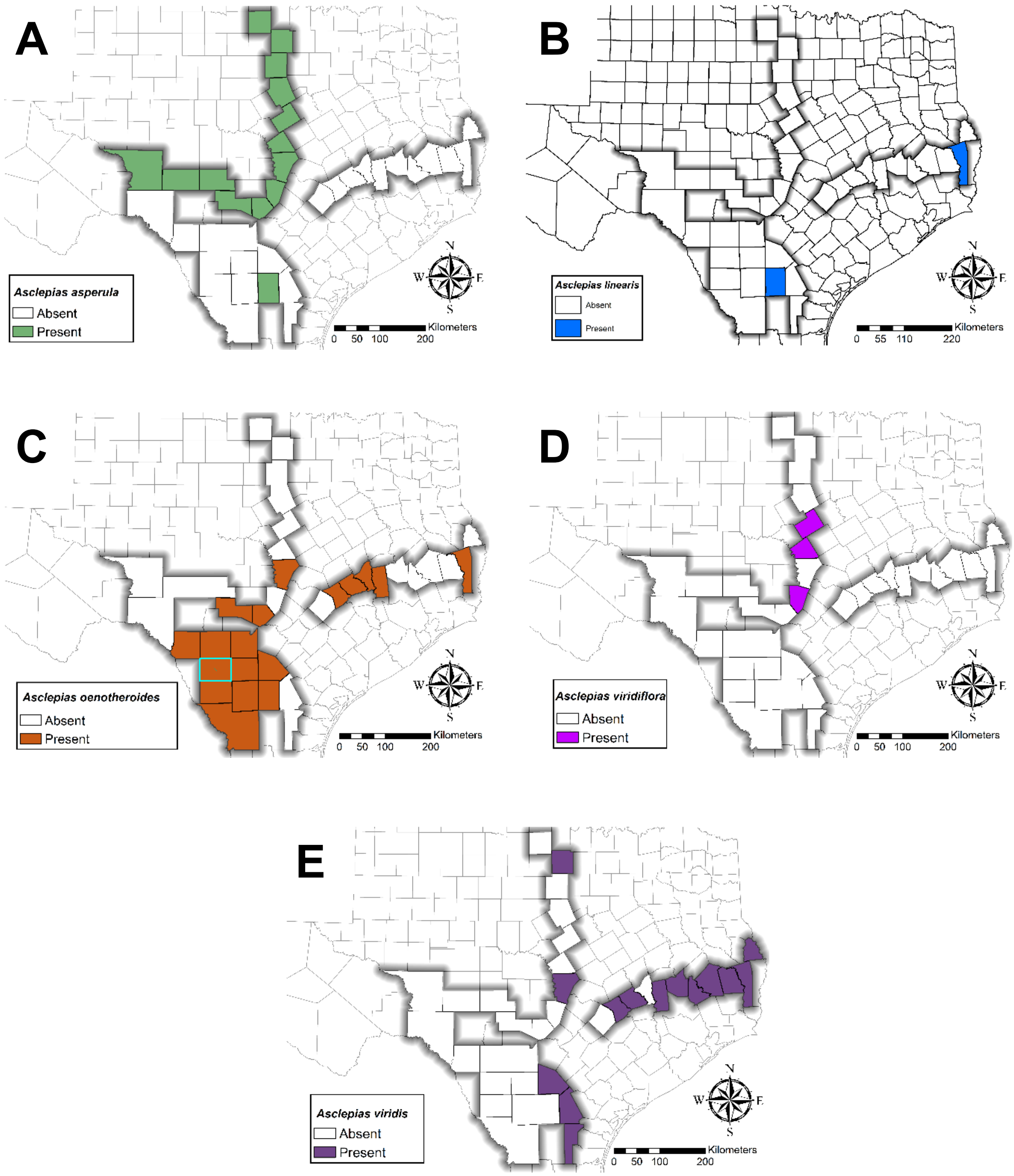

Figure 3. Presence and absence over all years during the spring for A) *Asclepias asperula*, B) *A. linearis,* C) *A. oenotheroides*, D) *A. viridiflora*, and E) *A. viridis* from east to west (Pineland to Ozona, Texas) and from north to south (Wichita Falls to Alice, Texas), and in areas of south Texas between San Antonio and Laredo, Texas. Counties sampled have shaded outlines.

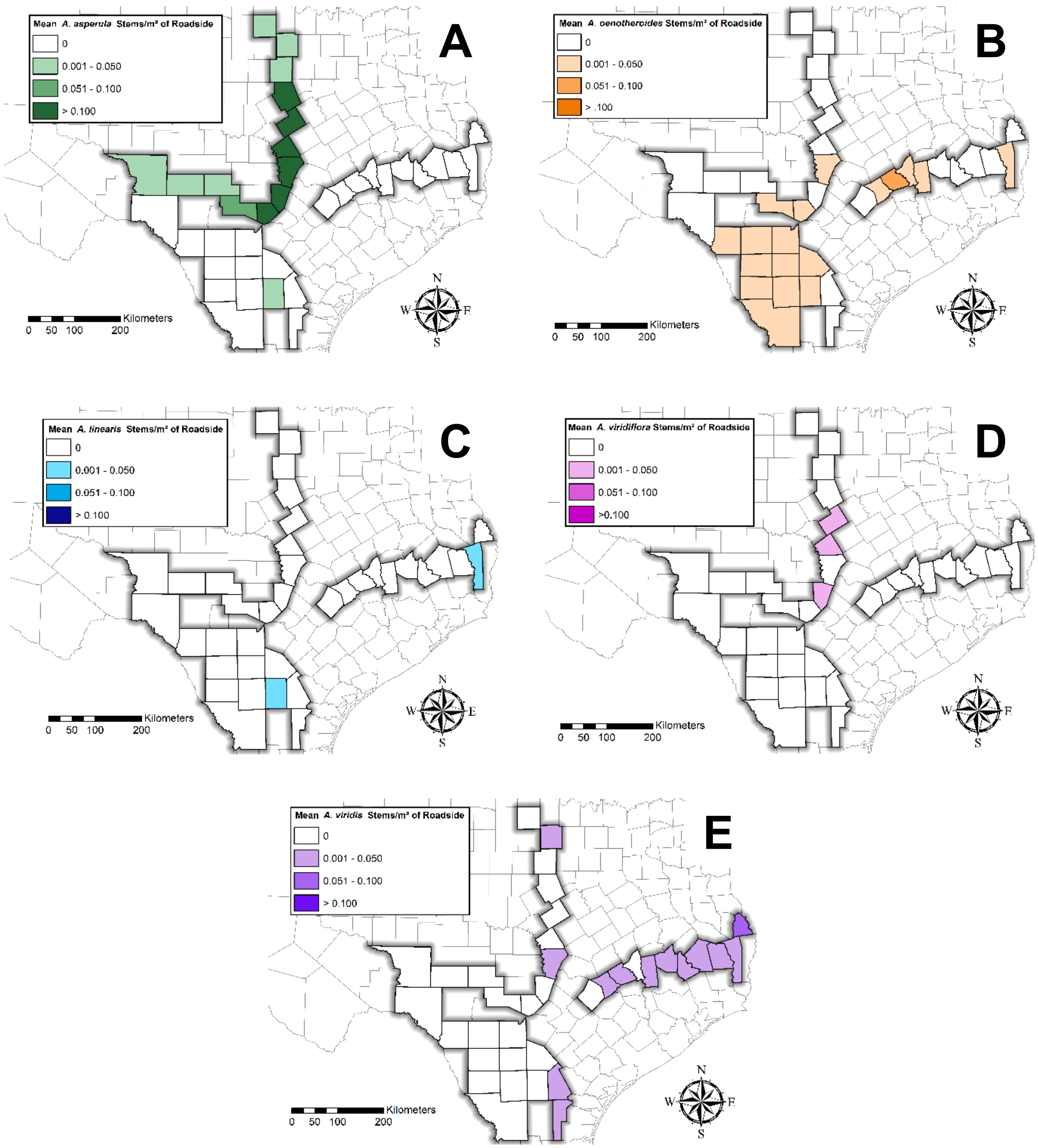

Figure 4. Mean density (stems/m^2; averaged over year) for spring of A) *Asclepias asperula* , B) *A. oenotheroides*, C) *A. linearis,* D) *A. viridiflora,* and E) *A. viridis* from east to west (Pineland to Ozona, Texas) and from north to south (Wichita Falls to Alice, Texas), and in areas of south Texas between San Antonio and Laredo, Texas. Counties sampled have shaded outlines.

Table 3. Total number of stems, number of sites where present, frequency of sites, relative frequency, and the stem density by species along all cross-Texas transects during the spring of 2016.

Milkweed Species	# of stems	# of sites where present	Frequency (% of sites where present)	Relative Frequency (% occurrence in transects with at least one milkweed plant)	Mean stem density ± SE (when present, plants/m^2)
A. asperula	1,021	16	36	64	0.106 ± 0.047
A. viridis	890	15	34	60	0.099 ± 0.022
A. viridiflora	48	8	18	32	0.010 ± 0.004
A. oenotheroides	13	2	5	8	0.0118 ± 0.004

Table 4. Total number of stems, number of sites where present, frequency of sites, relative frequency, and the stem density by species along all cross-Texas transects during the spring of 2017.

Milkweed Species	# of stems	# of sites where present	Frequency (% of sites where present)	Relative Frequency (% occurrence in transects with at least one milkweed plant)	Mean stem density ± SE (when present, plants/m^2)
A. asperula	988	20	45	83	0.082 ± 0.021
A. viridis	616	12	27	50	0.086 ± 0.024
A. viridiflora	56	6	14	25	0.016 ± 0.005
A. oenotheroides	3	1	2	4	0.005 ± 0.000

Table 5. Total number of stems, number of sites where present, frequency of sites, relative frequency, and the stem density by species along all cross-Texas transects during the spring of 2018.

Milkweed Species	# of stems	# of sites where present	Frequency (% of sites where present)	Relative Frequency (% occurrence in transects with at least one milkweed plant)	Mean stem density ± SE (when present, plants/m^2)
A. asperula	1,649	11	25	42	0.250 ± 0.080
A. viridis	645	8	18	31	0.134 ± 0.041
A. viridiflora	22	3	7	12	0.012 ± 0.005
A. oenotheroides	102	3	7	12	0.057 ± 0.048
A. latifolia	38	1	2	4	0.063 ± 0.000

Table 6. Total number of sites and percent of sites sampled by Texas ecoregion during the fall of 2105, 2016, and 2017, as well as the mean and standard deviation of percent of sites with at least one species of *Asclepias* averaged over the three years.

Texas Ecoregions	# of sites sampled	% of sites sampled	% of sites with *Asclepias* (milkweed)
Cross Timbers	57	17	46 ± 9
Edwards Plateau	84	25	43 ± 3
Gulf Prairies	6	2	17 ± 17
Piney Woods	43	13	18 ± 11
Post Oak Savanna	43	13	18 ± 6
Rolling Plains	9	3	11 ± 11
South Texas Plains	98	29	12 ± 4

Table 7. Mean and standard errors of total number of milkweed stems, number of sites where present, frequency of sites, relative frequency, and the mean stem density averaged over year by species along all cross-Texas transects during the fall of 2015, 2016, and 2017.

Asclepias (milkweed) Species	# of milkweed stems	# of sites where present	Frequency (% of sites where present)	Relative Frequency (% occurrence in sites with at least one milkweed plant)	Milkweed stem density when present (stems/m^2)
A. asperula	216 ± 38	16 ± 1	15 ± 0	60 ± 11	0.018 ± 0.004
A. viridis	44 ± 12	8 ± 2	7 ± 2	25 ± 1	0.008 ± 0.002
A. oenotheroides	23 ± 10	6 ± 3	5 ± 3	16 ± 6	0.007 ± 0.001
A. emoryii	4 ± 2	2 ± 1	1 ± 1	5 ± 3	0.002 ± 0.002
A. verticillata	2 ± 1	1 ± 1	1 ± 1	4 ± 3	0.002 ± 0.001
A. latifolia	1 ± 1	0 ± 0	0 ± 0	1 ± 1	0.001 ± 0.001

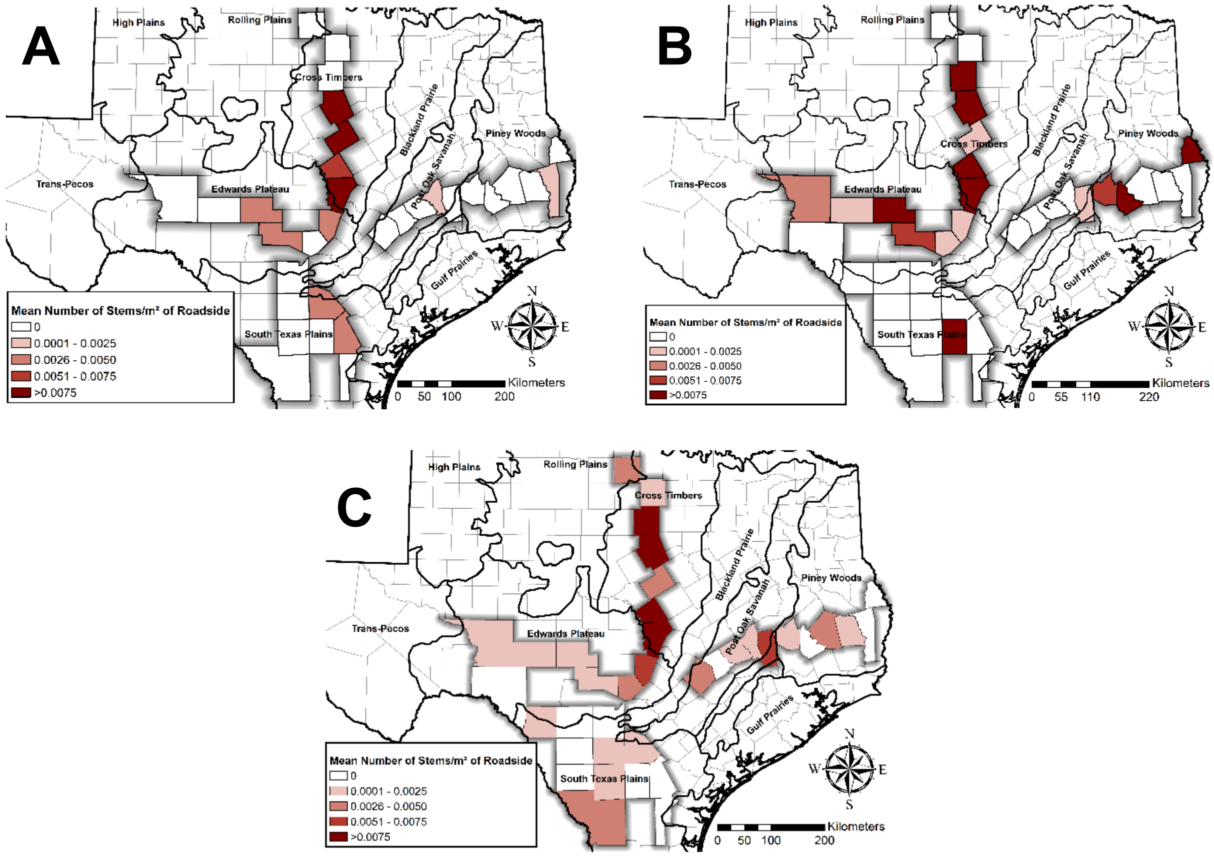

Figure 5. Density (stems/m^2) of *Asclepias* species in the fall of A) 2015, B) 2016, and C) 2017 from east to west (Pineland to Ozona, Texas) and from north to south (Wichita Falls to Alice, Texas), and in areas of south Texas between San Antonio and Laredo, Texas. Counties sampled have shaded outlines.

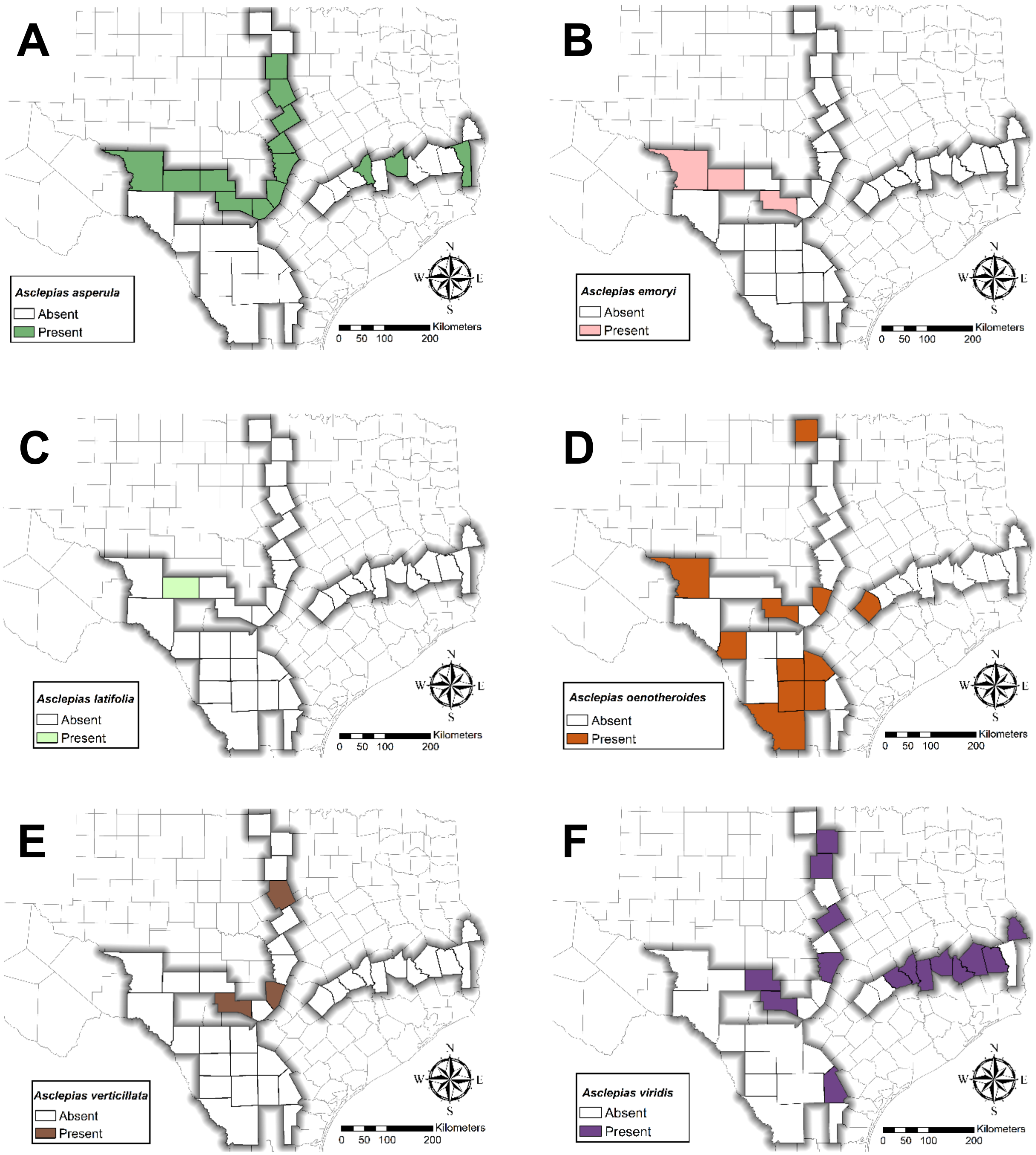

Figure 6. Presence and absence over all years during the fall for A) *Asclepias asperula*, B) *A. emoryi,* C) *A. latifolia,* D) *A. oenotheroides*, E) *A. verticillata*, and F) *A. viridis* from east to west (Pineland to Ozona, Texas) and from north to south (Wichita Falls to Alice, Texas), and in areas of south Texas between San Antonio and Laredo, Texas. Counties sampled have shaded outlines.

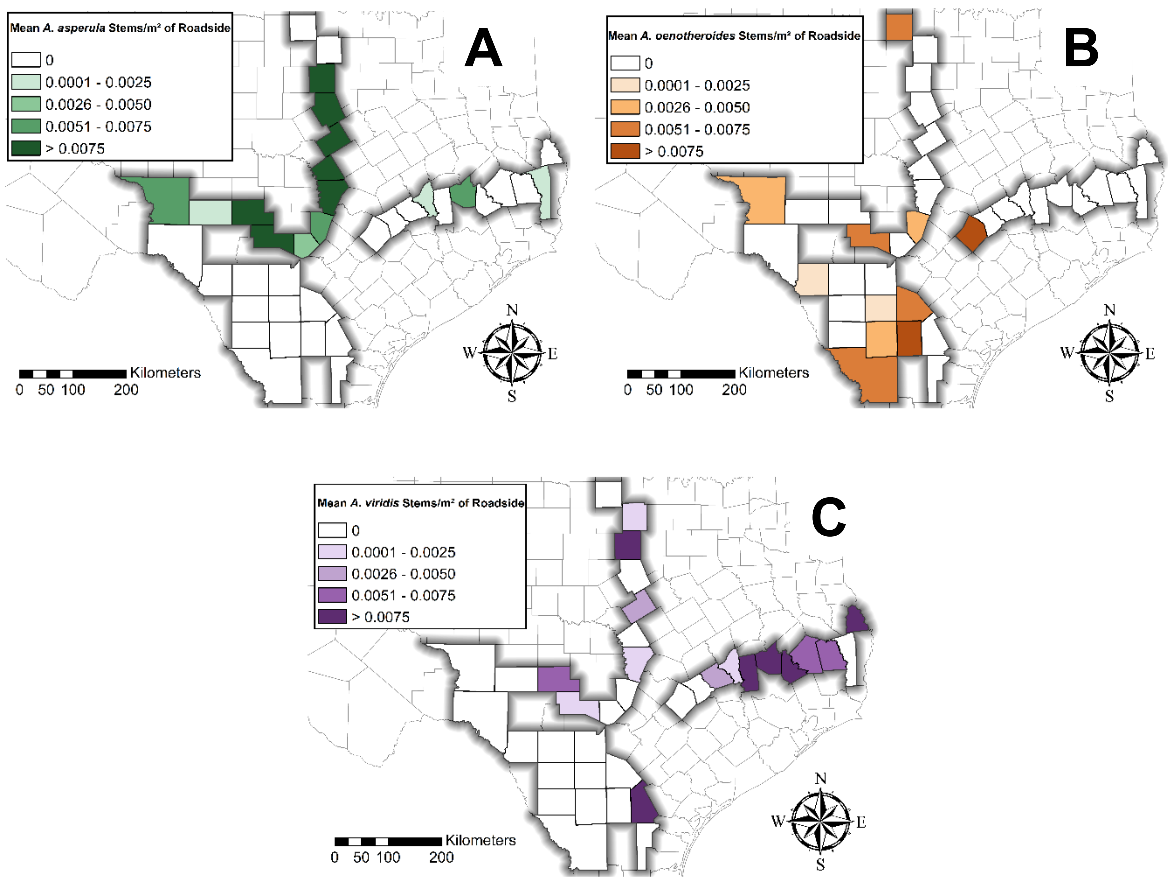

Figure 7. Mean density (stems/m^2; averaged over year) for fall of A) *Asclepias asperula*, B) *A. oenotheroides*, and C) *A. viridis* from east to west (Pineland to Ozona, Texas) and from north to south (Wichita Falls to Alice, Texas), and in areas of south Texas between San Antonio and Laredo, Texas. Counties sampled have shaded outlines.

Table 8. Total number of milkweed stems, number of sites where present, frequency of sites, relative frequency, and the stem density by species along all cross-Texas transects during the fall of 2016.

Milkweed Species	# of milkweed stems	# of sites where present	Frequency (% of sites where present)	Relative Frequency (% occurrence in transects with at least one milkweed plant)	Milkweed stem density ± SE (when present, plants/m^2)
A. asperula	9	4	9	50	0.004 ± 0.002
A. viridis	9	3	7	38	0.005 ± 0.001
A. viridiflora	1	1	2	12	0.002 ± 0.000
A. oenotheroides	1	1	2	13	0.002 ± 0.000

Table 9. Total number of milkweed stems, number of sites where present, frequency of sites, relative frequency, and the stem density by species along all cross-Texas transects during the fall of 2017.

Milkweed Species	# of milkweed stems	# of sites where present	Frequency (% of sites where present)	Relative Frequency (% occurrence in transects with at least one milkweed plant)	Milkweed stem density ± SE (when present, plants/m^2)
A. asperula	143	9	33	56	0.027 ± 0.180
A. viridis	73	4	15	25	0.030 ± 0.011
A. oenotheroides	4	3	11	19	0.002 ± 0.001

Table 10. Mean blooms per m^2 of nectaring plants for the fall and spring from fall 2016 through spring 2018 averaged over years.

Season	Blooms/m^2
Fall	3 ± 0
Spring	19 ± 11

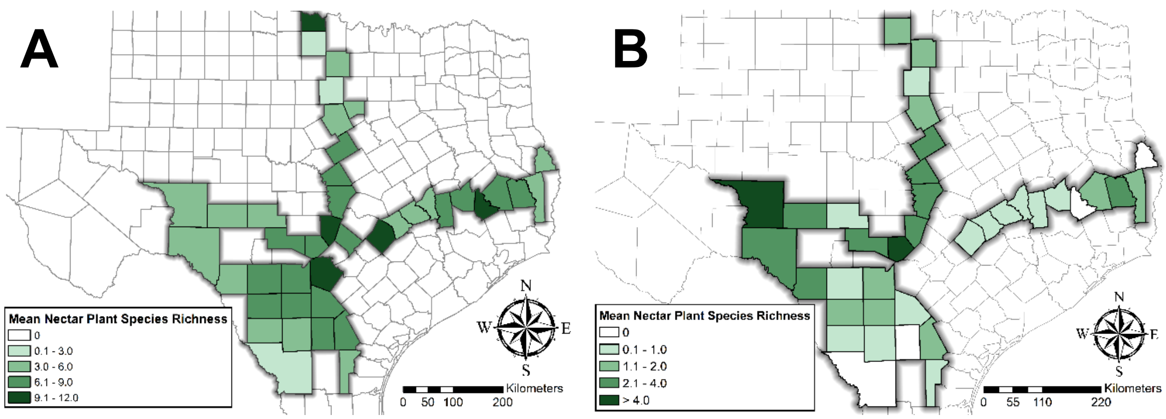

Figure 8. Mean species richness of nectaring plants (averaged over years) for A) spring (2017 and 2018) and B) fall (2016 and 2017) from east to west (Pineland to Ozona, Texas) and from north to south (Wichita Falls to Alice, Texas), and in areas of south Texas between San Antonio and Laredo, Texas. Note the different scales.

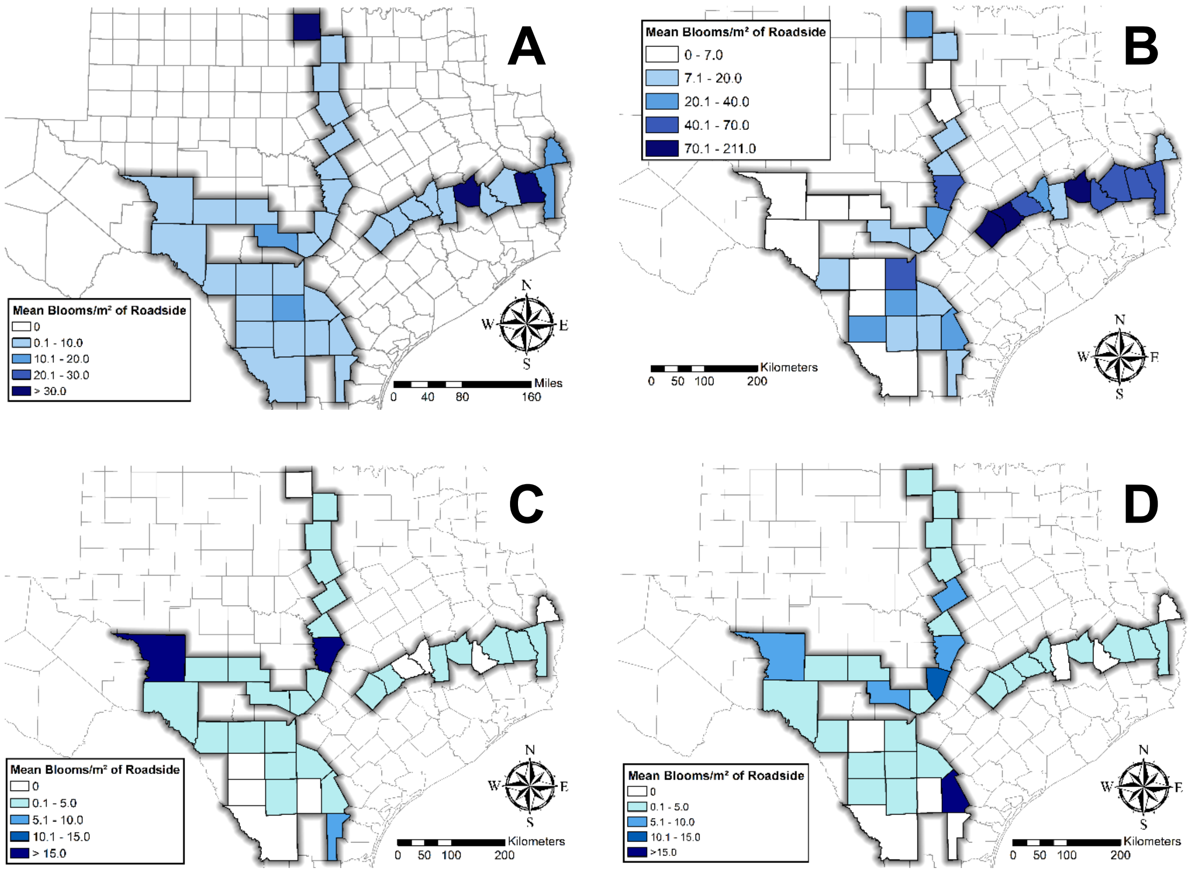

Figure 9. Blooms/m^2 of roadside for nectaring plants for A) spring 2017, B) spring 2018, C) fall 2016, and D) fall 2017 from east to west (Pineland to Ozona, Texas) and from north to south (Wichita Falls to Alice, Texas), and in areas of south Texas between San Antonio and Laredo, Texas. Note the different scales.

Table 11. Site and vegetation description of cover (soil, rock, litter, grass, herbaceous), level of disturbance, and soil depth for spring surveys by *Asclepias* species averaged over years.

Species of *Asclepias* (N)	Soil (%)	Rock (%)	Litter (%)	Grass (%)	Herbaceous (%)	Level of Disturbance*	Soil Depth (cm)
A. asperula (864)	6 ± 9	5 ± 12	11 ± 9	42 ± 21	27 ± 20	3 ± 1	15 ± 7
A. emoryii (1)	3	43	11	37	6	3	5
A. latifolia (2)	6 ± 1	47 ± 6	20 ± 16	23 ± 23	5 ± 2	3 ± 0	5 ± 0
A. linearis (3)	32 ± 13	0 ± 0	2 ± 0	0 ± 0	39 ± 4	3 ± 1	
A. oenotheroides (77)	8 ± 14	2 ± 7	37 ± 27	15 ± 24	21 ± 30	3 ± 0	18 ± 4
A. verticillata (2)	10 ± 8	39 ± 43	9 ± 6	37 ± 29	6 ± 0	3 ± 0	13 ± 11
A. viridflora (2)	1 ± 1	0 ± 0	26 ± 18	38 ± 54	16 ± 7	3 ± 1	10 ± 0
A. viridis (94)	5 ± 11	0 ± 2	12 ± 14	53 ± 19	28 ± 18	4 ±1	20 ± 1
None (8010)	12 ± 20	5 ± 14	16 ± 17	41 ± 26	23 ± 18	3 ± 1	18 ± 5

*Disturbance was a qualitative variable ranging from 0 (no disturbance) to 5 (most disturbed).

Table 12. Site and vegetation description of cover (soil, rock, litter, grass), level of disturbance, and soil depth for fall surveys by *Asclepias* species averaged over years.

Species of *Asclepias* (N)	**Soil (%)**	**Rock (%)**	**Litter (%)**	**Grass (%)**	**Level of Disturbance***	**Soil Depth (cm)**
***A. asperula* (180)**	11± 25	7 ± 15	17 ± 24	43 ± 11	4 ± 0	15 ± 6
***A. latifolia* (1)**	0	0	12	70	2	15
***A. oenotheroides* (12)**	4 ± 9	1 ± 3	26 ± 19	61 ± 21	3 ± 1	19 ± 2
***A. verticillata* (5)**	3 ± 9	0 ± 0	28 ± 40	61 ± 2	4 ± 1	18 ± 3
***A. viridis* (47)**	4 ± 6	2 ± 12	15 ± 12	52 ± 24	4 ± 0	19 ± 3
None (8306)	6 ± 12	5 ± 14	21 ± 21	54 ± 29	3 ± 1	18 ± 4

*Disturbance was a qualitative variable ranging from 0 (no disturbance) to 5 (most disturbed).

Table 13. Qualitative measure of monarch damage to milkweed.

Milkweed Species	Average Damage Ranked from 1 (no damage) to 5 (no leaves)					
	Spring			Fall		
	2016	2017	2018	2015	2016	2017
A. asperula	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	1.1 ± 0.2
A. emoryii	-	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	-	-
A. latifolia	-	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	-
A. linearis	-	-	1.0 ± 0.0	-	-	-
A. oenotheroides	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	1.3 ± 0.5
A. verticillata	-	1.0 ± 0.0	-	1.0 ± 0.0	-	1.0 ± 0.0
A. viridiflora	-	1.0 ± 0.0	-	-	-	-
A. viridis	1.0 ± 0.0	1.0 ± 0.0	1.2 ± 0.4	1.0 ± 0.0	1.0 ± 0.0	1.3 ± 0.5

Table 14. Percent of transects with fire ant mound and the average distance to the mound by season.

Number of Mounds	Average Distance to Mound	Percent of Quadrats with Mounds
Spring		
0	-	98.34%
1	0.69	1.36%
2	0.40	0.17%
3	0.33	0.10%
4	0.00	0.03%
Fall		
0	-	98.95%
1	0.58	0.87%
2	2.15	0.17%
3	0.3	0.02%

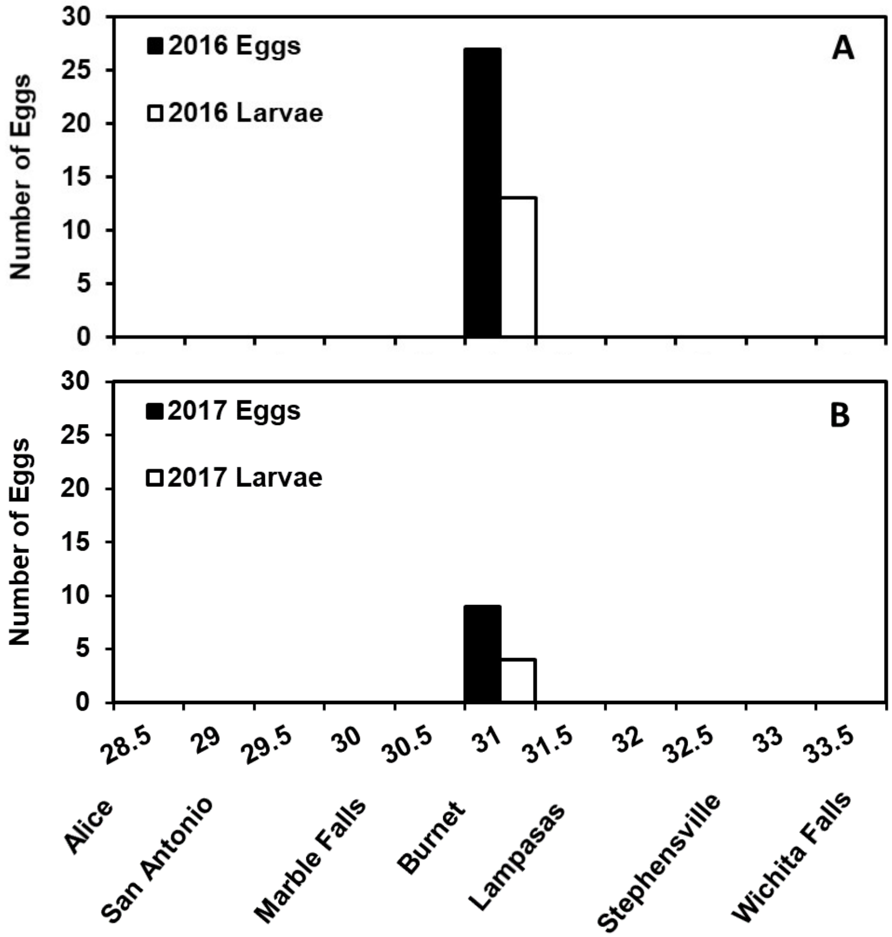

Figure 10. Total number of eggs and larvae found in south to north transects for spring 2016 and 2017. No eggs or larvae were found in the spring of 2018.

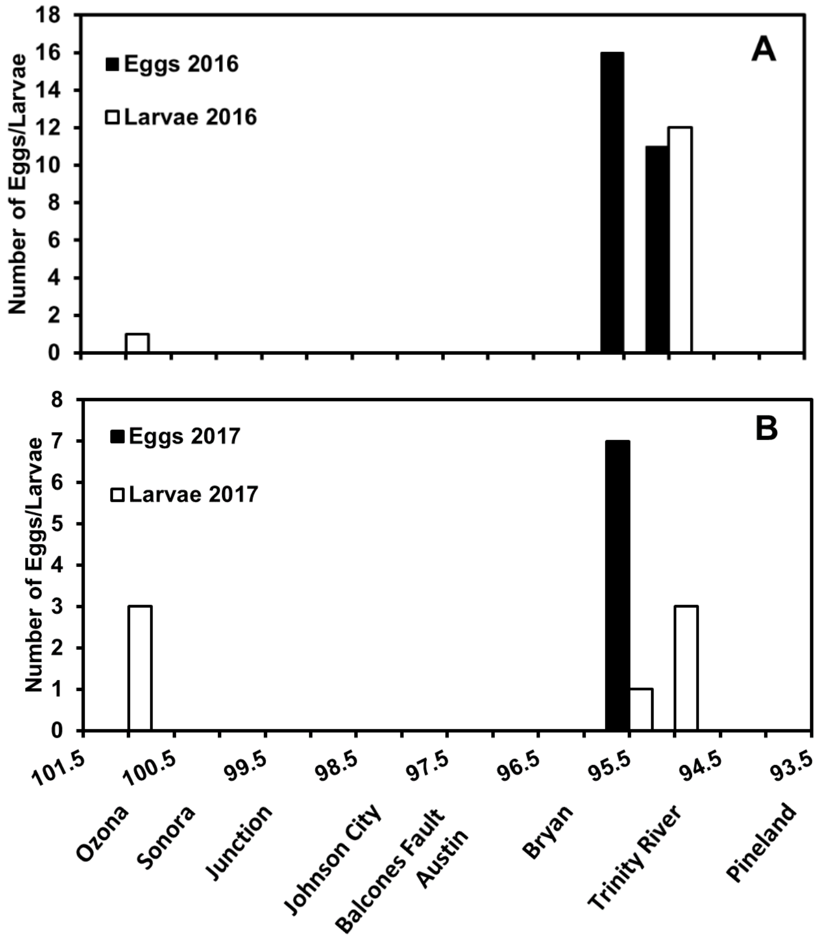

Figure 11. Total number of eggs and larvae found in west to east transects for spring 2016 and 2017. No eggs or larvae will found in the spring of 2018.

Task 2 – Site Specific Surveys

Methods

In addition to the roadside surveys, we sampled six site specific areas in the spring of 2016, 2017, and 2018; and the fall of 2016 and 2017 (Figure 12). Table 15 indicates the counties, ecoregion, soil types, management, and landuse of the sites. More details can be found in Appendix III– Site Specific Locations.

For each soil type and management type, we sampled a transect 25 m long using contiguous 1 m^2 quadrats. The sample size (n = 25) was determined by initial sample adequacy curves. The transect line was established 25 m from a random starting point parallel to the contour. In each quadrat we recorded the number of milkweed individuals and stems, the species of each milkweed plant, the number of monarch eggs, number of and stage of monarch larvae. Global Positioning System (GPS) coordinates of each site were also recorded along with sightings of adult monarchs. We also recorded the presence or absence of red-imported fire ant (*Solenopsis invicta*) mounds and estimated the percent cover of herbaceous and other ground cover variables (i.e. rock, soil, and litter), and counted the number of blooms of nectaring plants.

Two additional 25 m transects were established from each distal end of the 25 1 m^2 quadrats and sampled using a line-point transect to provide additional information on site characteristics. Each sampling point along these two transects were spaced 1 m apart and sampled for presence of milkweed. Finally, an area 10 m by 75 m was sampled to determine the total number of milkweed individuals and stems, number of milkweed species, number of monarch eggs, and the number and stage of monarch larvae present at the site.

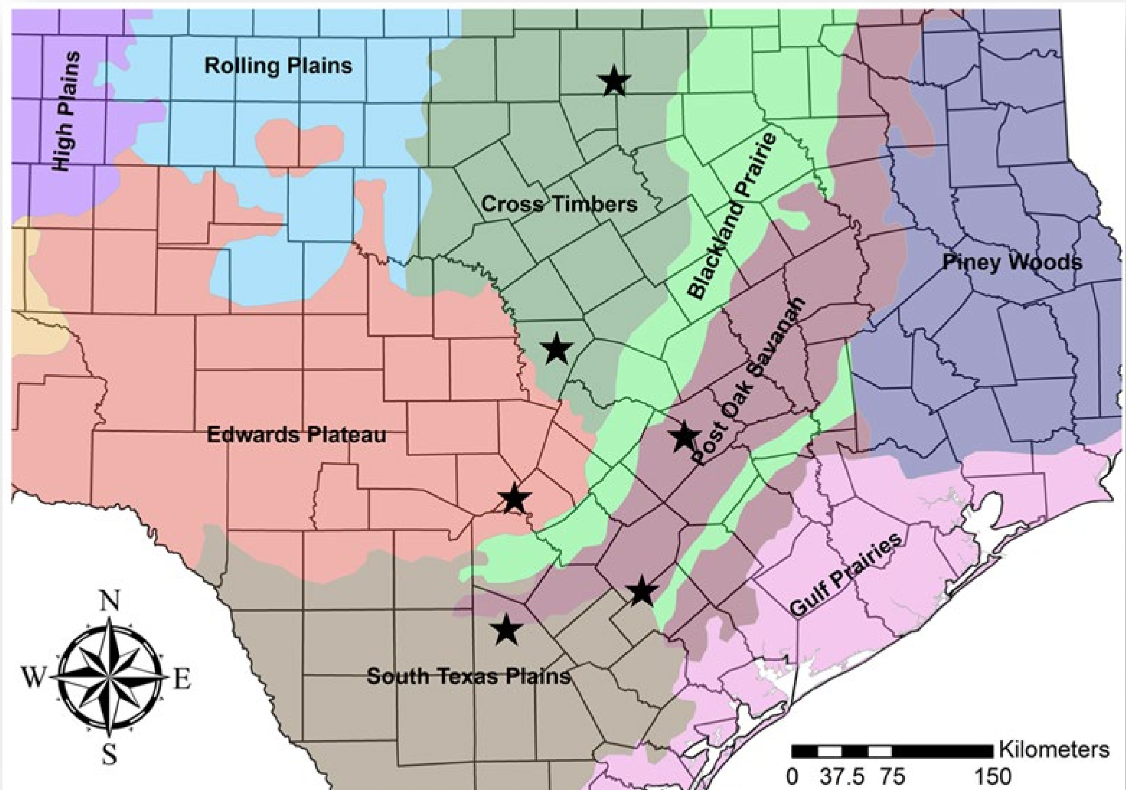

Figure 12. Location of site specific sample area.

Table 15. Description of six site specific sampling areas with ecoregion, soil types sampled, landuse classification, and management.

County	Ecoregion	Soil Type*/Management	Landuse**
Atascosa	South Texas Plains	Poteet/cattle grazing Webb fine sandy loam/cattle grazing Wilco loamy fine sand/cattle grazing	Pasture/hay Grassland/herbaceous
Bastrop	Blackland Prairie	Axtell fine sandy loam/control and burn Crockett fine sandy loam soils/control and burn Tabor fine sandy loam/none	Pasture/hay
Burnet	Cross Timbers Edwards Plateau	Bolar Clay/grazed Krum Clay/grazed Purves Association/grazed	Shrub/scrub Grassland/herbaceous
Comal/Kendall	Edwards Plateau	Bolar Clay Loam/none Brackett-Rock Outcrop-Comfort/none Real-Comfort-Doss/none	Shrub/Scrub Grassland/herbaceous
DeWitt	Post Oak Savannah Blackland Prairies	Heiden Clay/grazed Miguel Fine Loam/grazed Samosa Fine Sandy Loam/grazed	Pasture/hay
Parker	Cross Timbers	Aledo-Bolar Association/grazed and control Bolar Clay Loam/none Krum Clay/none	Grassland/herbaceous Pasture/hay

*Natural Resources Conservation Service, Web Soil Survey

**National Land Cover Database 2011

Results

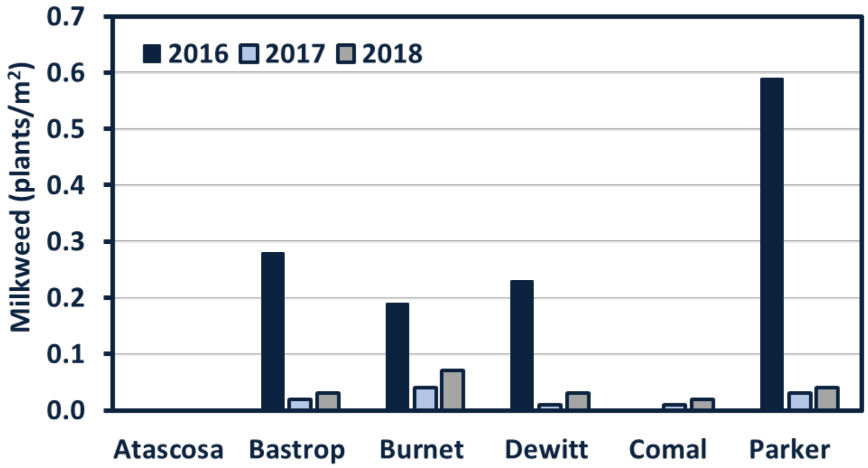

Figure 13. Total number of milkweed plants/m^2 for by county of the site for the spring of 2016, 2017, and 2018. No monarch eggs or larvae were found, however two *Asclepias* at Bastrop had slight herbivory damage.

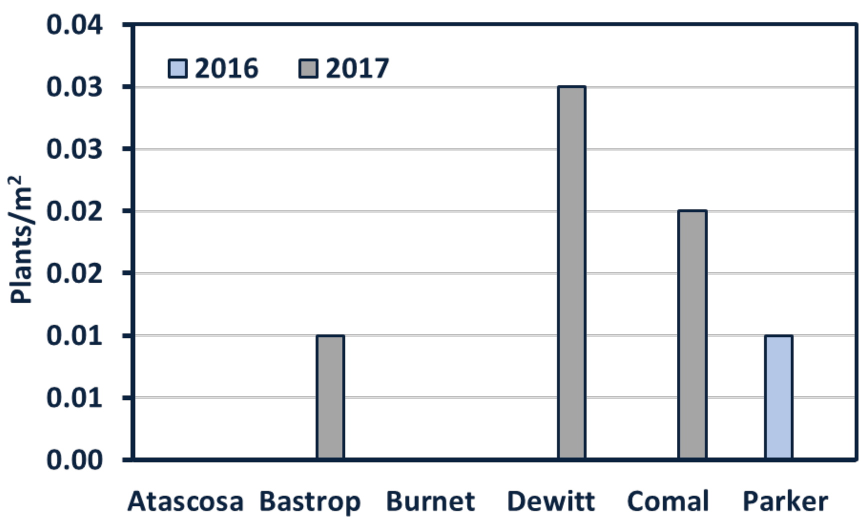

Figure 14. Number of milkweed plants/m^2 for each county for the fall of 2016 and 2017. No monarch eggs or larvae were found.

Table 16. Total number of *Asclepias* individuals found in each site specific location by soil type, management regime, and time of sampling. Each sampling area was 750 m^2.

Soil	Management	Spring			Fall	
		2016	2017	2018	2016	2017
Atascosa County, South Texas Plains						
Poteet	Cattle Grazing	0	0	0	0	0
Webb fine sandy loam	Cattle Grazing	0	0	0	0	0
Wilco loamy fine sand	Cattle Grazing	0	0	0	0	0
Bastrop County, Blackland Prairies						
Axtell fine sandy loam	Control	0	0	0	1	0
	Burn	0	0	0	0	0
Crockett fine sandy loam soils	Control	4	0	0	0	0
	Burn	0	1	2	0	1
Tabor fine sandy loam	None	0	0	1	0	0
Burnet County, Cross Timbers/Edwards Plateau						
Bolar Clay	Cattle Grazing	1	8	5	3	2
Krum Clay	Cattle Grazing	0	0	0	0	0
Purves Association	Cattle Grazing	0	0	0	0	0
Comal/Kendall Counties, Edwards Plateau						
Bolar Clay Loam	None	0	1	1	0	0
Brackett-Rock Outcrop-Comfort	None	0	0	0	0	0
Real-Comfort-Doss	None	0	0	0	0	0
DeWitt County, Post Oak Savannah/Blackland Prairies						
Heiden Clay	Cattle Grazing	2	12	8	0	2
Miguel Fine Loam	Cattle Grazing	0	0	0	0	0
Samosa Fine Sandy Loam	Cattle Grazing	0	0	0	1	0
Parker County, Cross Timbers						
Aledo-Bolar Association	Grazed	5	4	3	0	0
	Control	4	3	0	0	0
Bolar Clay Loam	None	0	0	0	0	0
Krum Clay	None	2	0	3	0	0

Task 3 – Seed Viability and Germination Experiments

Methods

Seed Viability.

Seed viability was tested using a Tetrazolium (TZ) assay, a fast evaluation for seed viability (Porter et al., 1947). The seeds of different *Asclepias* species (*asperula, curassavica, speciosa, syriaca, tuberosa, viridis*) were obtained from Native American Seed, Junction, Texas and Everwilde Farms, Inc., Sand Creek, Wisconsin and kept at room temperature (20 ± 2°C) prior to testing.

Using a scalpel, seeds were cut longitudinally through the midsection of the embryo and using forceps the seed coat was removed. Extracted seeds embryos were placed on one sheet of Whitman no. 2 filter paper in a 100 x 15 mm sterile petri dish and a prepared 1% solution of Tetrazolium using 100 ml of deionized water and 1 g of powdered 2,3,5-Triphenyl-tetrazolium chloride vortexed for one minute. Tetrazolium solution was added to each petri dish until all seed embryos were completely submerged. Petri dishes were then sealed to prevent desiccation and left out at room temperature (20 ± 2°C) for 24 hours. After 24 hours each seed was checked for distinct staining of vital parts of the embryo.

Tetrazolium solution is a colorless compound, which is converted into a carmine red colored water-insoluble formazan by hydrogen transfer reaction catalyzed by the cellular dehydrogenases in viable seeds (Porter et al., 1947). Seed staining was considered evidence of the ability to produce a normal seedling (Porter et al., 1947). The experiment was replicated three times, each replicate consisted of 10 seeds (n = 30).

Seed Germination.

The seeds of five difference *Asclepias* species (*asperula, incarnata, speciosa, tuberosa, and viridis*) were obtained from Native American Seed, Junction, Texas and Everwilde Farms, Sand Creek, Wisconsin and kept at room temperature (20 ± 2ºC) prior to testing. Chemical scarification treatments used to break seed dormancy were concentrated sulfuric acid and a 5 mM solution of gibberellic acid. Seeds treated with concentrated sulfuric acid were subject to various soaking times (30, 60, 120 seconds) with agitation (Evetts & Burnside, 1972). Gibberellic acid was used as it is a known plant growth hormone recognized to stimulate plant growth (Gupta & Chakrabarty, 2013). A 5 mM solution of gibberellic acid was prepared using 100 ml of deionized water and 0.175 g of powdered gibberellic acid and vortexed for one minute. Seeds were soaked in the 5 mM solution of gibberellic acid for three hours and then plated. The experiment was replicated three time, each replicate consisted of 10 seeds (n = 3).

Treated seeds were then placed on one sheet of Whitman no. 2 filter paper in 100 x 15 mm sterile petri dishes. Petri dishes were then sealed to prevent desiccation and left out at room temperature. Replications were checked daily for 14 consecutive days for emergence of seed radicle. Seeds were considered germinated when the radicle reached a length of 5 mm or more (Evetts & Burnside, 1972).

Data was evaluated to determine if significant differences existed between treatments (SA & GA) for each species. Mean germination rates (%) were calculated for replicates in the experiment. Percent germination was calculated as follows:

$$Percent\ Germination = \frac{\#\ of\ germinated\ seeds}{total\ \#\ of\ seeds\ sown}\ x\ 100$$

Germination (%) in the experiment violated parametric assumptions. Thus, to evaluate differences in mean germination rates (%) data was arcsine transformed and nonparametric all-pairs Student's t multiple comparisons and Steel-Dwass tests were used (Steel, 1960). For the analysis our significance level was 0.05. Analysis was performed using JMP Statistical Software®. See appendix for statistical summary of replicates for each species.

Results

Seed Viability.

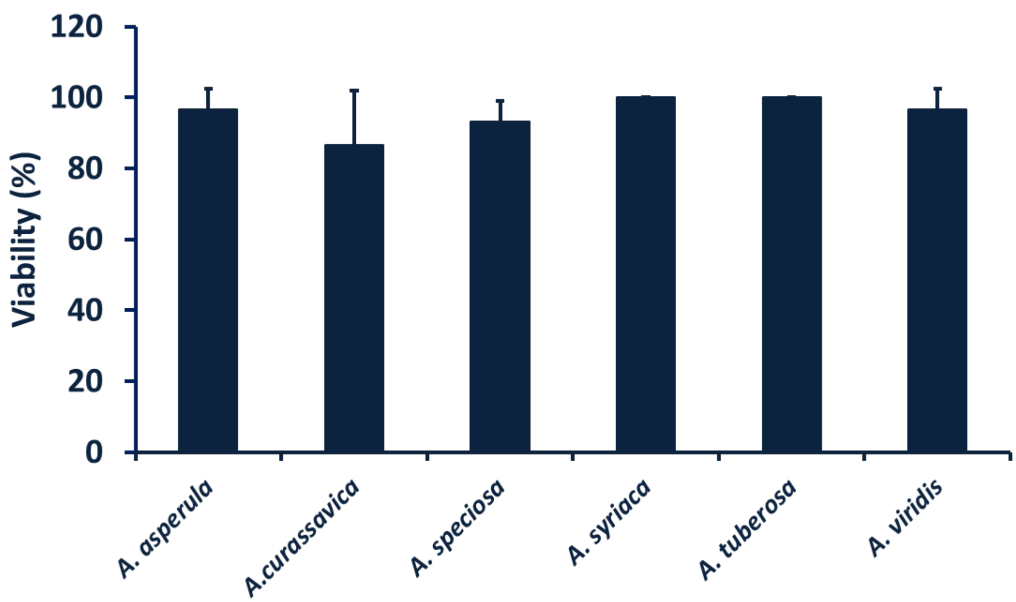

Figure 15. Mean seed viability for six species of *Asclepias* using the tetrazolium chloride test. Three replications of thirty seeds were used. Error bars represent one standard deviation. No significant differences were found in seed viability.

Germination.

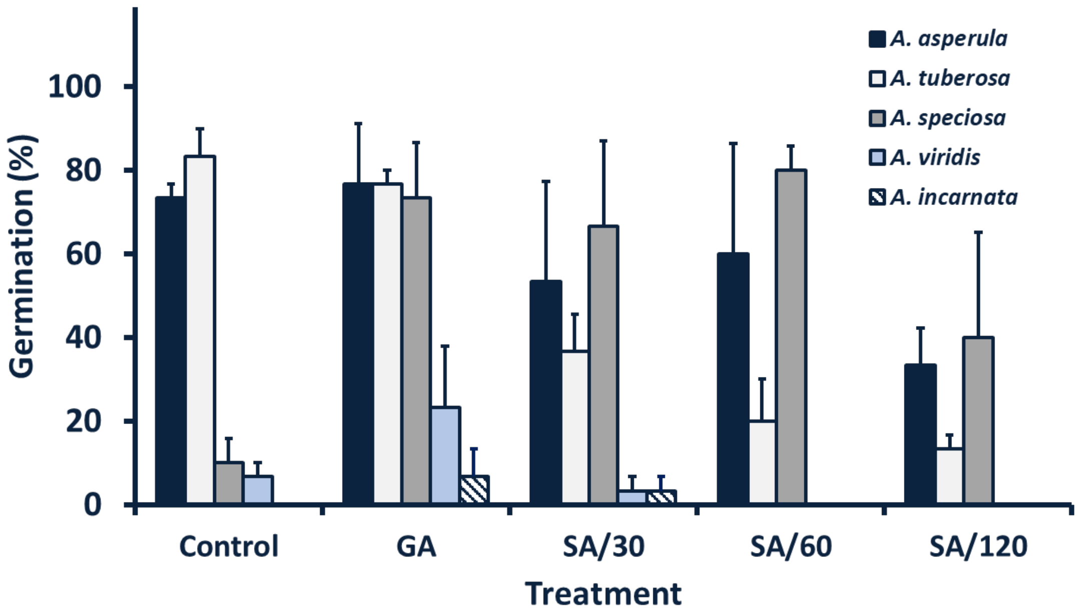

Figure 16. Mean germination of five species of *Asclepias* using five treatments (control, gibberellic acid [GA], and sulfuric acid [SA] at 30, 60, and 120 minutes). Three replications of ten seeds were used. Error bars represent one standard deviation.

Task 4. Greenhouse Experiments

Methods

Light.

The seeds of seven different milkweed species (Table 17) were obtained from two different commercial seed suppliers, Native American Seed, Junction, Texas and Everwilde Farms, Sand Creek, Wisconsin. Seeds were started in aluminum trays filled with Miracle-Gro® in mid-August 2016 and transplanted two weeks later into 15 cm tall, black Euro Pots, each containing 1,350 g of air dried, sieved (6.4 mm mesh), native soil (upper 10 cm of a Patrick-Series Mollisol, classified as clayey-over-sandy, carbonaticthermic, typic calciustoll) (Taylor et al., 1966). Pots were lined with plastic bags to prevent leaching of water and fertilizer.

For this experiment, five one-year old observably healthy individuals of each species were selected for leaf gas-exchange measurements (Table 17).

Table 17. Milkweeds (*Asclepias* spp.) species evaluated.

Genus species	Common name
Asclepias asperula	Antelope Horn milkweed
Asclepias curassavica	Tropical milkweed
Asclepias incarnata	Swamp milkweed
Asclepias oenotheroides	Zizotes milkweed
Asclepias syriaca	Common milkweed
Asclepias tuberosa	Butterfly milkweed
Asclepias viridis	Green milkweed

Leaf gas-exchange characteristics were measured on fully expanded leaves from each selected individual using an LI-COR® infrared gas analyzer (LI-6400XT, Li-COR Inc., Lincoln, NE, USA). Gas-exchange parameters were measured during the month of September 2017, using the standard leaf chamber (encloses 6 cm^2 of leaf area). The photosynthetic response to different light intensities (an A/Q curve) was measured for each selected leaf by measuring the steady-state responses of photosynthesis to external photosynthetically active radiation (PAR) supplied in 16 steps from (0-2000 $\mu mol\ m^{-2}\ sec^{-1}$). Irradiances were generated by the LI-COR® LED red-blue light source using the auto light curve program with a flow rate of (400 $\mu mol\ s^{-1}$) and CO_2

concentration of (400 µmol mol^{-1}). After placing a leaf in the chamber photosynthetic rates were allowed to stabilize for approximately nine to ten minutes. The LI-COR 6400XT® was operated at (30º C), relative humidity (30 – 40 %) and was calibrated daily. Response data were recorded after four minutes when a stable total coefficient of variation was reached (1%), usually less than five minutes.

Data was taken directly from LI-COR 6400XT®. The results were adjusted for each replication (plant) and fitted to the model of Prioul and Chartier (1977) using the PC software package Photosyn Assistant (Dundee Scientific, Dundee, Scotland). Fitted data included several parameters including (Amax; maximum photosynthesis) (µmol CO_2 m^{-2} s^{-1}), PAR at Amax (µmol m^{-2} s^{-1}), transpiration (E_{leaf}; mmol H_2O m^{-2} s^{-1}) at (2000 µmol CO_2 m^{-2} s^{-1}), stomatal conductance (g_{leaf}; mol H_2O m^{-2} s^{-1}) at (2000 µmol CO_2 m^{-2} s^{-1}), light saturation point (L_{sat}; µmol m^{-2} s^{-1}), dark respiration (R_d; µmol CO_2 m^{-2} s^{-1}), light compensation point (L_{cp}; µmol m^{-2} s^{-1}), and quantum yield efficiency (QY; µmol CO_2/µmol quanta^{-1}). Values were calculated for each replicate and then averaged.

Photosynthetic capacity (Amax) is a measure of the maximum rate at which leaves can fix carbon during photosynthesis. The PFD when the slope of the initial rate line reached Amax was light saturating photosynthesis. The gas exchange rate at zero µmol m^{-2} s^{-1} (y-intercept of the line for the initial rate) was dark respiration. The light compensation point was calculated as the PFD when the photosynthetic rate was zero µmol CO2 m^{-2} s^{-1} (x-intercept of the line for the initial rate). The quantum yield efficiency was calculated using the dark values and increasing PFDs until the regression coefficient of the slope decreased.

One-way analysis of variance (ANOVA) was used to determine if net photosynthesis (µmol CO_2 m^{-2} s^{-1}), stomatal conductance (mol H_2O m^{-2} s^{-1}), and transpiration (mmol H_2O m^{-2} s^{-1}) and other photosynthetic parameters calculated were significantly different over light intensities tested (see Alvarado-Miller, 2018). The Shapiro-Wilks test was used to test for normal distribution and Bartlett's Test was used to test for homogeneity of variances (see Appendix Table A1). If unequal variances were detected, data were log transformed prior to analyses. An alpha value of 0.05 was used for all the tests. Tukey-Kramer HSDs were used to detect significant differences among gas exchange rates at each PFD (Sall et al., 2000).

Nitrogen and Drought.

Numerous attempts were made to grow native Texas milkweeds (see the species list from the light experiment) in the greenhouse so that we could determine the effects of nutrients and drought on their growth. We attempted native soil, specialized soil obtained from the Lady Bird Johnson Wildflower Center, and hydroponics with and without mycorrhizae added. While we were able to get a few specimens to grow, we were not able to grow enough to complete the experiments.

Predatory relationship with red-imported fire ants.

Fire Ant Collection and Experimental Design

Red-imported fire ants colonies were collected in the field from two separate areas: one from an areas off Johns Road, Boerne, TX 78006 (29°47'42.13"N, 98°45'19.64"W) and an area located on the campus of University of Texas at San Antonio (29°35'15.08"N, 98°37'14.48"W and 29°35'00.85"N, 98°37'47.51"W). Red-imported fire ant colonies collected were identified under a microscope prior to testing (Cook, O'Keefe, Vinson, & Drees, 2016). Each colony was removed with as much of the native soil as possible after it was determined at least one queen was present (Porter & Tschinkel, 1987). The ants and soil were deposited in a modified 19 L Igloo™ cooler allowing the soil to reach within 14 cm of the top. The top 10 cm of the inner rim of each container was coated with Fluon and four 15 mm diameter holes were drilled 14 cm from the bottom into each container into which ½" polygon tubing was inserted (Vinson & Scarborough, 1989). The tubing lead to four 66-quart plastic test containers through a 15 mm hole drilled at their base. The bottom of each test container was lined with a granite soil aggregate and the side coated in Fluon. In all trials three tropical milkweed (*Asclepias curassavica*) stems were cut near their base, inserted into 4 x 4 wet floral foam blocks, and buried in the granite soil aggregate of the test container at equally distant locations.

Colonies were held in a greenhouse and maintained at an average temperature of 28˚± 3˚ C. Each colony was given at least 48-hours to adjust once collected before being deprived of food in preparation for a trial. Colonies were fed 5 mls of 1:3 honey and water mixture (Banks, 1981), provided with 20 ml of water in a cotton plugged test tube, and three to four crickets (*Acheta domesticus*) twice a week.

Monarch Larval Stage Preference Trials

We tested the monarch butterfly stage preference of the red-imported fire ant using eggs, first through fifth larval instars and chrysalis. Independent trials for each larval stage were conducted by placing five of each monarch butterfly stage on the milkweed stems in each test container. After 24 hours the number of survivors was recorded, and the percent survival determined. We also evaluated in independent trials the effect of red-imported fire ants on crickets and mealworms.

Prey Preference Trials

We tested the prey preference of the red-imported fire ant using three different prey items (monarch 3^{rd} instars, crickets, and mealworms) all offered simultaneously. In all prey preference trials five of each prey item were placed in the test containers at naturally occurring positions. Monarch 3^{rd} instars were placed on milkweeds stems, crickets and mealworms on the soil surface. After 24 hours the number of each surviving prey items was recorded, and the percent survival was determined.

Results

Light.

Table 18. Leaf gas-exchange parameters for *Asclepias* spp., including maximum photosynthetic rates (A_{max}), photosynthetic flux densities (PFDs) at A_{max}, light saturation levels (L_{sat}), light compensation point (L_{cp}), respiration rate (R_d), quantum yield efficiency, stomatal conductance (g_{leaf}), and transpiration (E_{leaf}) for container grown *Asclepias* species in San Antonio, Texas. Values are means ± standard deviations. Levels not connected by the same letter are significantly different.

Species (*Asclepias*)	A_{max} (µmol CO_2 m^{-2} s^{-1})	L_{sat} (µmol m^{-2} s^{-1})	L_{cp} (µmol m^{-2} s^{-1})	R_d (µmol CO_2 m^{-2} s^{-1})	Qe (µmol CO_2 µmolquanta)	g_{leaf} (mol H_2O m^{-2} s^{-1}) at 2000 (µmol m^{-2} s^{-1})	E_{leaf} (mmol H_2O m^{-2} s^{-1}) at 2000 (µmol m^{-2} s^{-1})
asperula	20.6 ± 3.04^{A}	636 ± 184^{A}	33.9 ± 15.8^{A}	1.11 ± 0.06^{A}	0.036 ± 0.015^{A}	0.137 ± 0.030^{AB}	4.72 ± 0.94^{AB}
curassavica	24.9 ± 5.04^{A}	426 ± 47^{A}	22.7 ± 1.1^{AB}	1.39 ± 0.19^{A}	0.062 ± 0.008^{A}	0.307 ± 0.089^{A}	8.71 ± 1.95^{A}
incarnata	23.5 ± 5.58^{A}	561 ± 91^{A}	13.2 ± 1.9^{B}	0.575 ± 0.18^{A}	0.043 ± 0.010^{A}	0.167 ± 0.047^{AB}	5.58 ± 1.36^{AB}
oenotheroides	23.1 ± 4.06^{A}	548 ± 227^{A}	20.4 ± 2.0^{AB}	0.966 ± 0.25^{A}	0.048 ± 0.014^{A}	0.193 ± 0.061^{AB}	5.68 ± 1.56^{A}
syriaca	5.28 ± 1.28^{B}	198 ± 2^{A}	33.3 ± 6.3^{A}	1.11 ± 0.52^{A}	0.032 ± 0.009^{A}	0.038 ± 0.000^{B}	0.964 ± 0.58^{B}
tuberosa	18.4 ± 2.65^{A}	341 ± 115^{A}	24.2 ± 6.2^{AB}	1.59 ± 0.82^{A}	0.063 ± 0.022^{A}	0.169 ± 0.028^{AB}	4.84 ± 3.17^{AB}
viridis	27.5 ± 6.29^{A}	583 ± 304^{A}	19.7 ± 8.5^{AB}	1.00 ± 0.16^{A}	0.055 ± 0.017^{A}	0.261 ± 0.059^{A}	7.07 ± 1.29^{A}

Predatory relationship between red-imported fire ants and monarch butterfly eggs and larvae.

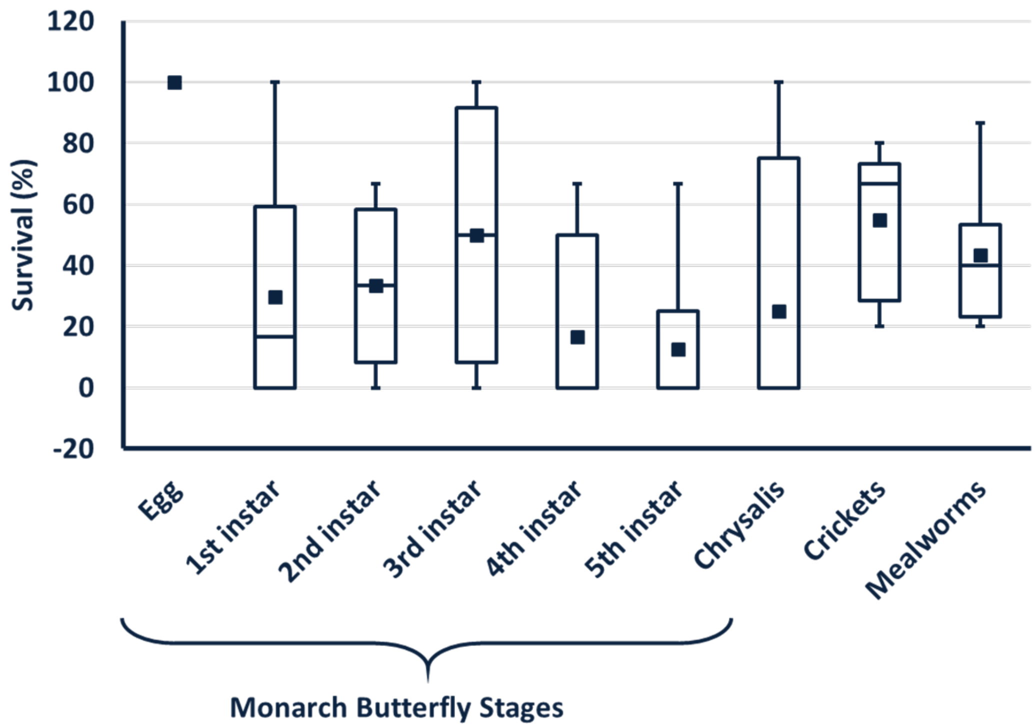

Figure 17. Quartile plots comparing independent trials measuring percent survival of imported ant prey item.

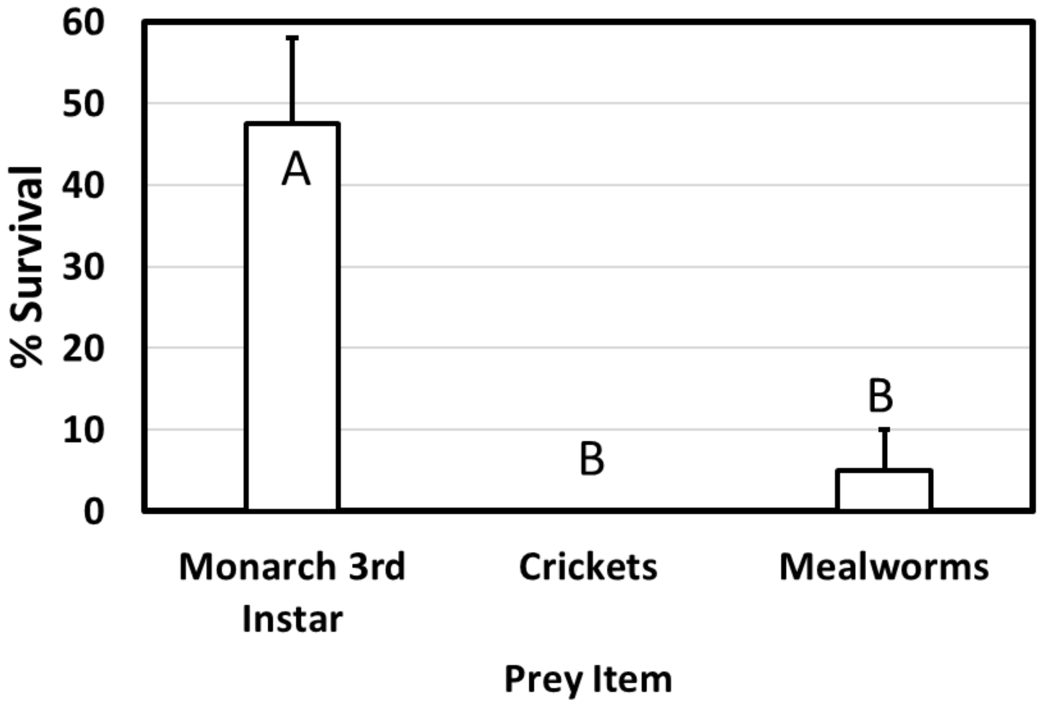

Figure 18. A comparison of the percent survival of various prey items after 24 hours when offered a choice of monarch butterfly 3rd instar, crickets, or mealworms. Error bars represent one standard error. Bars with the same letter are not significantly different.

Task 5 – Field Experiments

Methods (Best Management Practices – Experiment One)

We tested the effects of three best management treatments (prescribed fire, mowing, and cattle grazing) and compared them to a control (no treatment). On February 26, 2016, we established 5 x 5 m plots on an active cattle grazing pasture in the Blackland Prairie Ecoregion, in DeWitt County, Texas site using T-post and barbed wire. The cattle grazing plots were delineated, but no barbed wire was used so that the cattle on the property were free to use the plots. There were three replications of each treatment. Prior to the treatment, we identified all milkweed (*A. asperula*), counted the number of stems, and assigned a metal tag. We then burned three of the plots (replications) and mowed three of the plots (using a weed eater). Three additional plots were left alone. We monitored the number and stems of *A. asperula*, amount of damage from monarch larvae, number of monarch eggs, and number of monarch larvae at 2, 12, and 20 months after the treatments.

Results (Best Management Experiment – Experiment One)

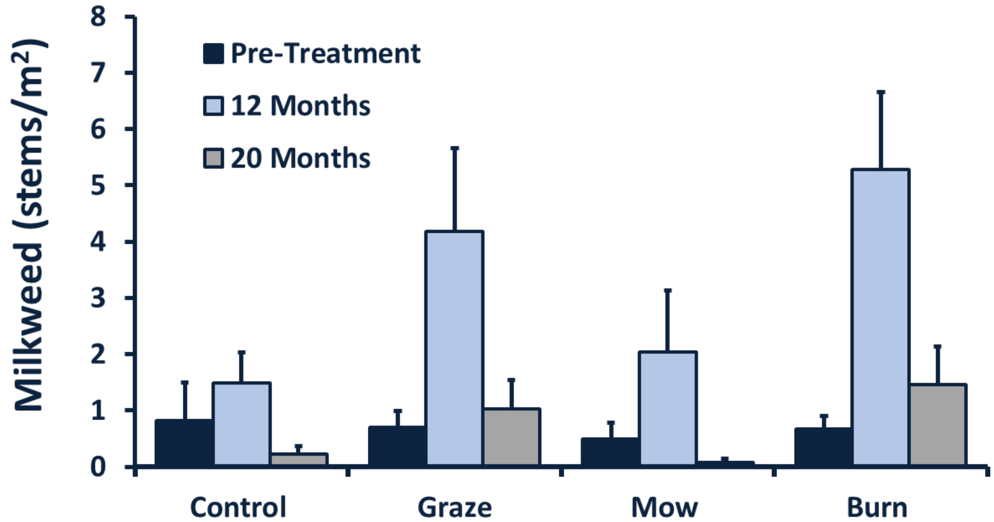

Figure 19. The number of stems of *Asclepias asperula* prior to and 12 and 20 months after best management practices treatments. Error bars represent one standard error.

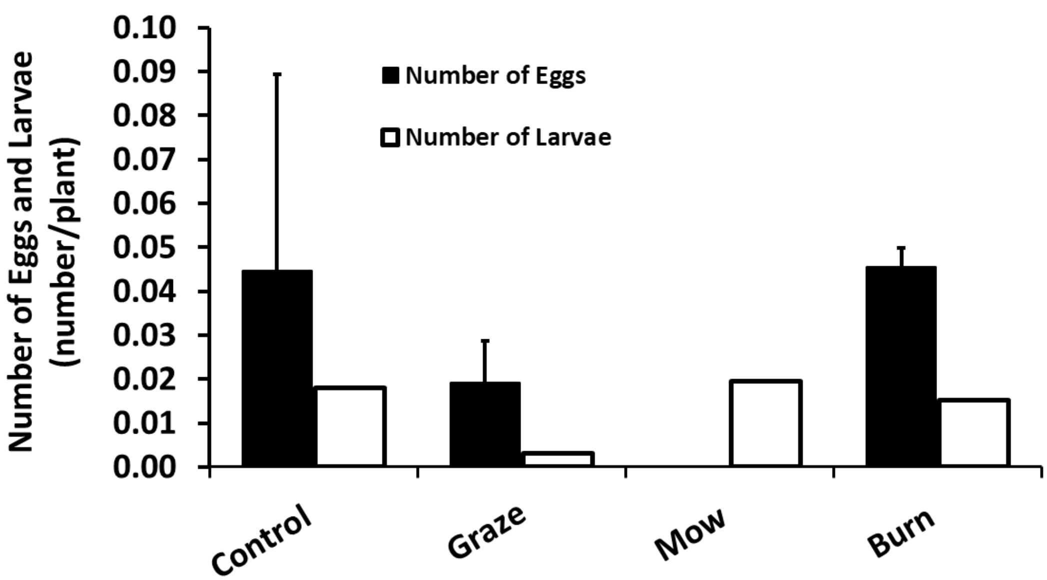

Figure 20. The number of eggs and larvae one year after best management practices treatments. Error bars represent one standard error.

Methods (Best Management Practices – Experiment Two)

We tested the effects of two best management treatments in a Blackland Prairie site in Bastrop County, Texas. Treatments included prescribed burn (two levels: summer and winter) and mowing (four levels: summer, fall, winter, and spring). We compared these to a control (no treatment). On September 23, 2016, we established 5 x 5 m plots and collected initial pre-treatment data. Plot were delineated using T-post. There were three replications of each treatment. We identified all milkweed, counted the number of stems, and assigned a metal tag. We then burned three of the plots (replications) and mowed three of the plots (using a weed eater) for the summer burn and mow treatment, respectively. The fall mow treatment was implemented on November 29, 2016, the winter burn and mow treatment was implemented on February 7, 2017, and the spring mow was implemented on May 11, 2017. We monitored the number and stems of *A. asperula*, amount of damage from monarch larvae, number of monarch eggs, and number of monarch larvae on the following dates: November 29, 2016; February 7, May 11, November 11, 2017; and February 14, April 27, and June 2018.

Results (Best Management Practices – Experiment Two)

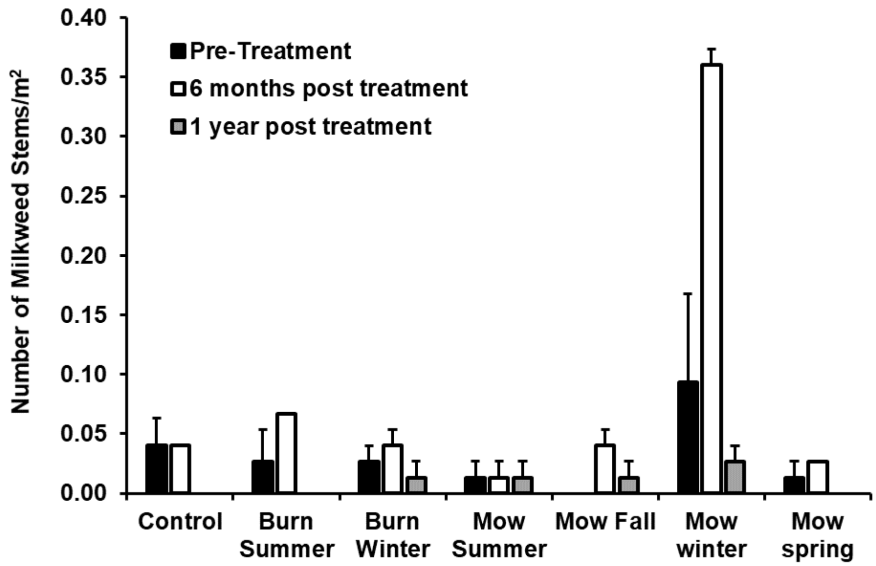

Figure 21. Number of *Asclepias* stems/m^2 in several best management scenarios prior to, six months, and twelve months after treatments. All plants were *A. viridis,* except for one *A. oenotheroides* in the winter mow in 07/10/18 and two *A. asperula* in 09/23/18, one in the summer mow and one in the winter mow treatment. No monarch eggs or larvae were found on any of the milkweeds.

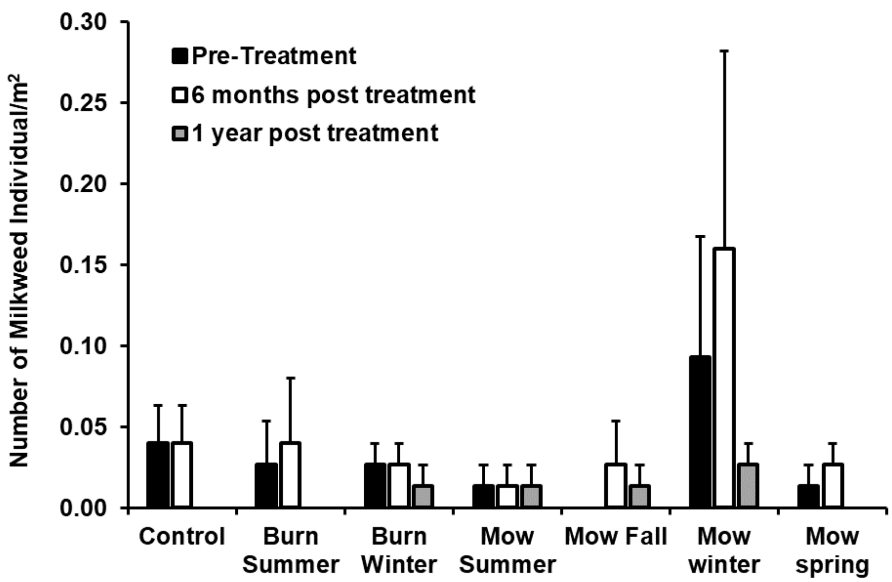

Figure 22. Number of *Asclepias viridis* individuals /m^2 in several best management scenarios prior to, six months, and twelve months after treatments.

Methods (Milkweed patch size dynamics)

Experimental Design.

There were two experiments set up to monitor *A. curassavica* plants in the spring of 2016 for *D. plexippus* eggs and larva in plots set up on a ranch located at 1735 Ernst Road, Pleasanton, Texas (28.6° N 98.3° W) in the South Texas Plains Ecoregion.

Two experiments were used to determine which patch size dynamic would receive the most oviposition and have the greatest survival of *D. plexippus* larva. The first experimental design tested different densities of *A. curassavica* plants placed together, and the second experimental design tested *A. curassavica* plants spaced at different distances from each other (see Rubal, 2017).

Asclepias asperula and *A. curassavica* were grown in a greenhouse. *Asclepias asperula* is native to Texas, and was found in all transects of the roadside surveys, so it was the first choice to use for this experiment. The second choice of milkweed to use was *A. curassavica*, because they grow quickly and are hardy plants. Four hundred plants of both species were propagated in a greenhouse at The University of Texas at San Antonio. *Ascelpias asperula* did not have enough growth by March to use for the experiment, and *A. curassavica* plants growing in the greenhouse also were not used due to herbivore damage. On February 29, 2016, two hundred *A. curassavica* plants were purchased from Joss Growers located in Austin, Texas, and they were placed in an outside enclosure where they were kept until the start of the experiment. They were checked on every day, and watered as needed.

Journey North's website (http://www.learner.org/jnorth/monarch/News.html) was monitored for the first reported spring 2016 movements of *D. plexippus* northern migration from Mexico. First reports of a colony break with activity of mating and drinking from the creeks came in on March 10, 2016. A late winter storm went through the monarch sanctuaries in Mexico on March 11, 2016. On March 12, 2016, two experimental designs using *A. curassavica* plants were put into position to commence observations.

The first experimental design used 93 *A. curassavica* plants in three replicates of five different treatments involving clumped plants within a patch that were placed in the center of plots. Fifteen 4 m^2 plots for the first design were measured out with 2 m spacing between each plot. The five treatments consisted of one plant, two plants, four plants, eight plants, and sixteen plants, which were randomized and placed as clumps in the center of the plots (Figure 23). The plants within the treatments were also randomized. To place the plants in the center of the plots diagonals of the squared plot were taken, and the middle was marked with a flag. A hole was dug where the flag marked the center for the plots with one potted *A. curassavica* plant, and for the other plots holes were dug next to each other in a circle around the center where potted *A. curassavica* plants were placed in the holes.

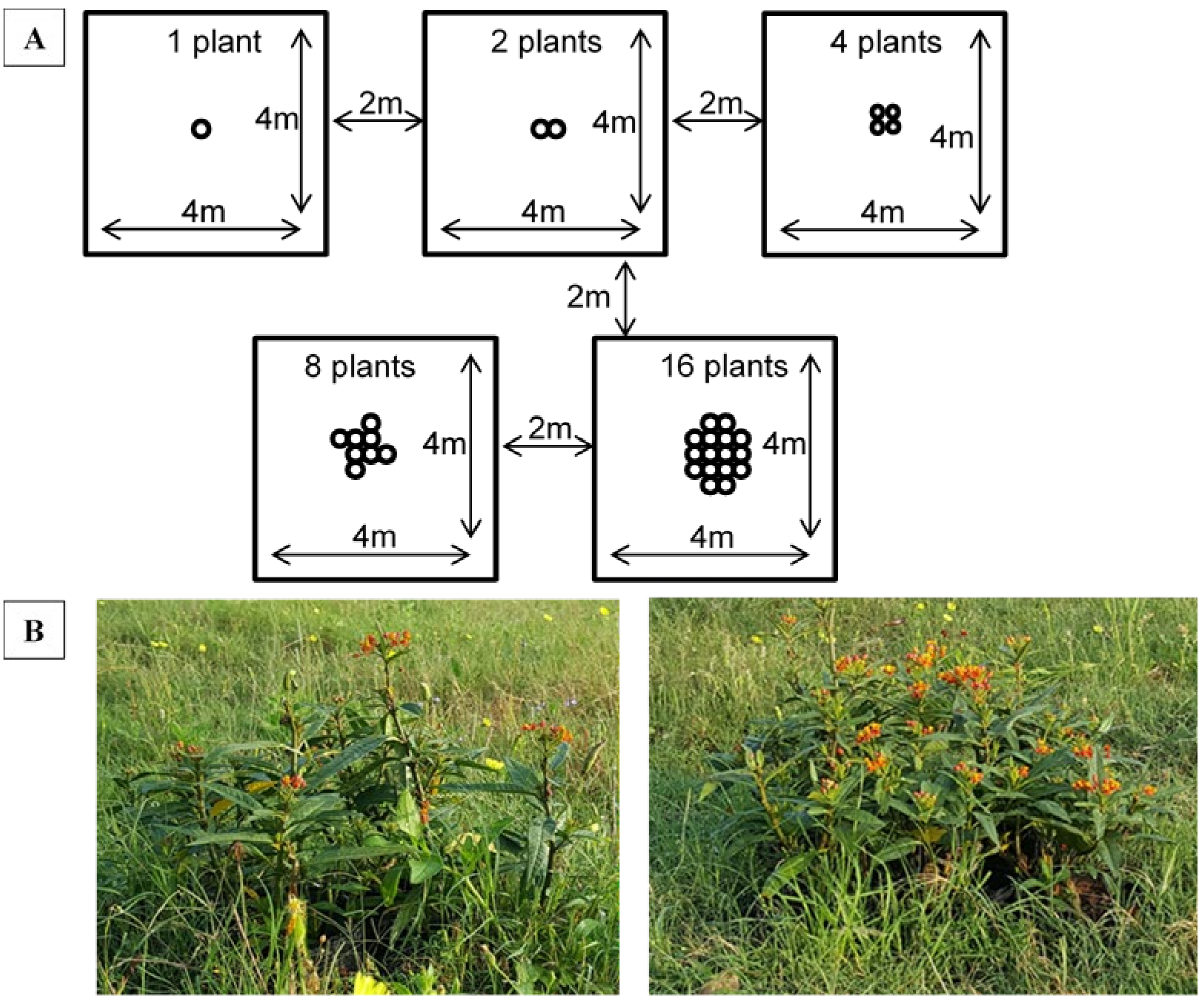

Figure 23. Experiment One Clumped Plants A) A. curassavica plants plot designs B) Pictures of plots with treatments of four and sixteen.

For the second experimental design, 80 plants were used in four replicates of five different treatments with *A. curassavica* plants spaced at different intervals. Twenty 4 m^2 plots were measured out with 2 m spacing between each plot. The five different treatments consisted of four plants per plot that were set up in a square. Treatment one had a spacing of 0.5 m between each plant, treatment two was 1.0 m, treatment 3 was 1.5 m, treatment four was 2.0 m, and treatment five was 2.5 m (Figure 24). The center of the plot was marked based off of diagonals, and flags marked the placement of the plants that were measured using the center and the edges of the plot. A hole was dug at each flag, and a potted plant was placed in the hole. The treatments and the plants within the treatments were all randomized.

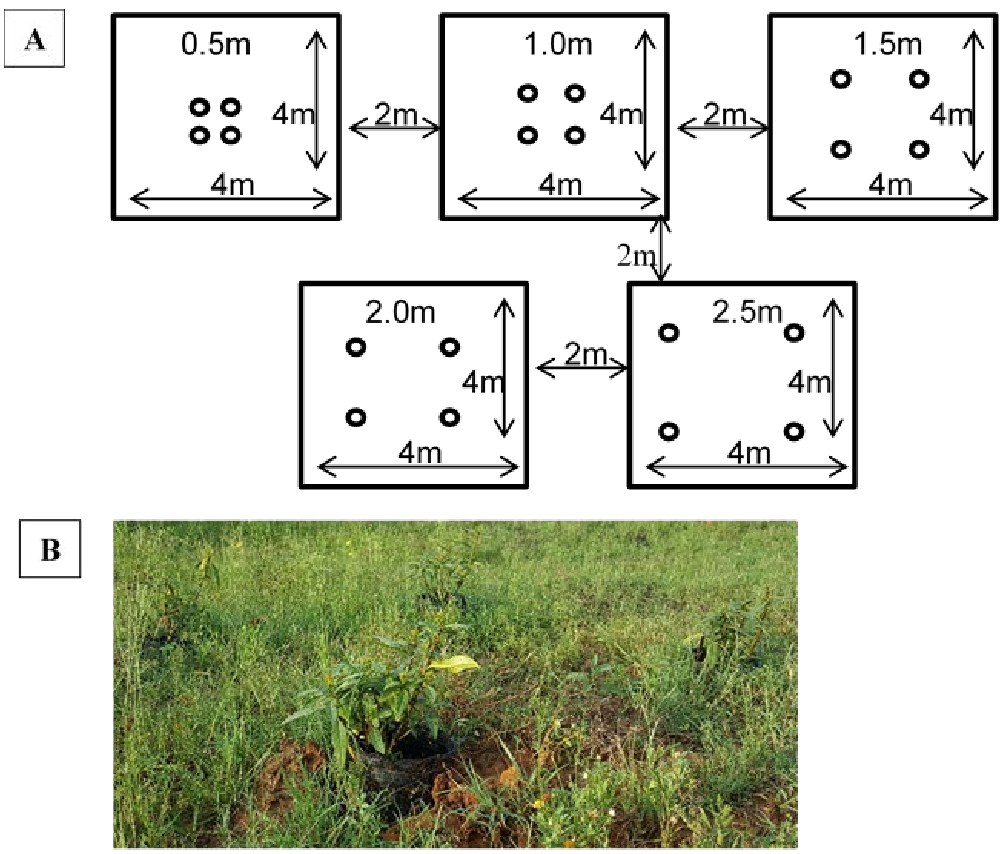

Figure 24. Experiment Two Spaced Plants. A) *A. curassavica* plants plot designs B) Picture of plants spaced at 1.5m marked with arrows.

The number of *D. plexippus* eggs and each larva instar stage per plant were recorded weekly to determine oviposition and survival rates on *A. asperula* patch treatments. Data was recorded only once a week to reduce the chances of over counting, since each stage lasts 4-7 days (Fischer et al., 2015; Levy & Connor, 2004; Oberhauser, 1997; Oberhauser et al., 2001; Zalucki, 1982). Plant data including plant height (cm), number of leaves, and damage using a scale from 1 – 4 with one being very little damage and four representing the most damage (Cutting and Tallamy, 2015) was also recorded weekly. A base line of plant data was taken on March 14, 2016.

Experiment one data of clumped plants was taken from March 22 to May 2, 2016, and experiment two data of spaced plants was taken from March 23 to May 5, 2016. Weather data during these times for both experiments was also used to determine any effects the weather had on the experiments (Table 19). To observe the plants each pot was gently lifted up and slowly rotated and then placed back into the hole. On May 2nd and 5th no eggs or larva were found, but for the next three weeks plants were monitored for any *D. plexippus* activity and none was found, which ended experimental observations.

Table 19. Recorded weather data including temperature (°C), precipitation (cm), and wind speed (km/h) collected from www.weatherunderground.com for the eight-week duration (March 12 to May 6, 2017) of the experiments.

Week	**Dates**	**Mean Temperature (°C)**		**Precipitation (cm)**	**Wind Speed (km/h)**
		Maximum	Minimum	Total	Mean
1	March 12-18	28	14	0.10	6
2	March 19-25	22	8	0.12	11
3	March 26- April 1	24	15	0.01	9
4	April 2-8	27	9	0.00	6
5	April 9-15	27	15	0.06	9
6	April 16-22	27	19	0.15	10
7	April 23-29	31	19	0.13	11
8	April 30-May 6	29	14	0.02	8

Statistical Analysis.

For the five spaced treatments in experiment one, and five clumped treatments in experiment two, a Shapiro-Wilks analysis was used to check for normality of distribution for the mean number of eggs/plant and larva/plant at each of the five instar stages. The nonparametric Kruskal-Wallis test was used to analyze differences for mean number of eggs/plant and larva/plant at each instar stage between the treatments in both experiments. A Kruskal-Wallis analysis was also conducted to check for differences between weekly counts of both experiments for mean number of eggs/plant and larva/plant at each instar sage. Means and standard error were reported.

Results (Milkweed patch size dynamics)

Reproduction as a function of milkweed density.

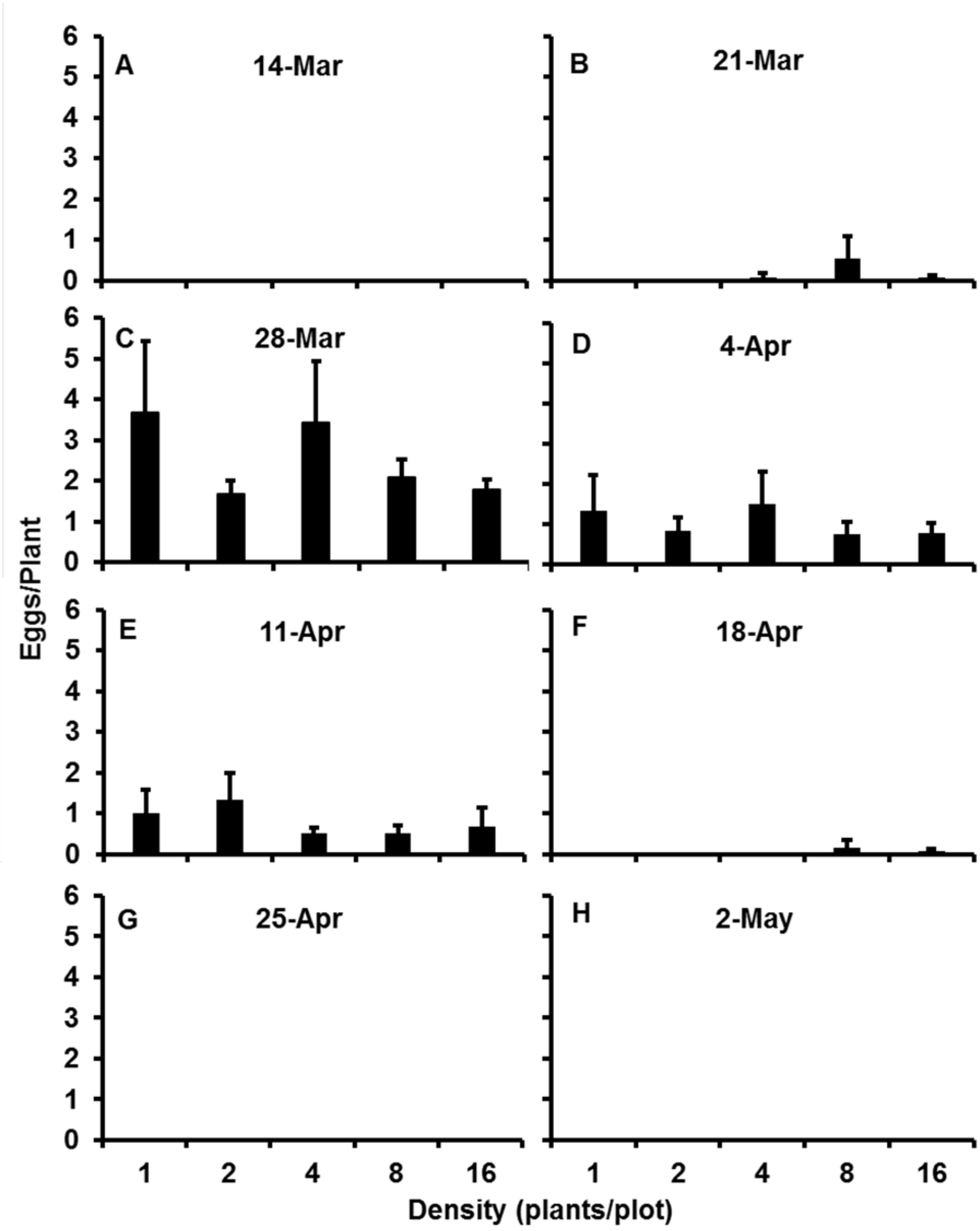

Figure 25. Mean number of *D. plexippus* eggs/plant by date for each clumped plant density treatment (n = 3). Error bars represent one standard error from the mean.

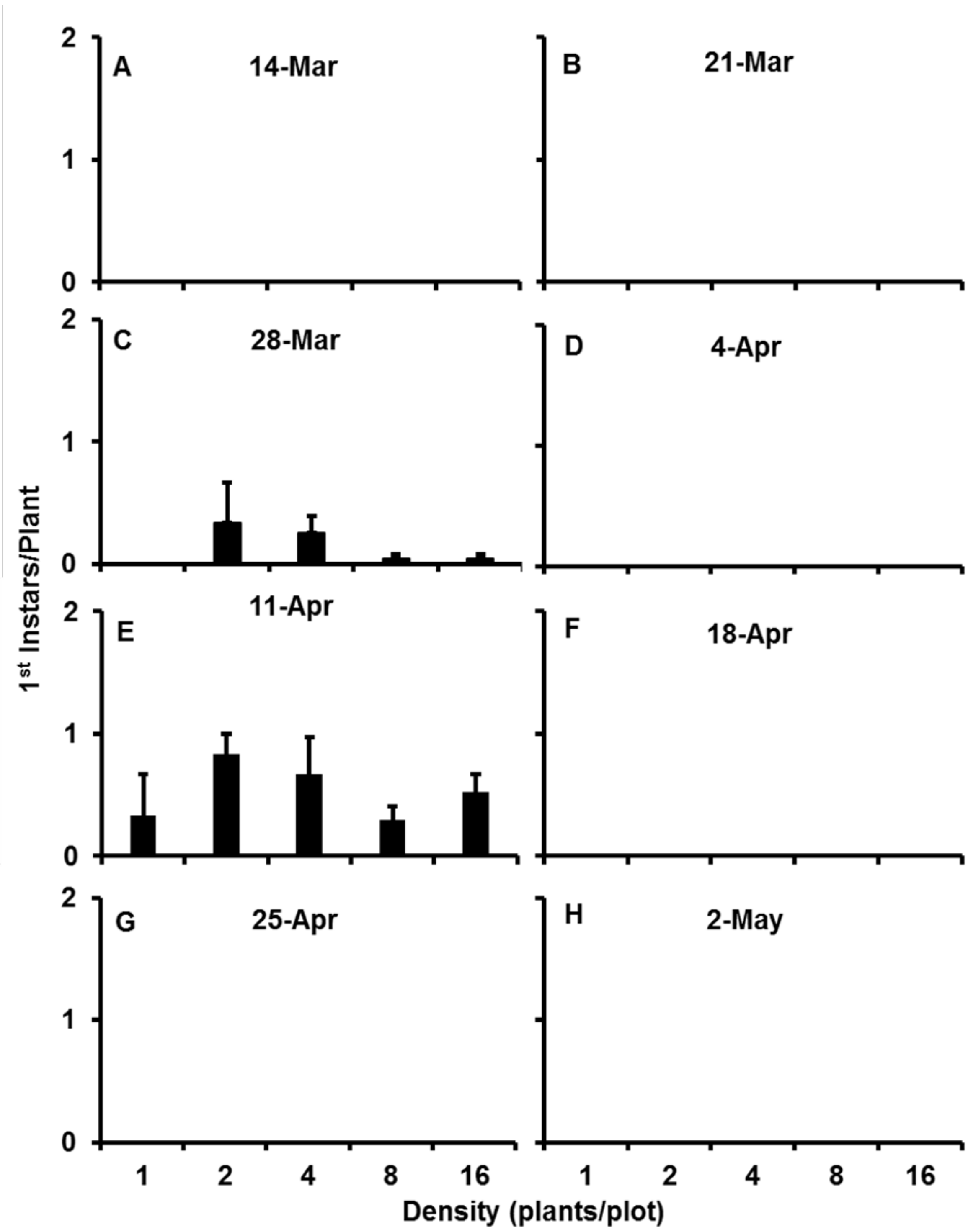

Figure 26. Mean number of *D. plexippus* first instars/plant by date for each clumped plant density treatment (n = 3). Error bars represent one standard error from the mean.

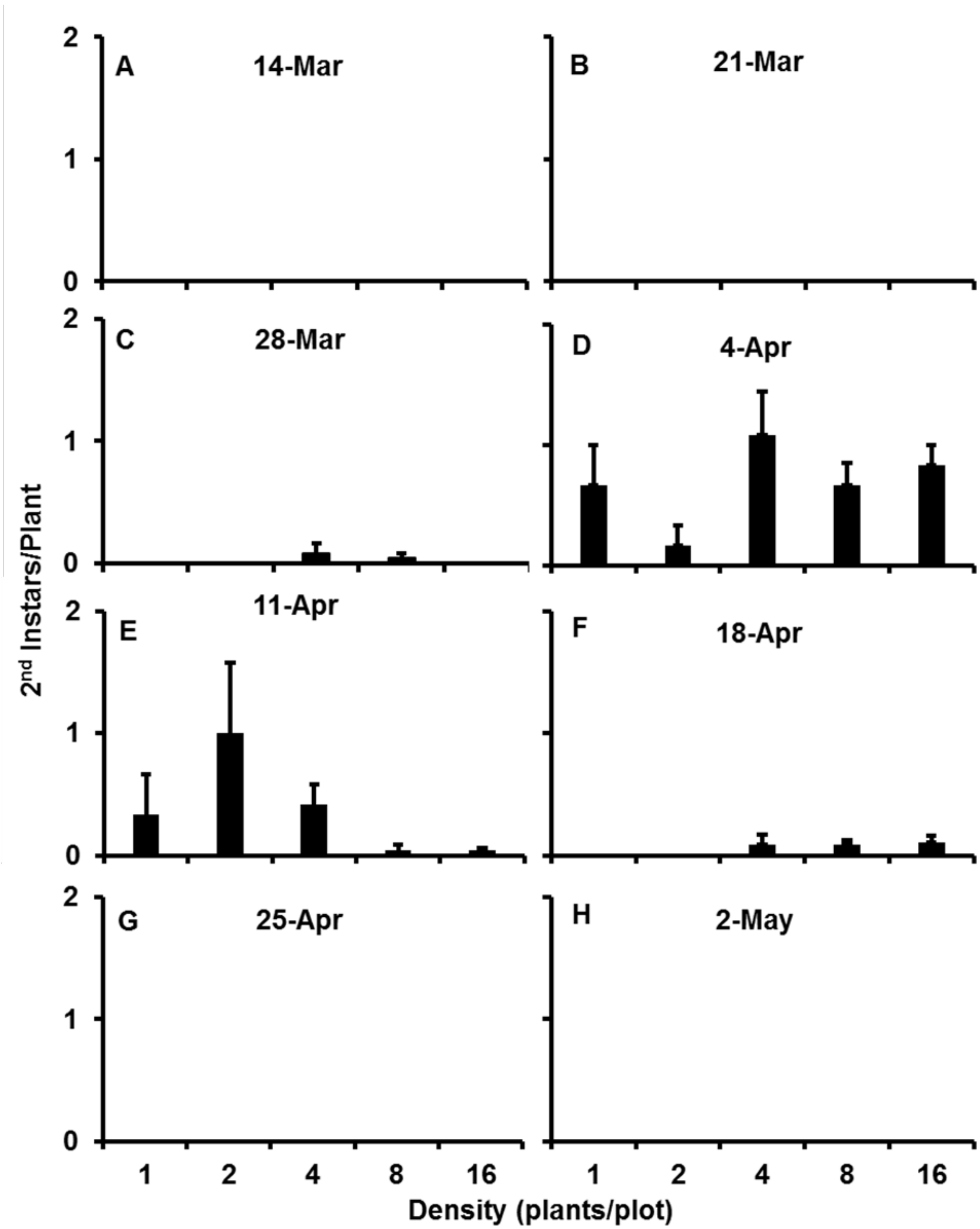

Figure 27. Mean number of *D. plexippus* second instars/plant by date for each clumped plant density treatment (n = 3). Error bars represent one standard error from the mean.

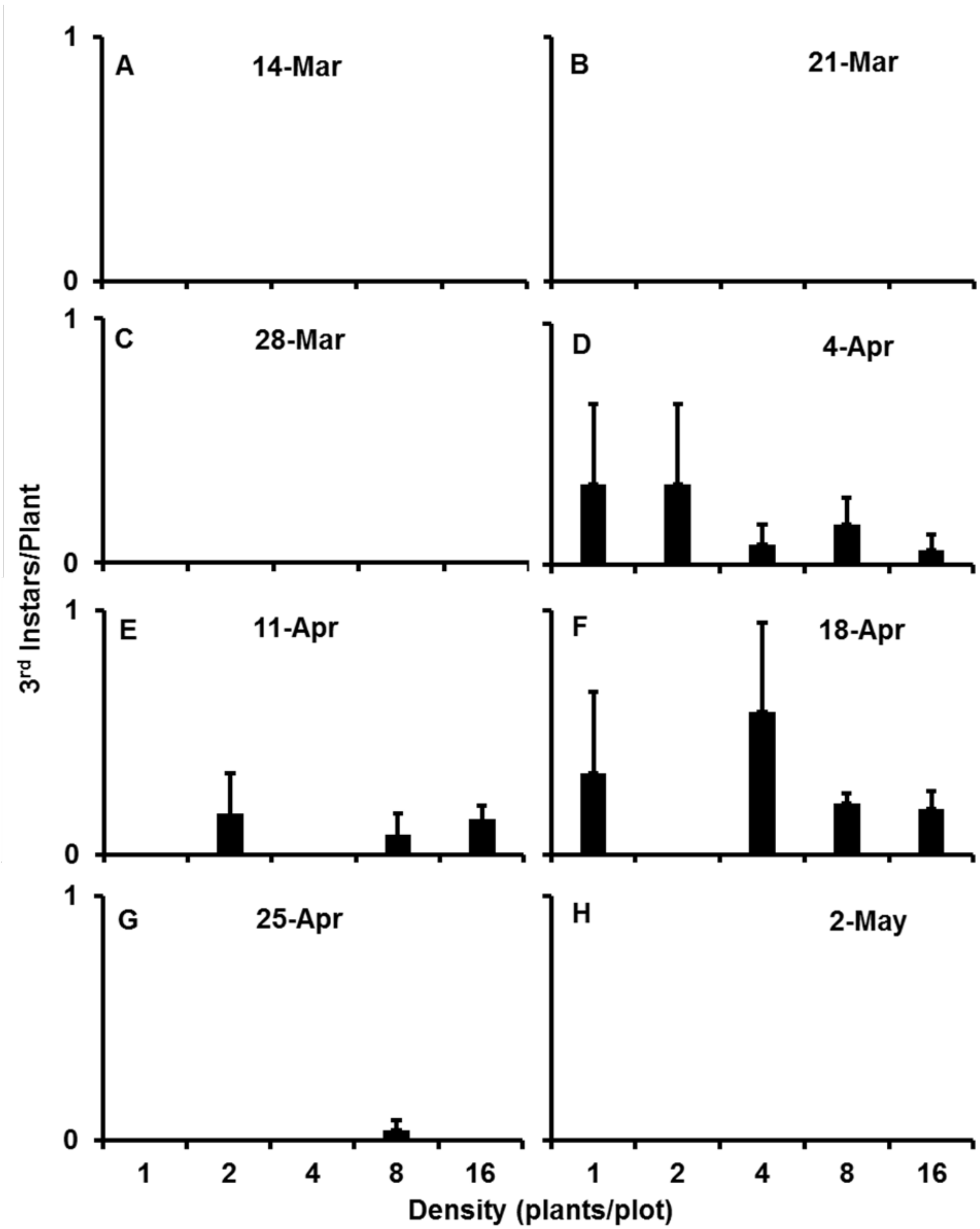

Figure 28. Mean number of *D. plexippus* third instars/plant by date for each clumped plant density treatment (n = 3). Error bars represent one standard error from the mean.

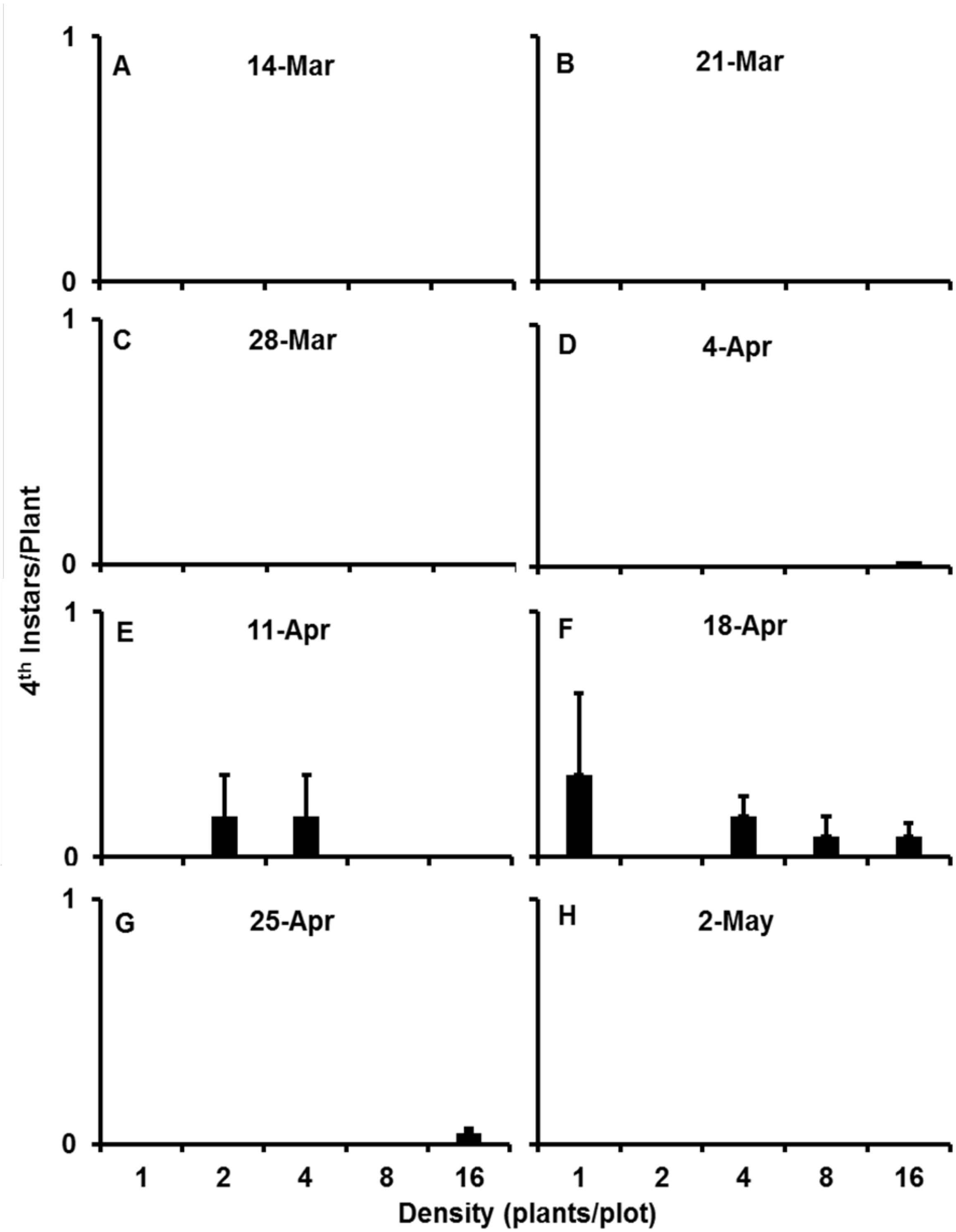

Figure 29. Mean number of *D. plexippus* fourth instars/plant by date for each clumped plant density treatment (n = 3). Error bars represent one standard error from the mean.

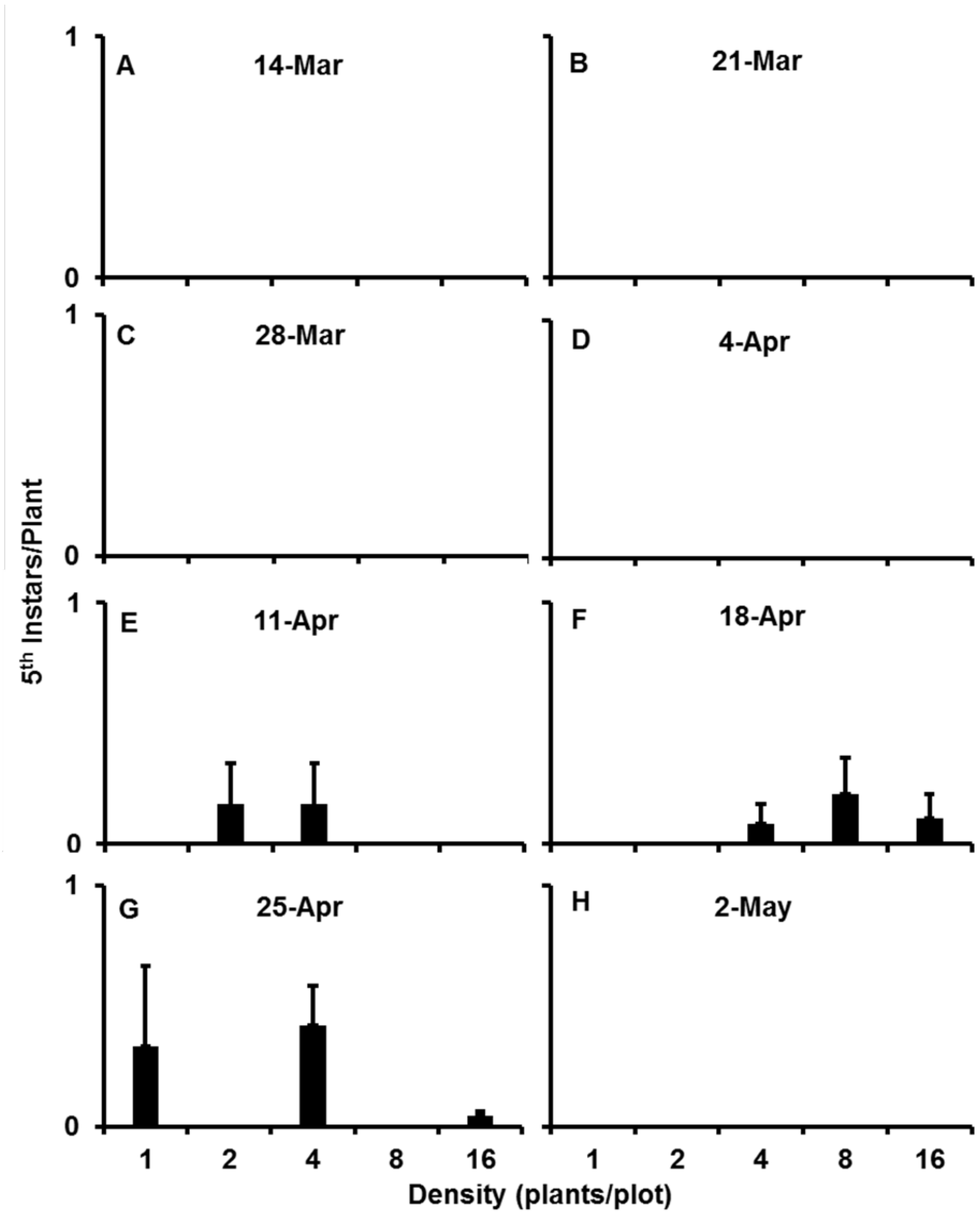

Figure 30. Mean number of *D. plexippus* fifth instars/plant by date for each clumped plant density treatment (n = 3). Error bars represent one standard error from the mean.

Reproduction as a function of milkweed spacing.

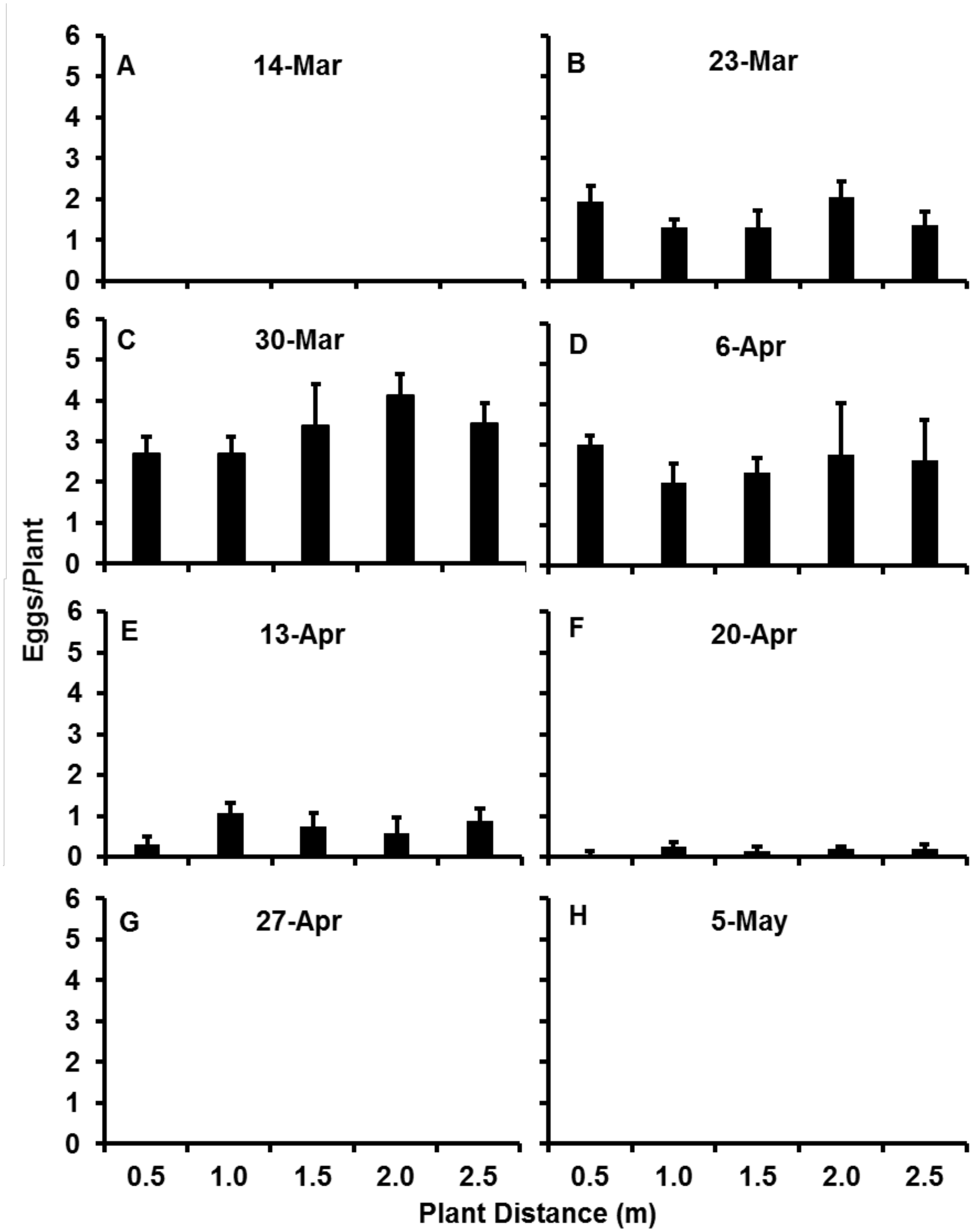

Figure 23. Mean number of *D. plexippus* eggs/plant by date for each spaced plant treatment (n = 4). Error bars represent one standard error from the mean.

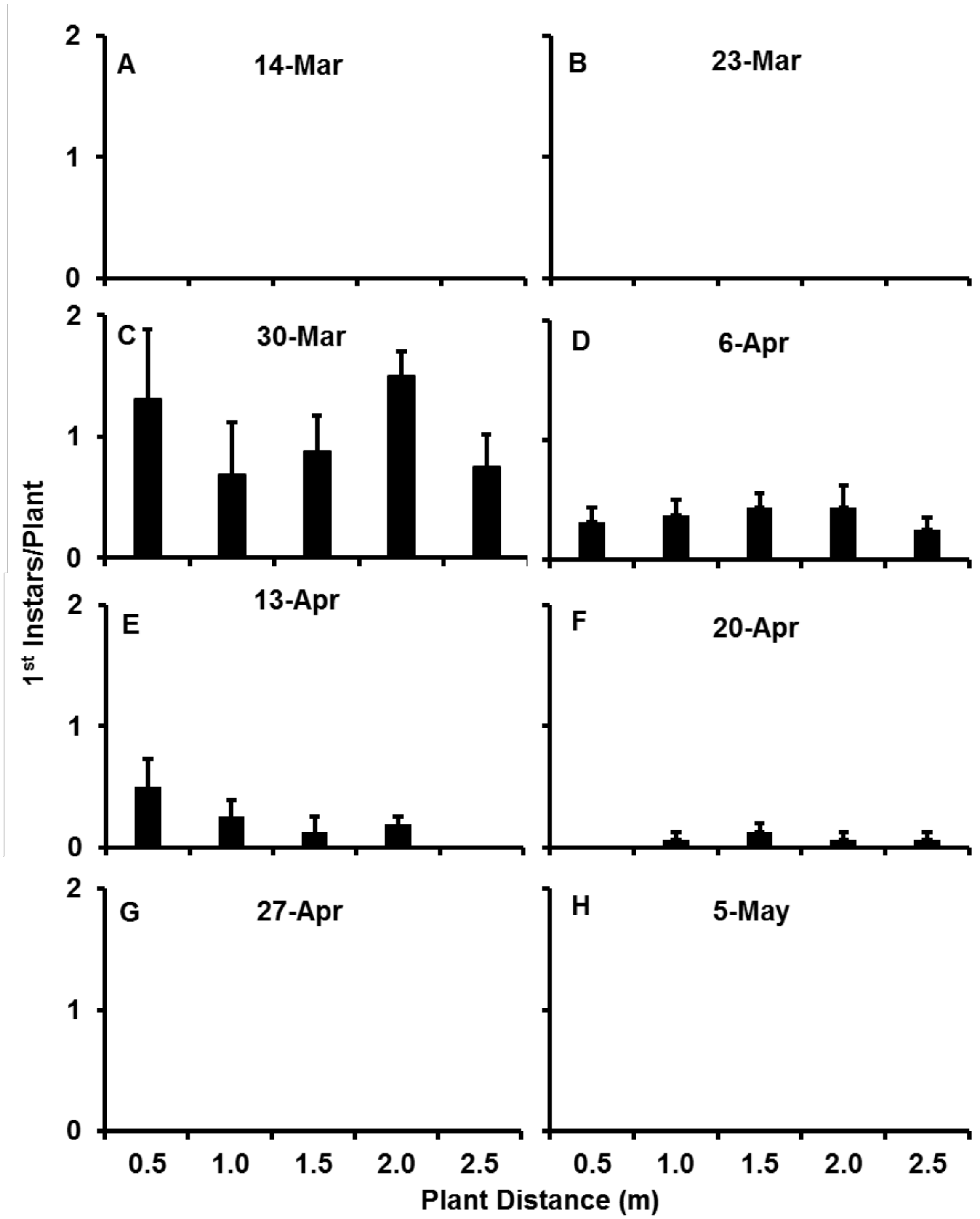

Figure 24. Mean number of *D. plexippus* first instars/plant by date for each spaced plant treatment (n = 4). Error bars represent one standard error from the mean.

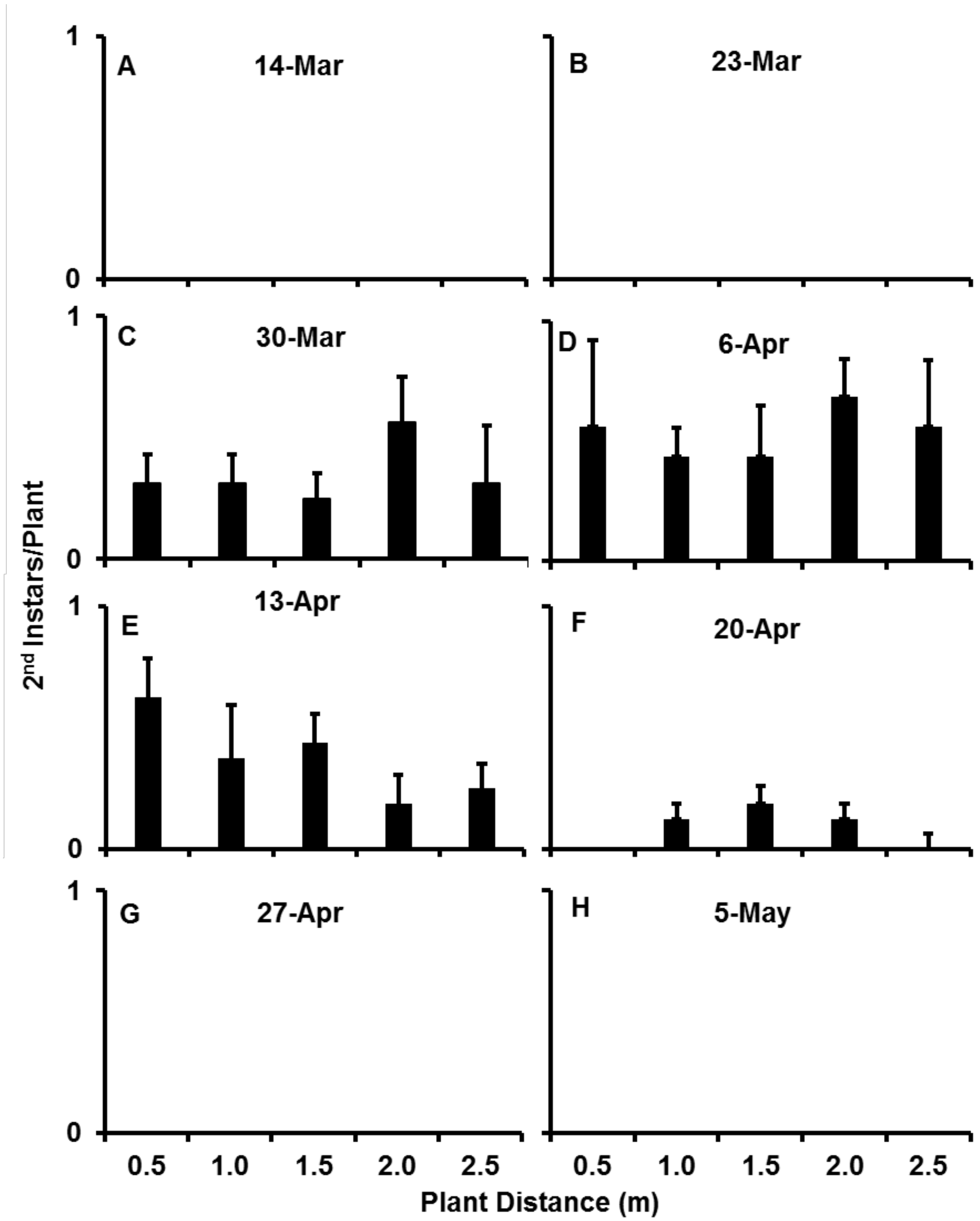

Figure 25. Mean number of *D. plexippus* second instars/plant by date for each spaced plant treatment (n = 4). Error bars represent one standard error from the mean.

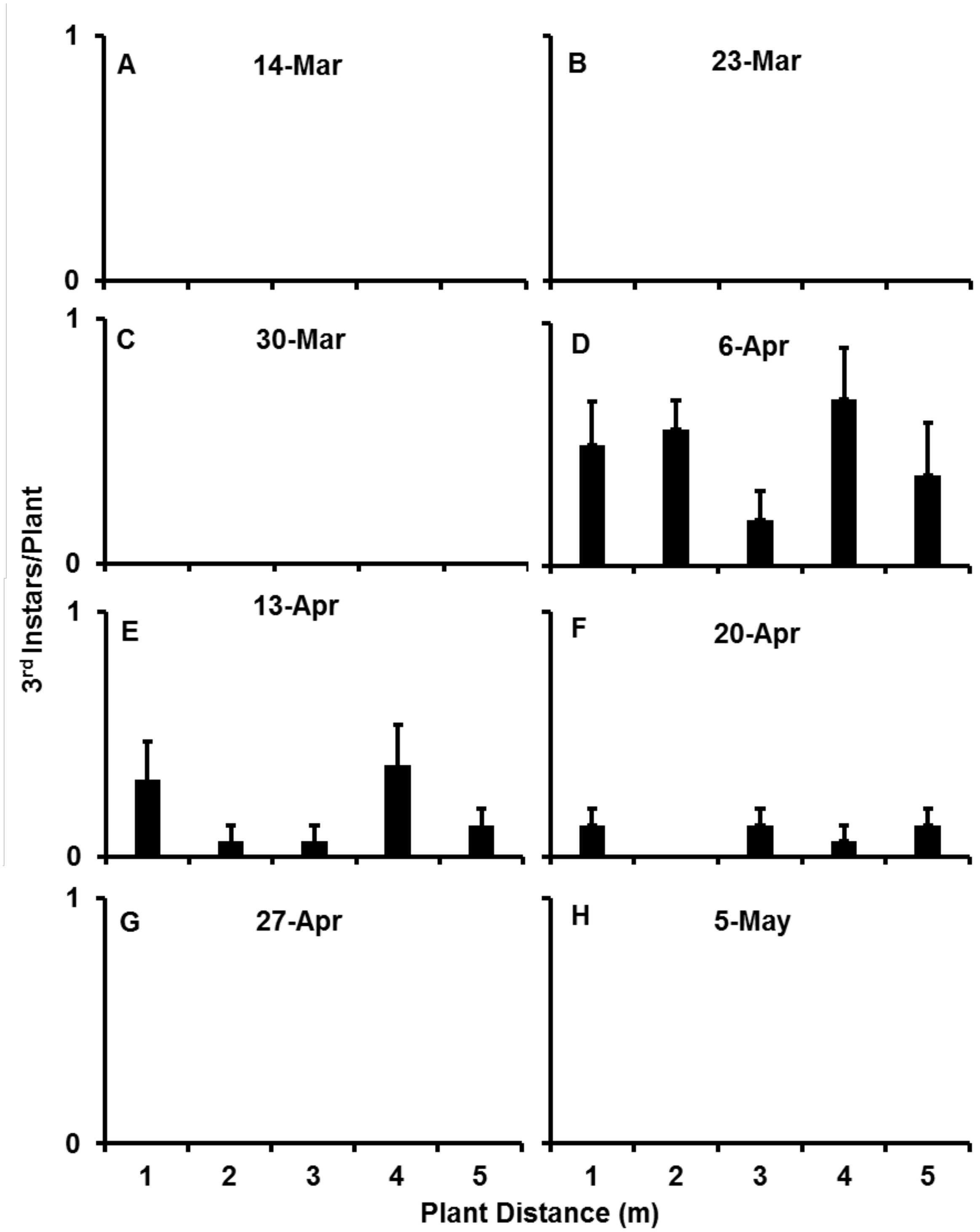

Figure 26. Mean number of *D. plexippus* third instars/plant by date for each spaced plant treatment (n = 4). Error bars represent one standard error from the mean.

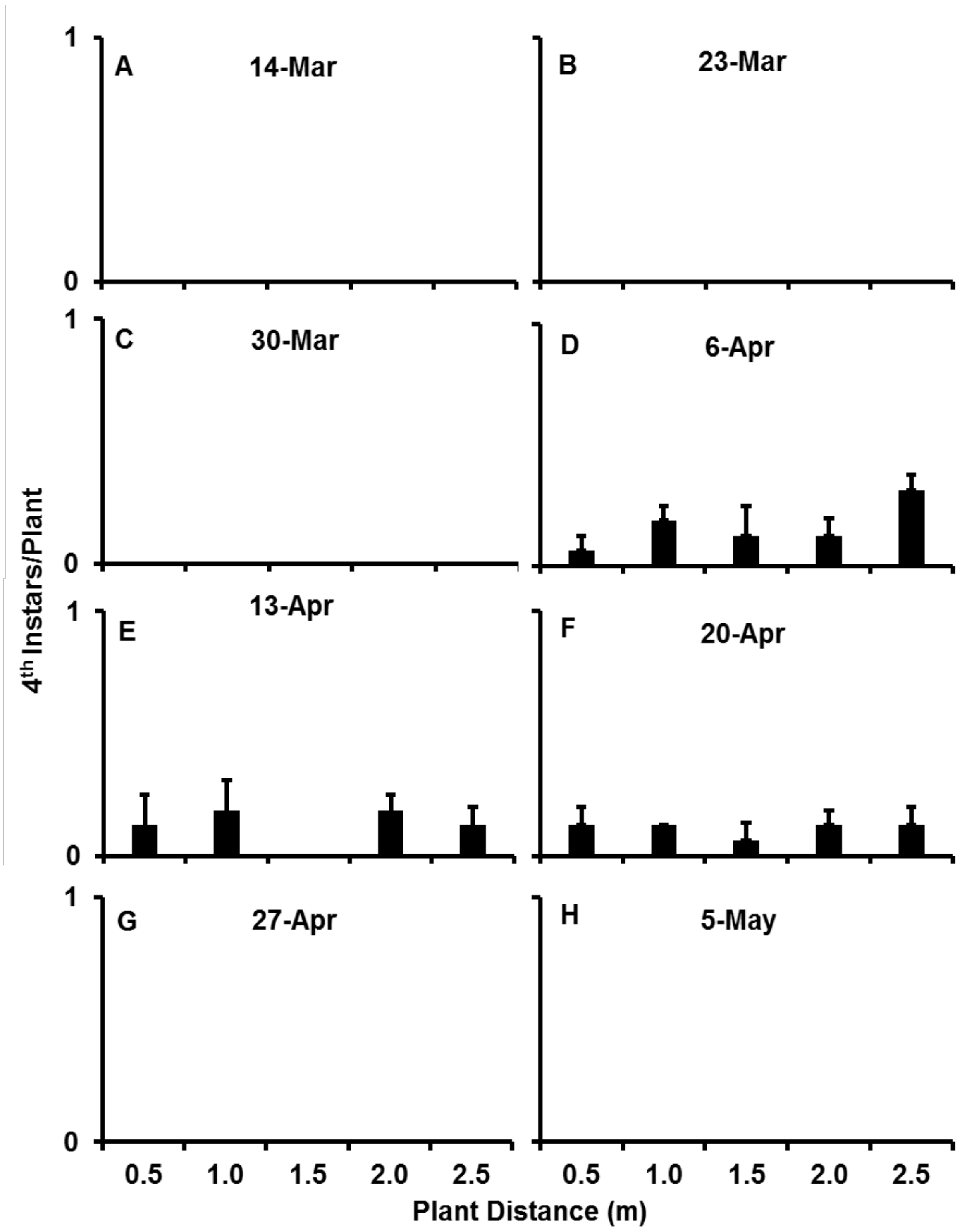

Figure 27. Mean number of *D. plexippus* fourth instars/plant by date for each spaced plant treatment (n = 4). Error bars represent one standard error from the mean.

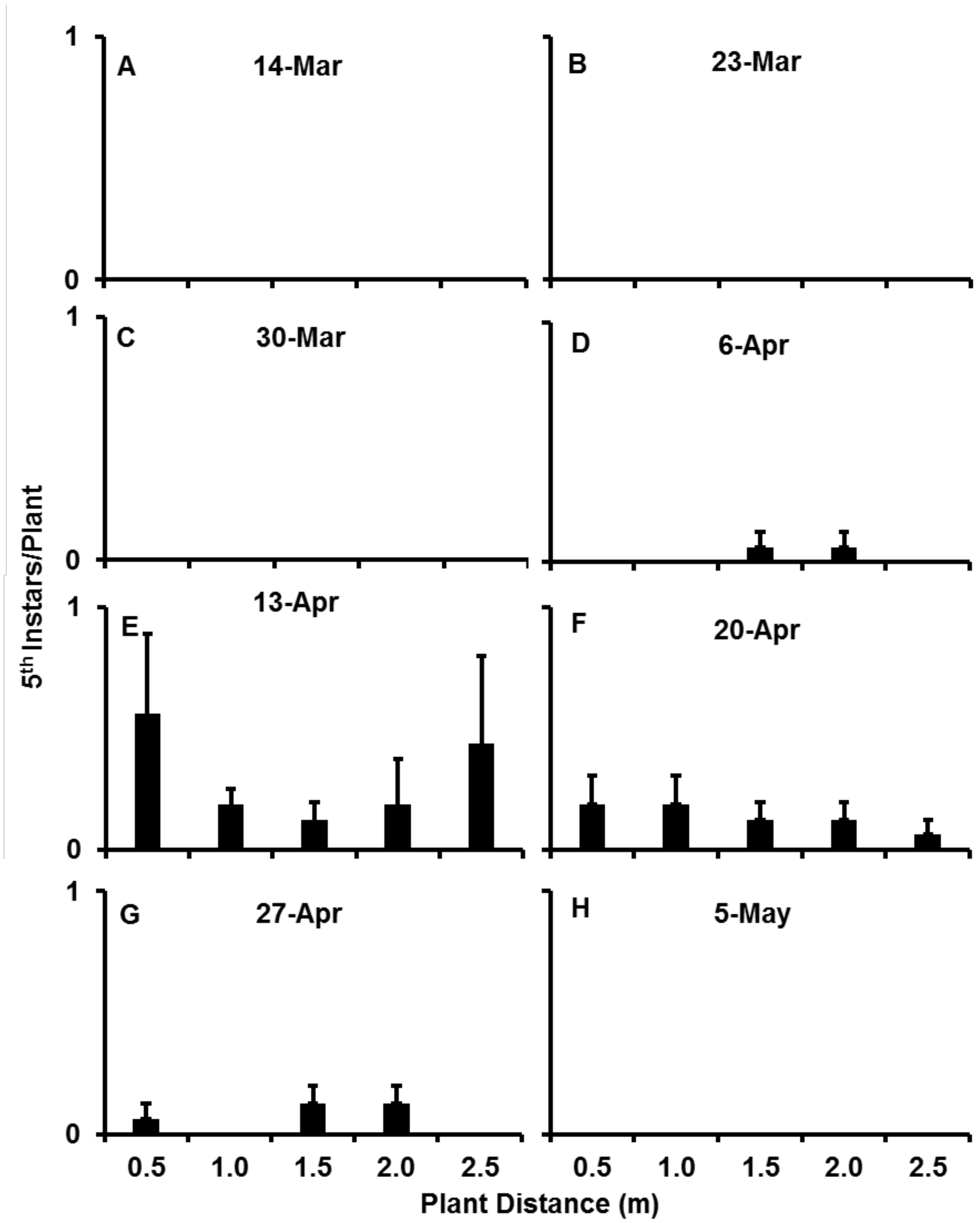

Figure 28. Mean number of *D. plexippus* fifth instars/plant by date for each spaced plant treatment (n = 4). Error bars represent one standard error from the mean.

Methods (Effects of Nectar Density on Monarch Reproduction – Experiment One)

Tropical milkweed (*Asclepias curassavica*) seeds obtained from a commercial seed source were sown into 13 cm x 13 cm pots containing a commercial potting mix (Miracle Gro® Moisture Control Potting Mix®). Four months after establishment, plants were used to establish milkweed patches in three configurations. On average plants were 17.2 ± 2.3 cm (mean ± standard deviation) in height and had 10 ± 2 leaves. No flowers were present on the plants.

Patches of tropical milkweed were established on a 2 hectare area in the Edward's Plateau Region of Texas (29°48'4.27" N, 98°44'18'18.36" W). The area is dominated by Hill Country Live Oak (*Quercus fusiformis*) with open areas dominated by Texas wintergrass (*Nasella leucotricha*). A large patch (150 m^2) of blooming Texas bluebonnets (*Lupinus texensis*.) was also in the study area. There were other potential sources of nectar, mainly from the family Asteraceae family.

Three replications of three milkweed patch-types were established on March 11, 2016. A patch was defined as three pots containing tropical milkweed (described above) arranged in a triangle. One patch-type contained the three milkweed pots and a fourth pot in the center of the triangle containing a penta (*Pentas lanceolata*), a species known to attract monarch butterflies (*Danaus plexippus*) (personal observation). A second patch-type contained only the three milkweed pots with the center area empty. The third patch-type contained the three milkweed placed in the large patch of Texas bluebonnets.

We observed the milkweed plants every few days and counted the number of eggs and larvae on each plant. The instar of the larvae was noted. The total number of eggs or larvae were determined for each patch-type replication. When no more eggs or larvae were found, the leaves were removed from each plant and the dry mass was determined.

We used one-way ANOVA to determine if eggs, 1st instar, 2nd star, 3rd instar, 4th instar, or 5th instar were significantly different among patch-type. We also used one-way ANOVA to determine if the amount of leaf tissue remaining differed among patch-type.

Results (Effects of Nectar Density on Monarch Reproduction – Experiment One)

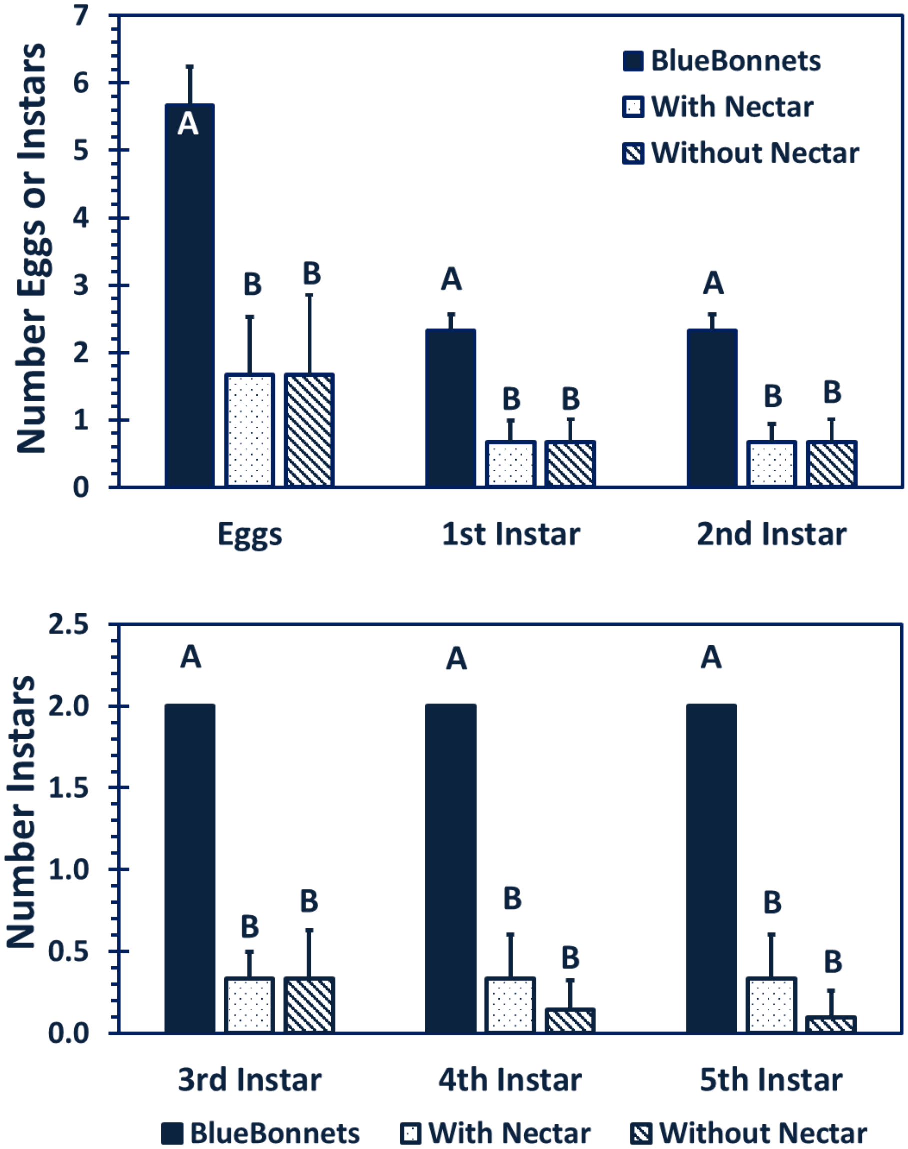

Figure 31. Number of eggs and instars in each of three treatments. Bars with the same letter are not significantly different. Error bars represent one standard deviation.

Methods (Effects of Nectar Density on Monarch Reproduction – Experiment Two)

We designed an experiment to evaluate the effects of nectar density on monarch reproduction. We selected a site (the Parman Ranch, 29°39.8495 N, 98°22.8375 W) on the southern edge of the Edward's Plateau in northern Bexar County (see) within an area dominated by Hill Country Live Oak (*Quercus fusiformis*) with open areas dominated by native Texas grasses. There were four densities of nectar plants (*Lantana* sp.): 4, 8, 16, and 25 plants/25 m^2; and one control (0 plants/25 m^2). One gallon potted *Lantana* were purchased from a commercial nursery and the pots were placed on landscape and water as needed. On Mar 31, 2017, we established 15, 5 x 5 m plots (5 treatments x 3 replications), with the *Lantana* evenly distributed. Each plot was at least 20 m from any other plot. Four milkweed (*Asclepias curassavica*) were placed in center of each plot, one meter apart. On April 3, 2017 we began monitoring each milkweed for monarch eggs and larvae, approximately every two days until April 26, 2017, when no more eggs or larvae were present. We compared the number of eggs and larvae by nectar density.

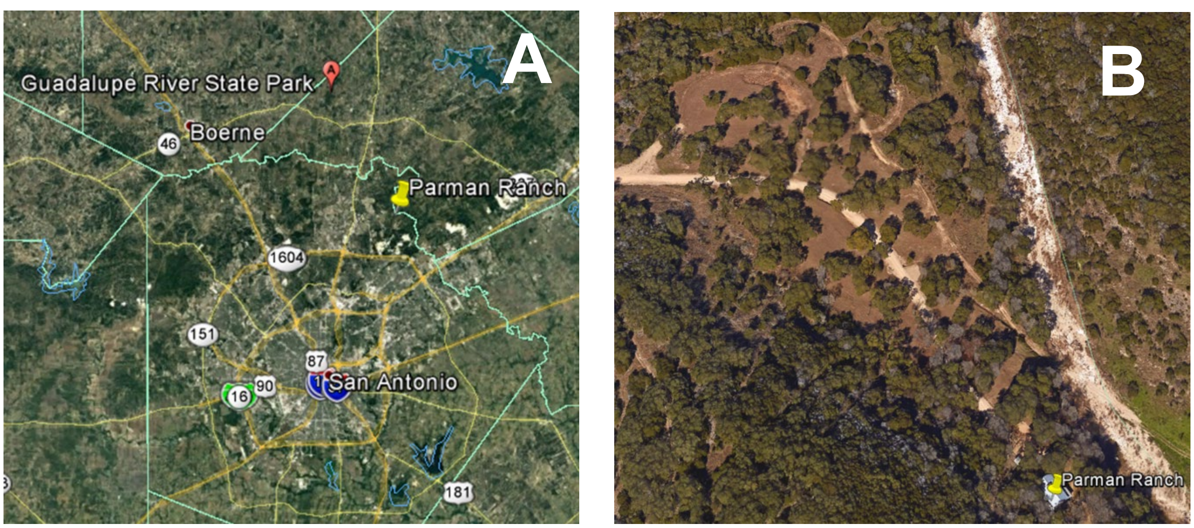

Figure 32. A) Map and B) aerial view of the Parman Ranch in northern Bexar County.

Results (Effects of Nectar Density on Monarch Reproduction – Experiment Two)

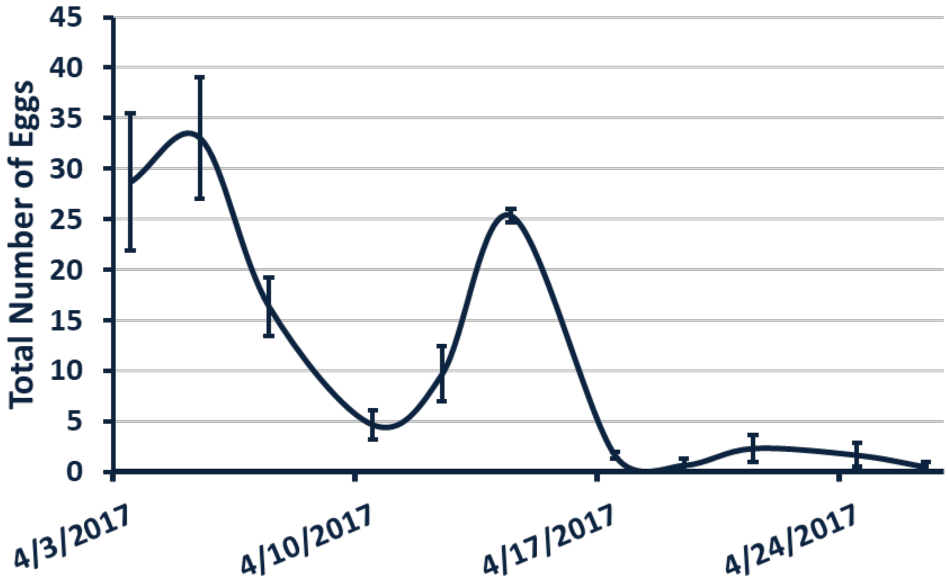

Figure 33. Number of monarch eggs as a function of day. Error bars represent one standard deviation.

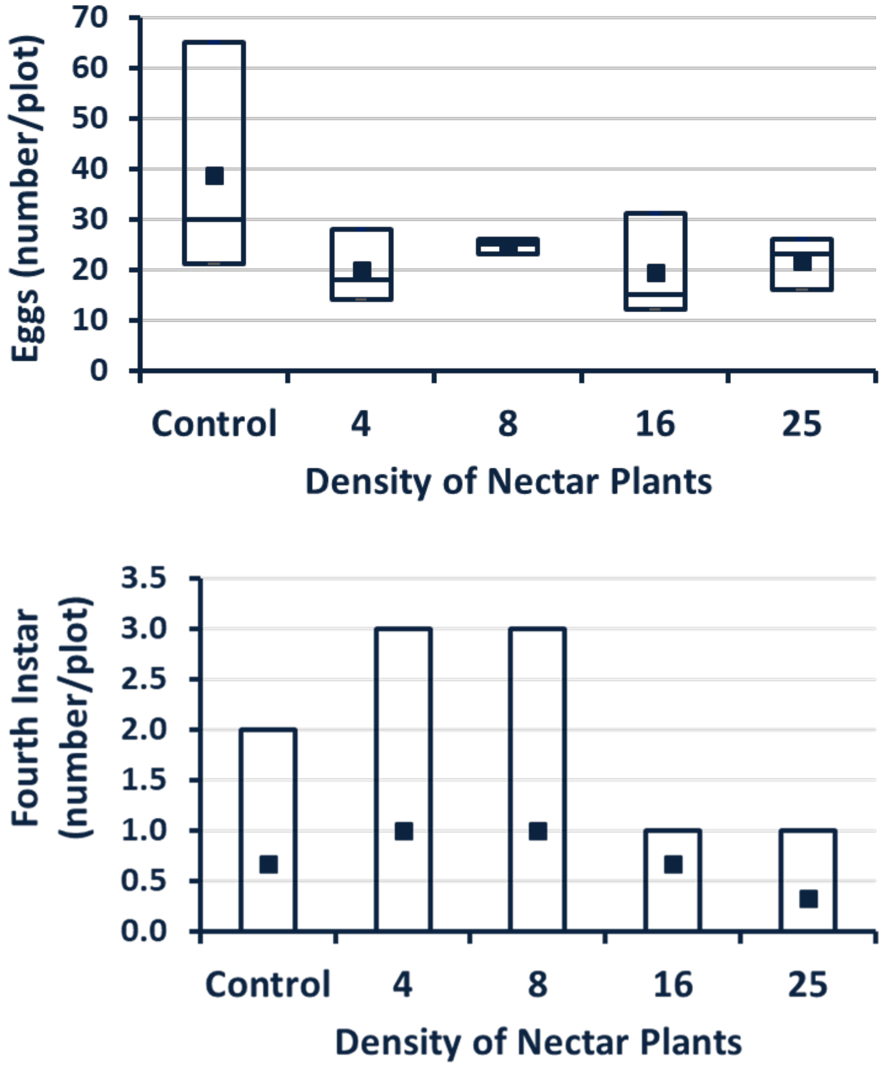

Figure 34. Box plots of eggs and fourth instars (numbers/25 m^2) as a function of various nectar densities. Presented are quantile plots.

Results (Effects of Nectar Density on Monarch Reproduction – Experiment Three)

In the third nectar density experiment, we selected a site within an ecotone between the Edward's Plateau and the South Texas Plain ecoregions in northern Bexar County (see Figure 35, 29°35.5090 N, 98°38.4620 W). There were four densities of nectar plants (*Lantana* sp.): 4, 8, 16, and 25 plants/9 m^2; and one control (0 plants/25 m^2). One gallon potted *Lantana* were purchased from a commercial nursery and the pots were placed on landscape and water as needed. On April 6, 2018, we established 15, 3 x 3 m plots (5 treatments x 3 replications), with the *Lantana* evenly distributed. Four milkweed (*Asclepias curassavica*) were placed in center of each plot, one meter apart. On April 9, 2018 we began monitoring each milkweed for monarch eggs and larvae, approximately every two days until May 14, 2018, when no more eggs or larvae were present. We compared the number of eggs and larvae by nectar density. Plants were watered as needed.

Figure 35. A) Map and B) aerial view of the study site in ecotone between Edward's Plateau and South Texas Plains Ecoregion in northern Bexar County.

Results (Effects of Nectar Density on Monarch Reproduction – Experiment Three)

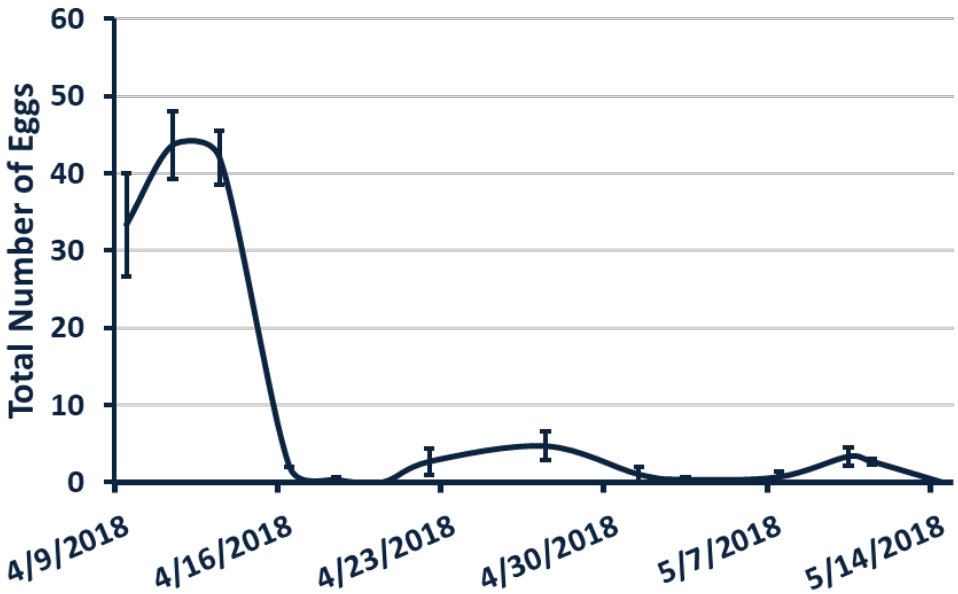

Figure 36. Number of monarch eggs as a function of day. Error bars represent one standard deviation.

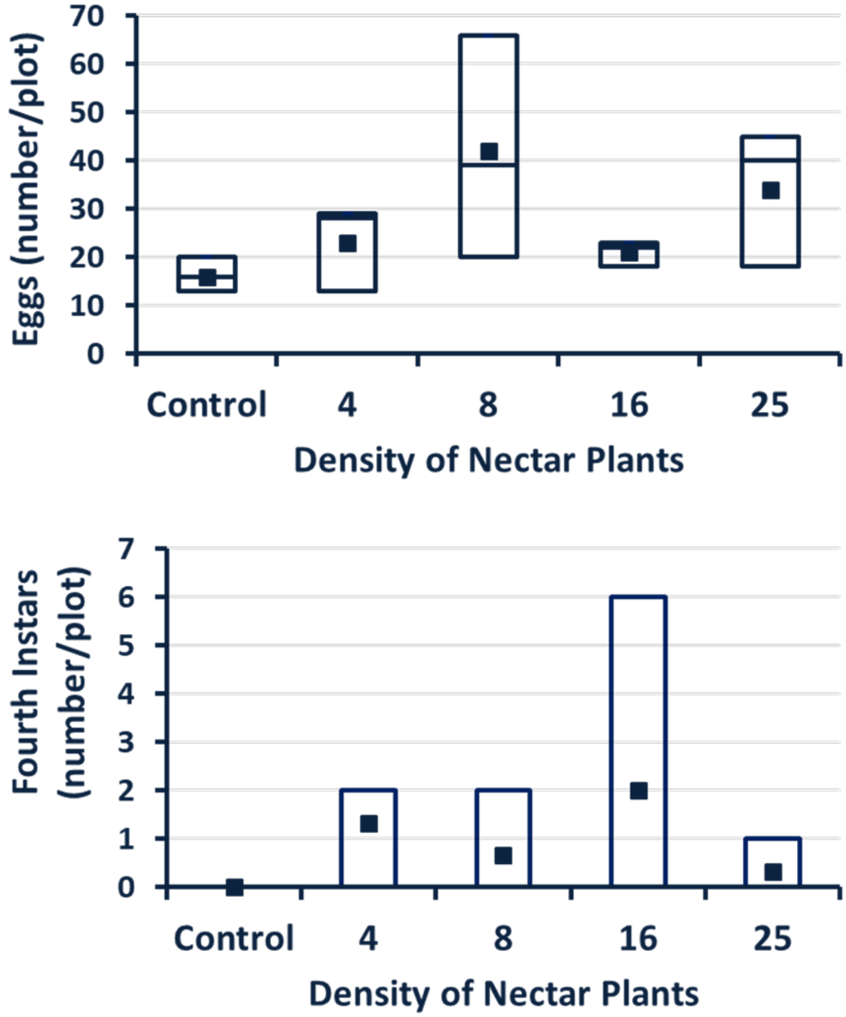

Figure 37. Box plots of eggs and fourth instars (numbers/9 m^2) as a function of various nectar densities. Presented are quantile plots.

Outreach

Table 20. Outreach activities from May 2015 through November 2018.

Start Date	Activity	Type	Number of Attendees
9/1/2015	Lion's Club Presentation	Presentation	15
10/1/2015	Alamo Heights and Terrel Hills garden Club	Presentation	25
1/13/2016	NoAh Project Event (Alamo Colleges)	Tabling	50
1/15/2016	City Council Chamber meeting with National Wildlife Federation	Proclamation	40
1/20/2016	San Antonio River Authority Office	Proclamation	50
1/23/2016	San Antonio girls Scout Troops	Presentation	25
2/16/2016	Greenhouse Tour	Presentation	10
2/16/2016	Glen Oaks Elementary	Presentation	100
2/18/2016	Villarreal Elementary	Presentation	150
2/22/2016	Galm elementary	Presentation	100
2/23/2016	Native Plant Society	Presentation	80
2/24/2016	Steubing Elementary	Presentation	45
2/25/2016	Henderson Elementary	Presentation	150
3/3/2016	San Antonio Zoo Monarch Migration Festival	Tabling/ Activity	10000
3/4/2016	Leon Valley Earthwise Living Day Festival	Tabling	100
3/12/2016	Spring Bloom Event	Tabling	50
3/18/2016	Texas A&M Agrilife Office	Presentation	25
4/28/2016	UTSA Mayor's Monarch Champion City Pledge	Presentation/Activity	200
7/11/2016	Monarch Butterfly Ecology Summer Camp	Summer Camp	30
7/29/2016	Texas Agrilife Junior Master Gardener Training	Presentation	150
8/9/2016	US Green Building Society Council	Presentation	30
9/1/2016	Lions Club of San Antonio	Presentation	20
9/17/2016	San Antonio Zoo Monarchs and Margaritas Festival	Tabling/ Activity	150
9/17/2016	Cibolo Nature Center, Science in Nature	Tabling/Activity	150
9/22/2016	Equinox Sustainability Event	Tabling	100
9/27/2016	Texas Agrilife Master Volunteer Specialist Training	Presentation	50
9/30/2016	City of San Antonio, Transportation and Capital Improvements Department	Presentation	25
10/7/2016	Sibley Nature Center	Presentation	50
10/11/2016	CEC National Workshop on Monarch Conservation Efforts	Collaborative Meeting	0
10/21/2016	Forest Hills Library Botany STEM Event	Presentation/Tabling	300

10/28/2016	TBG Landscape Architecture Firm/ National Wildlife Federation Habitat Stewardship Workshop	Presentation	50
10/31/2016	Alamo Area Monarch Collaborative Meeting	Collaborative Meeting	0
11/5/2016	Dairy Days at Phil Hardberger Park	Tabling/ Activity	300
12/5/2016	Alamo Area Monarch Collaborative Meeting	Collaborative Meeting	0
12/7/2016	Tri-national Monarch Mayors Pledge Workshop	Collaborative Meeting	0
2/9/2017	Alamo Area Monarch Collaborative Meeting	Collaborative Meeting	0
2/10/2017	Glen Oaks Elementary	Presentation	100
2/28/2017	Glen Oaks Elementary	Presentation/Activity	100
2/28/2017	Great Conversations Scholarship Program	Presentation	10
3/1/2017	Henderson Elementary	Presentation	150
3/3/2017	San Antonio Zoos Monarch Migration Festival	Tabling/ Activity	9000
3/3/2017	Family-friendly Monarch Butterfly Conservation Program at Hemisphere Park Monarch with BASF	Tabling	30
3/4/2017	Leon Valley Community Center	Tabling	100
3/4/2017	Leon Valley Earthwise Living Day Festival	Presentation/Activity	100
3/6/2017	CEC National Workshop on Monarch Conservation Efforts	Conference	150
3/10/2017	Oak Hills Terrace Elementary School	Presentation	30
3/24/2017	Homeschool Visit	Presentation	15
4/20/2017	Fabra Elementary	Presentation	30
4/27/2017	Alamo Area Monarch Collaborative Meeting	Collaborative Meeting	0
5/3/2017	First Wednesday Cappy's Breakfast	Presentation	30
5/31/2017	South-Central Monarch Symposium, Austin	Presentation	60
5/31/2017	UTSA Houston Alumni	Presentation	30
6/3/2017	Thousand Oaks Library Stem Event	Presentation	20
6/10/2017	Forest Hills Library STEM Event	Presentation	20
6/14/2017	KSAT INTERVIEW	Interview	0
6/17/2017	Tobin at Oakwell Farms Library	Presentation	20
6/24/2017	Mission Library	Presentation	20
7/10/2017	Monarch Butterfly Ecology Summer Camp	Summer Camp	55
7/19/2017	Monarch Joint Venture/Western sampling Idaho	Workshop	10
9/22/2017	Alamo Area Monarch Collaborative Meeting	Collaborative Meeting	0
9/23/2017	Science in Nature Back to School Event	Tabling/ Activity	30
10/4/2017	Universal City Public Library	Presentation	20

10/16/2017	Mayors Monarch Pledge Re-signing	Collaborative Meeting	50
10/22/2017	Monarch Festival At the Pearl	Tabling/Activity	1000
12/11/2017	Texan by Nature Working Group	Workshop	10
1/26/2018	Martin Elementary	Presentation	50
3/3/2018	San Antonio Zoo Monarch Migration Festival	Tabling/ Activity	9000
4/18/2018	Alamo Area Monarch Collaborative Meeting	Collaborative Meeting	0
7/9/2018	Monarch Butterfly Ecology Summer Camp	Summer Camp	60
9/12/2018	State Comptroller Meeting	Presentation	30
9/14/2018	Alamo Area Monarch Collaborative Meeting	Collaborative Meeting	0
9/26/2018	Horseshoe Bay	Presentation	30
10/6/2018	Phil Hardberger Park Conservancy Tree-Centennial Festival	Tabling/ Activity	50
10/19/2018	Butterflies Without Boarders	Tabling	150
10/20/2018	Witte Museum	Tabling/Activity	50
10/21/2018	Monarch Festival At the Pearl	Tabling/ Activity	1000
11/3/2018	Kirchoff Prairie	Presentation	20
11/1/2018	Oakes Club	Presentation	20
11/28/2018	Monarch Joint Venture and Midwest Association of Fish and Wildlife Agencies Conservation Partners Meeting	Collaborative Meeting	120
		Total	**34050**

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Appendix I - Roadside Survey Site Locations

Table 21. Counties, Ecoregions, Latitudes, and Longitude for all Roadside Surveys for each Sampling Time

Ecoregion	County	Longitude	Latitude
Spring 2016			
Black Land Prairie	Grimes	-95.9205	30.5961
Cross Timbers	Archer	-98.2561	33.7886
Cross Timbers	Archer	-98.2396	33.6809
Cross Timbers	Burnett	-98.2207	30.6626
Cross Timbers	Burnett	-98.1916	30.8121
Cross Timbers	Burnett	-98.1764	30.9530
Cross Timbers	Erath	-98.1751	32.1923
Cross Timbers	Erath	-98.1153	32.3440
Cross Timbers	Erath	-98.1662	32.4853
Cross Timbers	Erath	-98.1406	32.0819
Cross Timbers	Hamilton	-98.0427	31.5226
Cross Timbers	Hamilton	-98.1013	31.6641
Cross Timbers	Hamilton	-98.1754	31.4923
Cross Timbers	Hamilton	-98.1744	31.9583
Cross Timbers	Jack	-98.1361	33.3865
Cross Timbers	Jack	-98.1062	33.2683
Cross Timbers	Jack	-98.1057	33.1917
Cross Timbers	Jack	-98.0724	33.0705
Cross Timbers	Lampasas	-98.0662	31.0971
Cross Timbers	Lampasas	-98.1385	31.2370
Cross Timbers	Lampasas	-98.2790	31.3874
Cross Timbers	Palo Pinto	-98.3633	32.6339
Cross Timbers	Palo Pinto	-98.4706	32.7712
Cross Timbers	Palo Pinto	-98.4826	32.9269
Edwards Plateau	Blanco	-98.4479	29.9857
Edwards Plateau	Blanco	-98.7064	29.9857
Edwards Plateau	Blanco	-98.9111	30.1498
Edwards Plateau	Blanco	-98.5568	30.2580
Edwards Plateau	Blanco	-98.4086	30.3977
Edwards Plateau	Blanco	-98.4086	30.1900
Edwards Plateau	Burnett	-98.8257	30.5310
Edwards Plateau	Crocket	-99.0366	30.7097
Edwards Plateau	Hays	-99.1805	30.2059

Ecoregion	County	Longitude	Latitude
Edwards Plateau	Kendall	-98.3947	29.9828
Edwards Plateau	Kendall	-99.3031	29.9969
Edwards Plateau	Kendall	-98.3265	29.9801
Edwards Plateau	Kendall	-98.1296	29.9836
Edwards Plateau	Kendall	-99.4660	29.9634
Edwards Plateau	Kerr	-98.3913	30.2570
Edwards Plateau	Kerr	-99.5877	30.1833
Edwards Plateau	Kerr	-98.3604	30.1076
Edwards Plateau	Kerr	-99.7173	30.0544
Edwards Plateau	Kimble	-100.1715	30.4942
Edwards Plateau	Kimble	-100.3199	30.5245
Edwards Plateau	Kimble	-100.0193	30.4443
Edwards Plateau	Kimble	-99.8334	30.3444
Edwards Plateau	Sutton	-98.2834	30.6204
Edwards Plateau	Sutton	-100.4985	30.5863
Edwards Plateau	Sutton	-100.6659	30.5553
Edwards Plateau	Sutton	-100.8349	30.4786
Edwards Plateau	Sutton	-101.1647	30.4524
Piney Woods	Jasper	-95.7752	30.8650
Piney Woods	Jasper	-95.6928	30.9467
Piney Woods	Polk	-95.4787	30.7987
Piney Woods	Polk	-94.8852	30.7105
Piney Woods	San Jacinto	-95.3014	30.7441
Piney Woods	San Jacinto	-94.5970	30.7654
Piney Woods	Tyler	-95.2702	30.7522
Piney Woods	Tyler	-94.4431	30.7716
Piney Woods	Tyler	-95.0579	30.8385
Piney Woods	Walker	-94.2804	30.6764
Piney Woods	Walker	-94.1201	30.6855
Piney Woods	Walker	-93.9959	30.7059
Post Oak Savanah	Atascosa	-98.4793	29.0200
Post Oak Savanah	Bastrop	-98.8490	30.2152
Post Oak Savanah	Brazos	-97.1416	30.6623
Post Oak Savanah	Burleson	-97.0433	30.4196
Post Oak Savanah	Burleson	-96.9295	30.5186
Post Oak Savanah	Burleson	-96.8073	30.6109
Post Oak Savanah	Grimes	-96.7236	30.5950
Post Oak Savanah	Lee	-96.0605	30.2305
Post Oak Savanah	Lee	-96.5685	30.3202

Ecoregion	County	Longitude	Latitude
Post Oak Savanah	Medina	-96.4188	29.1794
Rolling Plains	Archer	-98.4465	33.5028
South Texas Plains	Atascosa	-99.4432	28.8602
South Texas Plains	Atascosa	-98.1073	28.7323
South Texas Plains	Bexar	-98.0886	29.2570
South Texas Plains	Frio	-99.3952	28.7100
South Texas Plains	Frio	-99.3587	28.8508
South Texas Plains	Frio	-98.0968	29.0078
South Texas Plains	Jim Wells	-99.3177	27.7632
South Texas Plains	Jim Wells	-98.1046	28.0509
South Texas Plains	Jim Wells	-99.2850	27.9036
South Texas Plains	La Salle	-98.1228	28.1758
South Texas Plains	La Salle	-99.2337	28.2785
South Texas Plains	La Salle	-98.1795	28.4595
South Texas Plains	La Salle	-99.2005	28.5699
South Texas Plains	Live Oak	-98.2336	28.6056
South Texas Plains	Live Oak	-99.1587	28.4898
South Texas Plains	Live Oak	-98.2980	28.3393
South Texas Plains	Live Oak	-99.1100	28.1928
South Texas Plains	Medina	-98.3858	29.0899
South Texas Plains	Webb	-99.0588	27.7436
South Texas Plains	Webb	-98.9556	27.9051
South Texas Plains	Webb	-98.7236	28.0291
Spring 2017			
Black Land Prairie	Grimes	-95.8539	30.6445
Cross Timbers	Archer	-98.4826	33.7886
Cross Timbers	Archer	-98.4706	33.6809
Cross Timbers	Burnet	-98.2561	30.6626
Cross Timbers	Burnet	-98.2396	30.8121
Cross Timbers	Burnet	-98.2207	30.9530
Cross Timbers	Erath	-98.1754	32.1923
Cross Timbers	Erath	-98.1744	32.3440
Cross Timbers	Erath	-98.1361	32.4853
Cross Timbers	Erath	-98.1013	32.0819
Cross Timbers	Hamilton	-98.1662	31.5226
Cross Timbers	Hamilton	-98.1406	31.6641
Cross Timbers	Hamilton	-98.1153	31.4923
Cross Timbers	Hamilton	-98.0427	31.9583
Cross Timbers	Jack	-98.3633	33.3865

Ecoregion	County	Longitude	Latitude
Cross Timbers	Jack	-98.2790	33.2683
Cross Timbers	Jack	-98.1385	33.1917
Cross Timbers	Jack	-98.0662	33.0705
Cross Timbers	Lampasas	-98.1916	31.0971
Cross Timbers	Lampasas	-98.1764	31.2370
Cross Timbers	Lampasas	-98.1751	31.3874
Cross Timbers	Palo Pinto	-98.1062	32.6339
Cross Timbers	Palo Pinto	-98.1057	32.7712
Cross Timbers	Palo Pinto	-98.0724	32.9269
Edwards Plateau	Blanco	-98.4135	29.9769
Edwards Plateau	Blanco	-98.4129	30.1207
Edwards Plateau	Blanco	-98.4086	29.9857
Edwards Plateau	Blanco	-98.3913	30.2580
Edwards Plateau	Blanco	-98.3604	30.3977
Edwards Plateau	Blanco	-98.2947	30.2094
Edwards Plateau	Burnet	-98.2834	30.5310
Edwards Plateau	Crockett	-101.1647	30.7097
Edwards Plateau	Hays	-98.1386	30.2064
Edwards Plateau	Kendall	-98.9111	29.9828
Edwards Plateau	Kendall	-98.8396	29.9943
Edwards Plateau	Kendall	-98.7064	29.9801
Edwards Plateau	Kendall	-98.5515	29.9834
Edwards Plateau	Kerr	-99.4660	30.2570
Edwards Plateau	Kerr	-99.3031	30.1833
Edwards Plateau	Kerr	-99.1805	30.1076
Edwards Plateau	Kerr	-99.0366	30.0544
Edwards Plateau	Kimble	-100.0193	30.4942
Edwards Plateau	Kimble	-99.8334	30.5245
Edwards Plateau	Kimble	-99.7173	30.4443
Edwards Plateau	Kimble	-99.5877	30.3444
Edwards Plateau	Kinney	-100.4951	30.5545
Edwards Plateau	Sutton	-100.8349	30.6204
Edwards Plateau	Sutton	-100.6659	30.5863
Edwards Plateau	Sutton	-100.4985	30.5553
Edwards Plateau	Sutton	-100.3199	30.4786
Edwards Plateau	Sutton	-100.1715	30.4512
Piney Woods	Jasper	-94.1070	30.8700
Piney Woods	Jasper	-93.9924	30.9619
Piney Woods	Jasper	-93.9869	31.0948

Ecoregion	County	Longitude	Latitude
Piney Woods	Polk	-95.0605	30.8015
Piney Woods	Polk	-94.9726	30.7276
Piney Woods	Polk	-94.7632	30.6983
Piney Woods	Polk	-94.6127	30.7500
Piney Woods	Sabine	-93.9856	31.2309
Piney Woods	San Jacinto	-95.1999	30.7615
Piney Woods	Tyler	-94.4456	30.7706
Piney Woods	Tyler	-94.2673	30.8416
Piney Woods	Walker	-95.7087	30.6844
Piney Woods	Walker	-95.5140	30.7119
Piney Woods	Walker	-95.3867	30.7305
Post Oak Savanah	Atascosa	-98.4795	29.0205
Post Oak Savanah	Bastrop	-97.2616	30.1334
Post Oak Savanah	Bastrop	-97.1105	30.2180
Post Oak Savanah	Bexar	-98.4831	29.1514
Post Oak Savanah	Brazos	-96.4797	30.6489
Post Oak Savanah	Burleson	-96.7529	30.4900
Post Oak Savanah	Burleson	-96.6260	30.5879
Post Oak Savanah	Grimes	-96.1564	30.6038
Post Oak Savanah	Grimes	-95.9757	30.5909
Post Oak Savanah	Lee	-96.9641	30.2730
Post Oak Savanah	Lee	-96.8595	30.3791
Post Oak Savanah	Medina	-98.9319	29.1092
Rolling Plains	Archer	-98.4465	33.5028
South Texas Plains	Atascosa	-98.4337	28.9454
South Texas Plains	Atascosa	-98.3527	28.8122
South Texas Plains	Atascosa	-98.2918	28.6873
South Texas Plains	Bexar	-98.3670	29.2778
South Texas Plains	Dimmit	-99.5582	28.5734
South Texas Plains	Dimmit	-99.4230	28.5365
South Texas Plains	Frio	-99.1470	28.7355
South Texas Plains	Frio	-99.1132	28.8756
South Texas Plains	Frio	-99.0593	29.0103
South Texas Plains	Jim Wells	-98.0926	27.9748
South Texas Plains	Jim Wells	-98.0924	28.0181
South Texas Plains	Jim Wells	-98.0833	27.8201
South Texas Plains	Kinney	-100.6348	29.3634
South Texas Plains	Kinney	-100.3170	29.2788
South Texas Plains	Kinney	-100.1495	29.2370

Ecoregion	County	Longitude	Latitude
South Texas Plains	La Salle	-99.3253	28.1548
South Texas Plains	La Salle	-99.2912	28.4670
South Texas Plains	La Salle	-99.2789	28.2986
South Texas Plains	La Salle	-99.2343	28.4583
South Texas Plains	La Salle	-99.2104	28.4252
South Texas Plains	La Salle	-99.1917	28.5989
South Texas Plains	La Salle	-99.0996	28.3233
South Texas Plains	La Salle	-99.0227	28.2015
South Texas Plains	La Salle	-98.8459	28.2021
South Texas Plains	Live Oak	-98.2120	28.5891
South Texas Plains	Live Oak	-98.1828	28.0897
South Texas Plains	Live Oak	-98.1732	28.4131
South Texas Plains	Live Oak	-98.1104	28.2631
South Texas Plains	Live Oak	-98.1003	28.1144
South Texas Plains	McMullen	-98.6785	28.1695
South Texas Plains	McMullen	-98.5245	28.1253
South Texas Plains	McMullen	-98.3434	28.1047
South Texas Plains	Medina	-98.8118	29.2090
South Texas Plains	Sutton	-100.4774	29.3257
South Texas Plains	Uvalde	-99.9716	29.2220
South Texas Plains	Uvalde	-99.7771	29.1840
South Texas Plains	Val Verde	-100.7504	29.3841
South Texas Plains	Webb	-99.4858	27.6471
South Texas Plains	Webb	-99.4278	27.7746
South Texas Plains	Webb	-99.4009	27.8701
South Texas Plains	Webb	-99.3644	28.0106
South Texas Plains	Zavala	-99.7086	29.0659
South Texas Plains	Zavala	-99.6300	28.8128
South Texas Plains	Zavala	-99.6093	28.9348
South Texas Plains	Zavala	-99.5688	28.7153
Spring 2018			
Cross Timbers	Archer	-98.4550	33.6405
Cross Timbers	Burnet	-98.2394	30.8134
Cross Timbers	Burnet	-98.2394	30.8134
Cross Timbers	Burnet	-98.2394	30.8134
Cross Timbers	Burnet	-98.2552	30.6752
Cross Timbers	Erath	-98.1755	32.3683
Cross Timbers	Erath	-98.1855	32.2097
Cross Timbers	Hamilton	-98.1111	32.1019

Ecoregion	County	Longitude	Latitude
Cross Timbers	Hamilton	-98.0373	31.9693
Cross Timbers	Hamilton	-98.1135	31.8465
Cross Timbers	Hamilton	-98.1404	31.6645
Cross Timbers	Hamilton	-98.1490	31.5212
Cross Timbers	Hamilton	-98.1490	31.5212
Cross Timbers	Hood	-98.1306	32.5113
Cross Timbers	Jack	-98.3645	33.3902
Cross Timbers	Jack	-98.2829	33.2715
Cross Timbers	Jack	-98.1381	33.1914
Cross Timbers	Jack	-98.0657	33.0748
Cross Timbers	Lampasas	-98.1767	31.3787
Cross Timbers	Lampasas	-98.1756	31.2320
Cross Timbers	Lampasas	-98.1756	31.2320
Cross Timbers	Lampasas	-98.1902	31.0930
Cross Timbers	Lampasas	-98.1902	31.0930
Cross Timbers	Lampasas	-98.2195	30.9549
Cross Timbers	Mineral Wells	-98.0700	32.9327
Cross Timbers	Mineral Wells	-98.1097	32.7861
Cross Timbers	Palo Pinto	-98.0966	32.6505
Edwards Plateau	Blanco	-98.2999	30.2087
Edwards Plateau	Blanco	-98.4120	29.9766
Edwards Plateau	Blanco	-98.3583	30.4014
Edwards Plateau	Blanco	-98.3925	30.2611
Edwards Plateau	Blanco	-98.4110	30.1249
Edwards Plateau	Blanco	-98.4069	29.9933
Edwards Plateau	Burnet	-98.2813	30.5351
Edwards Plateau	Crockett	-101.1481	30.7097
Edwards Plateau	Crockett	-101.0019	30.6724
Edwards Plateau	Gillespie	-99.2322	30.1457
Edwards Plateau	Gillespie	-99.2322	30.1457
Edwards Plateau	Hays	-98.1383	30.2064
Edwards Plateau	Kendall	-98.5585	29.9836
Edwards Plateau	Kendall	-98.5585	29.9836
Edwards Plateau	Kendall	-98.7076	29.9762
Edwards Plateau	Kendall	-98.8457	29.9880
Edwards Plateau	Kendall	-98.9595	30.0145
Edwards Plateau	Kerr	-99.5202	30.2873
Edwards Plateau	Kerr	-99.3839	30.2060
Edwards Plateau	Kerr	-99.3839	30.2060

Ecoregion	County	Longitude	Latitude
Edwards Plateau	Kerr	-99.1022	30.0701
Edwards Plateau	Kimble	-100.0602	30.4822
Edwards Plateau	Kimble	-99.8992	30.5186
Edwards Plateau	Kimble	-99.7396	30.3988
Edwards Plateau	Kimble	-99.6305	30.3988
Edwards Plateau	Sutton	-100.8438	30.6233
Edwards Plateau	Sutton	-100.6937	30.5910
Edwards Plateau	Sutton	-100.5269	30.5641
Edwards Plateau	Sutton	-100.3734	30.5005
Edwards Plateau	Sutton	-100.2197	30.4441
Piney Woods	Jasper	-93.9864	31.0929
Piney Woods	Jasper	-93.9863	31.0929
Piney Woods	Jasper	-94.0333	30.8986
Piney Woods	Jasper	-94.1707	30.8530
Piney Woods	Polk	-94.6396	30.7251
Piney Woods	Polk	-94.7968	30.6989
Piney Woods	Polk	-94.9724	30.7274
Piney Woods	Polk	-95.0777	30.8126
Piney Woods	Sabine	-93.9855	31.2310
Piney Woods	San Jacinto	-95.2138	30.7500
Piney Woods	Tyler	-94.3298	30.8173
Piney Woods	Tyler	-94.4836	30.7642
Piney Woods	Walker	-95.3833	30.7310
Piney Woods	Walker	-95.5230	30.7149
Piney Woods	Walker	-95.6966	30.7149
Piney Woods	Walker	-95.5975	30.6464
Post Oak Savanah	Bastrop	-97.1028	30.2195
Post Oak Savanah	Bexar	-98.4830	29.1527
Post Oak Savanah	Brazos	-96.4779	30.6492
Post Oak Savanah	Burleson	-96.6243	30.5889
Post Oak Savanah	Burleson	-96.7497	30.4932
Post Oak Savanah	Burleson	-96.7497	30.4848
Post Oak Savanah	Grimes	-95.9952	30.5925
Post Oak Savanah	Lee	-96.8506	30.3836
Post Oak Savanah	Lee	-96.8506	30.3836
Post Oak Savanah	Lee	-96.9622	30.2764
Post Oak Savanah	Medina	-98.9268	29.1136
Rolling Plains	Archer	-98.4465	33.5087
South Texas Plains	Atascosa	-98.8117	29.2090

Ecoregion	County	Longitude	Latitude
South Texas Plains	Atascosa	-98.3086	28.7523
South Texas Plains	Atascosa	-98.3931	28.8695
South Texas Plains	Atascosa	-98.4806	28.9761
South Texas Plains	Dimmit	-99.5691	28.6197
South Texas Plains	Dimmit	-99.4770	28.5455
South Texas Plains	Frio	-99.0531	29.0210
South Texas Plains	Frio	-99.1177	28.8851
South Texas Plains	Frio	-99.1404	28.7467
South Texas Plains	Frio	-99.1859	28.6184
South Texas Plains	Jim Wells	-98.2193	28.1047
South Texas Plains	Jim Wells	-98.1107	28.0344
South Texas Plains	Jim Wells	-98.1017	27.7684
South Texas Plains	Jim Wells	-98.0900	27.9282
South Texas Plains	Jim Wells	-98.0984	28.0763
South Texas Plains	Jim Wells	-98.1062	28.2228
South Texas Plains	Kinney	-100.6326	29.3628
South Texas Plains	Kinney	-100.4711	29.3244
South Texas Plains	Kinney	-100.3151	29.2783
South Texas Plains	Kinney	-100.1543	29.2377
South Texas Plains	La Salle	-99.3389	28.4807
South Texas Plains	La Salle	-99.2102	28.4263
South Texas Plains	La Salle	-99.0976	28.3214
South Texas Plains	La Salle	-99.0204	28.2015
South Texas Plains	La Salle	-98.8567	28.2021
South Texas Plains	La Salle	-99.2286	28.4762
South Texas Plains	La Salle	-99.2730	28.3381
South Texas Plains	La Salle	-99.3094	28.1990
South Texas Plains	La Salle	-99.3502	28.0566
South Texas Plains	Live Oak	-98.1385	28.3616
South Texas Plains	Live Oak	-98.1808	28.4962
South Texas Plains	Live Oak	-98.2519	28.6205
South Texas Plains	McMillen	-98.6970	28.1754
South Texas Plains	McMillen	-98.6970	28.1754
South Texas Plains	McMillen	-98.5416	28.1326
South Texas Plains	McMillen	-98.3844	28.1048
South Texas Plains	McMillen	-98.3844	28.1048
South Texas Plains	Uvalde	-99.9287	29.2275
South Texas Plains	Uvalde	-99.8313	29.2002
South Texas Plains	Uvalde	-99.7498	29.1101

Ecoregion	County	Longitude	Latitude
South Texas Plains	Val Verde	-100.7893	29.3712
South Texas Plains	Webb	-99.3913	27.9198
South Texas Plains	Webb	-99.4284	27.7789
South Texas Plains	Webb	-99.4590	27.6600
South Texas Plains	Wichita	-98.4826	33.7889
South Texas Plains	Zavala	-99.6518	28.9918
South Texas Plains	Zavala	-99.6095	28.8616
South Texas Plains	Zavala	-99.5812	28.7564
Fall 2015			
Black Land Prairie	Grimes	-95.9227	30.5938
Black Land Prairie	Grimes	-95.9203	30.5963
Cross Timbers	Archer	-98.4861	33.8248
Cross Timbers	Archer	-98.4780	33.7218
Cross Timbers	Archer	-98.4576	33.6437
Cross Timbers	Burnet	-98.2626	30.6210
Cross Timbers	Burnet	-98.2400	30.7233
Cross Timbers	Burnet	-98.2386	30.8207
Cross Timbers	Burnet	-98.2109	30.9698
Cross Timbers	Erath	-98.1665	32.1875
Cross Timbers	Erath	-98.1564	32.4067
Cross Timbers	Erath	-98.0945	32.0646
Cross Timbers	Erath	-98.1728	32.3417
Cross Timbers	Hamilton	-98.1557	31.5877
Cross Timbers	Hamilton	-98.1442	31.5030
Cross Timbers	Hamilton	-98.1387	31.6721
Cross Timbers	Hamilton	-98.1062	31.8097
Cross Timbers	Hamilton	-98.0353	31.9853
Cross Timbers	Jack	-98.2834	33.2718
Cross Timbers	Jack	-98.1403	33.1900
Cross Timbers	Lampasas	-98.1892	31.1282
Cross Timbers	Lampasas	-98.1808	31.0450
Cross Timbers	Lampasas	-98.1774	31.2521
Cross Timbers	Palo Pinto	-98.1257	32.5277
Cross Timbers	Palo Pinto	-98.1086	32.7867
Cross Timbers	Palo Pinto	-98.1000	32.6538
Cross Timbers	Palo Pinto	-98.0803	32.9099
Edwards Plateau	Blanco	-98.4125	30.0667
Edwards Plateau	Blanco	-98.4075	29.9727
Edwards Plateau	Blanco	-98.4017	30.2697

Ecoregion	County	Longitude	Latitude
Edwards Plateau	Blanco	-98.3610	30.3995
Edwards Plateau	Blanco	-98.2959	30.2093
Edwards Plateau	Crockett	-101.1647	30.7097
Edwards Plateau	Crockett	-101.0039	30.6729
Edwards Plateau	Hays	-98.1386	30.2066
Edwards Plateau	Kendall	-98.5582	29.9836
Edwards Plateau	Kerr	-99.3671	30.1997
Edwards Plateau	Kerr	-99.3671	30.1997
Edwards Plateau	Kerr	-99.1743	30.1026
Edwards Plateau	Kerr	-99.0849	30.0693
Edwards Plateau	Kerr	-98.9377	29.9972
Edwards Plateau	Kimble	-100.0376	30.4868
Edwards Plateau	Kimble	-99.8524	30.5242
Edwards Plateau	Kimble	-99.7225	30.4516
Edwards Plateau	Kimble	-99.5924	30.3502
Edwards Plateau	Sutton	-100.8571	30.6308
Edwards Plateau	Sutton	-100.6659	30.5863
Edwards Plateau	Sutton	-100.4986	30.5553
Edwards Plateau	Sutton	-100.3580	30.4939
Edwards Plateau	Sutton	-100.1801	30.4497
Piney Woods	Jasper	-93.9996	30.9188
Piney Woods	Jasper	-93.9959	30.9467
Piney Woods	Jasper	-93.9859	31.0813
Piney Woods	Jasper	-94.0602	30.8882
Piney Woods	Jasper	-93.9859	31.0853
Piney Woods	Polk	-95.0266	30.7607
Piney Woods	Polk	-94.9032	30.7089
Piney Woods	Polk	-94.7990	30.7033
Piney Woods	Polk	-95.1253	30.8113
Piney Woods	Polk	-95.0337	30.7679
Piney Woods	Polk	-94.8616	30.7071
Piney Woods	Polk	-94.6906	30.7202
Piney Woods	Sabine	-93.9857	31.2302
Piney Woods	Sabine	-93.9856	31.2309
Piney Woods	San Jacinto	-95.3149	30.7427
Piney Woods	San Jacinto	-95.1656	30.7951
Piney Woods	San Jacinto	-95.2841	30.7440
Piney Woods	Tyler	-94.5690	30.7539
Piney Woods	Tyler	-94.4457	30.7706

Ecoregion	County	Longitude	Latitude
Piney Woods	Tyler	-94.2692	30.8408
Piney Woods	Tyler	-94.5382	30.7530
Piney Woods	Tyler	-94.3770	30.7919
Piney Woods	Tyler	-94.2397	30.8489
Piney Woods	Walker	-95.7903	30.6717
Piney Woods	Walker	-95.6180	30.7007
Piney Woods	Walker	-95.8084	30.6661
Piney Woods	Walker	-95.8084	30.6661
Piney Woods	Walker	-95.6165	30.7010
Piney Woods	Walker	-95.4773	30.7056
Post Oak Savanah	Atascosa	-98.4799	28.9859
Post Oak Savanah	Bastrop	-97.3298	30.1025
Post Oak Savanah	Bastrop	-97.1490	30.2156
Post Oak Savanah	Bastrop	-97.0961	30.2221
Post Oak Savanah	Bexar	-98.4812	29.1760
Post Oak Savanah	Brazos	-96.5036	30.6445
Post Oak Savanah	Brazos	-96.4185	30.6626
Post Oak Savanah	Brazos	-96.3949	30.6748
Post Oak Savanah	Brazos	-96.3949	30.6748
Post Oak Savanah	Brazos	-96.3445	30.6806
Post Oak Savanah	Brazos	-96.2524	30.6416
Post Oak Savanah	Brazos	-96.4780	30.6493
Post Oak Savanah	Brazos	-96.2495	30.6401
Post Oak Savanah	Burleson	-96.7890	30.4512
Post Oak Savanah	Burleson	-96.6769	30.5545
Post Oak Savanah	Burleson	-96.7529	30.4899
Post Oak Savanah	Burleson	-96.6268	30.5874
Post Oak Savanah	Grimes	-96.0913	30.5962
Post Oak Savanah	Grimes	-96.1529	30.6051
Post Oak Savanah	Grimes	-96.0916	30.5957
Post Oak Savanah	Lee	-97.0059	30.2367
Post Oak Savanah	Lee	-96.9680	30.2688
Post Oak Savanah	Lee	-96.8472	30.3854
Post Oak Savanah	Medina	-98.9337	29.1080
Rolling Plains	Archer	-98.4463	33.4929
South Texas Plains	Atascosa	-98.3728	28.8405
South Texas Plains	Frio	-99.1403	28.7468
South Texas Plains	Frio	-99.1178	28.8787
South Texas Plains	Frio	-99.0539	29.0193

Ecoregion	County	Longitude	Latitude
South Texas Plains	Jim Wells	-98.1065	27.7577
South Texas Plains	Jim Wells	-98.0913	28.0567
South Texas Plains	Jim Wells	-98.0886	27.9037
South Texas Plains	La Salle	-99.3506	28.0425
South Texas Plains	La Salle	-99.3166	28.1787
South Texas Plains	La Salle	-99.2734	28.3331
South Texas Plains	La Salle	-99.2305	28.4699
South Texas Plains	La Salle	-99.1875	28.6128
South Texas Plains	Live Oak	-98.2137	28.5933
South Texas Plains	Live Oak	-98.1788	28.4866
South Texas Plains	Live Oak	-98.1217	28.3388
South Texas Plains	Live Oak	-98.1053	28.2038
South Texas Plains	Medina	-98.8196	29.2035
South Texas Plains	Webb	-99.4285	27.7723
South Texas Plains	Webb	-99.3971	27.8980
Fall 2016			
Black Land Prairie	Grimes	-95.9203	30.5963
Cross Timbers	Archer	-98.4826	33.7886
Cross Timbers	Archer	-98.4661	33.6509
Cross Timbers	Burnet	-98.2565	30.6574
Cross Timbers	Burnet	-98.2358	30.9337
Cross Timbers	Burnet	-98.2348	30.7816
Cross Timbers	Erath	-98.1812	32.1990
Cross Timbers	Erath	-98.1735	32.3481
Cross Timbers	Erath	-98.1339	32.4964
Cross Timbers	Erath	-98.0973	32.0718
Cross Timbers	Hamilton	-98.1487	31.5135
Cross Timbers	Hamilton	-98.1408	31.6636
Cross Timbers	Hamilton	-98.1200	31.7947
Cross Timbers	Hamilton	-98.1200	31.7947
Cross Timbers	Hamilton	-98.0603	31.9373
Cross Timbers	Jack	-98.3676	33.4014
Cross Timbers	Jack	-98.2845	33.2725
Cross Timbers	Jack	-98.1383	33.1915
Cross Timbers	Jack	-98.0660	33.0717
Cross Timbers	Lampasas	-98.1907	31.0942
Cross Timbers	Lampasas	-98.1772	31.2426
Cross Timbers	Lampasas	-98.1757	31.3841
Cross Timbers	Palo Pinto	-98.1066	32.6331

Ecoregion	County	Longitude	Latitude
Cross Timbers	Palo Pinto	-98.1059	32.7743
Cross Timbers	Palo Pinto	-98.1059	32.7743
Cross Timbers	Palo Pinto	-98.0715	32.9289
Edwards Plateau	Blanco	-98.4135	29.9769
Edwards Plateau	Blanco	-98.4132	30.1200
Edwards Plateau	Blanco	-98.4104	29.9482
Edwards Plateau	Blanco	-98.3910	30.2570
Edwards Plateau	Blanco	-98.3646	30.3901
Edwards Plateau	Blanco	-98.3114	30.2043
Edwards Plateau	Burnet	-98.2878	30.5227
Edwards Plateau	Crockett	-101.1647	30.7097
Edwards Plateau	Crockett	-101.1647	30.7097
Edwards Plateau	Crockett	-100.9809	30.6677
Edwards Plateau	Gillespie	-99.3007	30.1828
Edwards Plateau	Kendall	-98.8458	29.9879
Edwards Plateau	Kendall	-98.7159	29.9696
Edwards Plateau	Kendall	-98.5622	29.9837
Edwards Plateau	Kerr	-99.4601	30.2542
Edwards Plateau	Kerr	-99.1925	30.1101
Edwards Plateau	Kerr	-99.0364	30.0543
Edwards Plateau	Kerr	-99.0364	30.0543
Edwards Plateau	Kerr	-98.9645	30.0182
Edwards Plateau	Kimble	-100.0322	30.4890
Edwards Plateau	Kimble	-99.8851	30.5209
Edwards Plateau	Kimble	-99.7226	30.4521
Edwards Plateau	Kimble	-99.5833	30.3381
Edwards Plateau	Sutton	-100.8542	30.6297
Edwards Plateau	Sutton	-100.7063	30.5972
Edwards Plateau	Sutton	-100.5455	30.5666
Edwards Plateau	Sutton	-100.3630	30.4963
Edwards Plateau	Sutton	-100.1850	30.4481
Piney Woods	Jasper	-94.0602	30.8882
Piney Woods	Jasper	-93.9859	31.0853
Piney Woods	Polk	-95.1253	30.8113
Piney Woods	Polk	-95.0337	30.7679
Piney Woods	Polk	-94.8616	30.7071
Piney Woods	Polk	-94.6906	30.7202
Piney Woods	Sabine	-93.9856	31.2309
Piney Woods	San Jacinto	-95.2841	30.7440

Ecoregion	County	Longitude	Latitude
Piney Woods	Tyler	-94.5382	30.7530
Piney Woods	Tyler	-94.3770	30.7919
Piney Woods	Tyler	-94.2397	30.8489
Piney Woods	Walker	-95.8084	30.6661
Piney Woods	Walker	-95.8084	30.6661
Piney Woods	Walker	-95.6165	30.7010
Piney Woods	Walker	-95.4773	30.7056
Post Oak Savanah	Atascosa	-98.4316	29.0343
Post Oak Savanah	Bastrop	-97.0961	30.2221
Post Oak Savanah	Bexar	-98.4812	29.1760
Post Oak Savanah	Brazos	-96.4780	30.6493
Post Oak Savanah	Brazos	-96.2495	30.6401
Post Oak Savanah	Burleson	-96.7529	30.4899
Post Oak Savanah	Burleson	-96.6268	30.5874
Post Oak Savanah	Grimes	-96.1529	30.6051
Post Oak Savanah	Grimes	-96.0916	30.5957
Post Oak Savanah	Lee	-96.9680	30.2688
Post Oak Savanah	Lee	-96.8472	30.3854
Post Oak Savanah	Medina	-98.9465	29.0981
South Texas Plains	Atascosa	-98.4308	28.9090
South Texas Plains	Atascosa	-98.3260	28.7879
South Texas Plains	Atascosa	-98.2914	28.6829
South Texas Plains	Dimmit	-99.5692	28.6077
South Texas Plains	Dimmit	-99.4635	28.5430
South Texas Plains	Frio	-99.1677	28.6945
South Texas Plains	Frio	-99.1118	28.8460
South Texas Plains	Frio	-99.0762	28.9675
South Texas Plains	Jim Wells	-98.0920	27.9644
South Texas Plains	Jim Wells	-98.0836	27.8198
South Texas Plains	Kinney	-100.6357	29.3636
South Texas Plains	Kinney	-100.4704	29.3243
South Texas Plains	Kinney	-100.3081	29.2771
South Texas Plains	Kinney	-100.1526	29.2375
South Texas Plains	La Salle	-99.3330	28.1127
South Texas Plains	La Salle	-99.3245	28.4765
South Texas Plains	La Salle	-99.2851	28.2783
South Texas Plains	La Salle	-99.2536	28.4133
South Texas Plains	La Salle	-99.2108	28.4200
South Texas Plains	La Salle	-99.2035	28.5596

Ecoregion	County	Longitude	Latitude
South Texas Plains	La Salle	-99.0848	28.3100
South Texas Plains	La Salle	-99.0350	28.2070
South Texas Plains	La Salle	-98.8461	28.2021
South Texas Plains	Live Oak	-98.2059	28.5834
South Texas Plains	Live Oak	-98.1913	28.0974
South Texas Plains	Live Oak	-98.1723	28.4110
South Texas Plains	Live Oak	-98.1126	28.2754
South Texas Plains	Live Oak	-98.1003	28.1146
South Texas Plains	McMullen	-98.6778	28.1692
South Texas Plains	McMullen	-98.5302	28.1280
South Texas Plains	McMullen	-98.3642	28.1047
South Texas Plains	Medina	-98.8188	29.2035
South Texas Plains	Uvalde	-99.9947	29.2275
South Texas Plains	Uvalde	-99.8162	29.1993
South Texas Plains	Uvalde	-99.7465	29.1051
South Texas Plains	Val Verde	-100.7504	29.3841
South Texas Plains	Webb	-99.4556	27.7021
South Texas Plains	Webb	-99.4068	27.8454
South Texas Plains	Webb	-99.3690	27.9958
South Texas Plains	Zavala	-99.6472	28.9868
South Texas Plains	Zavala	-99.6116	28.8582
South Texas Plains	Zavala	-99.5779	28.7486
Fall 2017			
Black Land Prairie	Grimes	-95.9252	30.5911
Cross Timbers	Archer	-98.4826	33.7886
Cross Timbers	Archer	-98.4630	33.6484
Cross Timbers	Burnet	-98.2560	30.6633
Cross Timbers	Burnet	-98.2390	30.8195
Cross Timbers	Burnet	-98.2199	30.9541
Cross Timbers	Burnet	-98.2199	30.9541
Cross Timbers	Erath	-98.1839	32.2037
Cross Timbers	Erath	-98.1735	32.3484
Cross Timbers	Erath	-98.1335	32.4992
Cross Timbers	Erath	-98.0998	32.0782
Cross Timbers	Hamilton	-98.1571	31.5409
Cross Timbers	Hamilton	-98.1317	31.6848
Cross Timbers	Hamilton	-98.1153	31.8218
Cross Timbers	Hamilton	-98.0452	31.9547
Cross Timbers	Jack	-98.4465	33.5091

Ecoregion	County	Longitude	Latitude
Cross Timbers	Jack	-98.3664	33.3951
Cross Timbers	Jack	-98.2853	33.2730
Cross Timbers	Jack	-98.1381	33.1914
Cross Timbers	Jack	-98.0670	33.0634
Cross Timbers	Lampasas	-98.1946	31.1061
Cross Timbers	Lampasas	-98.1772	31.2431
Cross Timbers	Lampasas	-98.1727	31.4002
Cross Timbers	Palo Pinto	-98.1063	32.6336
Cross Timbers	Palo Pinto	-98.1060	32.7747
Cross Timbers	Palo Pinto	-98.0785	32.9125
Edwards Plateau	Atascosa	-98.6868	30.9381
Edwards Plateau	Blanco	-98.4134	29.9769
Edwards Plateau	Blanco	-98.4088	30.1281
Edwards Plateau	Blanco	-98.4079	29.9904
Edwards Plateau	Blanco	-98.3914	30.2583
Edwards Plateau	Blanco	-98.3615	30.3956
Edwards Plateau	Blanco	-98.3018	30.2086
Edwards Plateau	Blanco	-98.3018	30.2086
Edwards Plateau	Burnet	-98.2834	30.5309
Edwards Plateau	Crockett	-101.1481	30.7097
Edwards Plateau	Crockett	-100.9998	30.6721
Edwards Plateau	Gillespie	-99.2307	30.1398
Edwards Plateau	Hays	-98.1398	30.2068
Edwards Plateau	Kendall	-98.8458	29.9879
Edwards Plateau	Kendall	-98.7083	29.9742
Edwards Plateau	Kendall	-98.5626	29.9838
Edwards Plateau	Kerr	-99.5061	30.2786
Edwards Plateau	Kerr	-99.3746	30.2022
Edwards Plateau	Kerr	-99.0997	30.0698
Edwards Plateau	Kerr	-98.9589	30.0141
Edwards Plateau	Kimble	-100.0370	30.4871
Edwards Plateau	Kimble	-99.8771	30.5222
Edwards Plateau	Kimble	-99.6155	30.3876
Edwards Plateau	Kimble	-99.7370	30.4774
Edwards Plateau	Sutton	-100.8417	30.6225
Edwards Plateau	Sutton	-100.6894	30.5903
Edwards Plateau	Sutton	-100.5203	30.5624
Edwards Plateau	Sutton	-100.3602	30.4952
Edwards Plateau	Sutton	-100.1968	30.4446

Ecoregion	County	Longitude	Latitude
Piney Woods	Jasper	-94.1071	30.8700
Piney Woods	Jasper	-93.9949	30.9506
Piney Woods	Jasper	-93.9869	31.0948
Piney Woods	Polk	-95.0327	30.7680
Piney Woods	Polk	-94.8966	30.7093
Piney Woods	Polk	-94.7367	30.7100
Piney Woods	Sabine	-93.9855	31.2310
Piney Woods	San Jacinto	-95.3042	30.7441
Piney Woods	San Jacinto	-95.1688	30.7890
Piney Woods	Tyler	-94.5869	30.7526
Piney Woods	Tyler	-94.4373	30.7736
Piney Woods	Tyler	-94.2659	30.8421
Piney Woods	Walker	-95.7892	30.6721
Piney Woods	Walker	-95.6213	30.7002
Piney Woods	Walker	-95.4779	30.7058
Post Oak Savanah	Atascosa	-98.4841	29.1276
Post Oak Savanah	Atascosa	-98.4791	28.9907
Post Oak Savanah	Bastrop	-97.2199	30.1553
Post Oak Savanah	Bastrop	-97.0924	30.2241
Post Oak Savanah	Brazos	-96.4697	30.6507
Post Oak Savanah	Brazos	-96.2524	30.6416
Post Oak Savanah	Burleson	-96.7505	30.4923
Post Oak Savanah	Burleson	-96.6149	30.5948
Post Oak Savanah	Grimes	-96.0893	30.5949
Post Oak Savanah	Lee	-96.9614	30.2826
Post Oak Savanah	Lee	-96.8394	30.3894
Post Oak Savanah	Medina	-98.9323	29.1089
South Texas Plains	Atascosa	-98.3993	28.8787
South Texas Plains	Atascosa	-98.3100	28.7538
South Texas Plains	Dimmit	-99.5689	28.6350
South Texas Plains	Dimmit	-99.5048	28.5506
South Texas Plains	Frio	-99.1473	28.7350
South Texas Plains	Frio	-99.1137	28.8765
South Texas Plains	Frio	-99.0536	29.0197
South Texas Plains	Jim Wells	-98.0910	27.9458
South Texas Plains	Jim Wells	-98.0833	27.8115
South Texas Plains	Kinney	-100.6450	29.3667
South Texas Plains	Kinney	-100.4870	29.3274
South Texas Plains	Kinney	-100.3358	29.2826

Ecoregion	County	Longitude	Latitude
South Texas Plains	Kinney	-100.1761	29.2412
South Texas Plains	La Salle	-99.3649	28.4887
South Texas Plains	La Salle	-99.3184	28.1738
South Texas Plains	La Salle	-99.2738	28.3294
South Texas Plains	La Salle	-99.2299	28.4717
South Texas Plains	La Salle	-99.2106	28.4231
South Texas Plains	La Salle	-99.1881	28.6109
South Texas Plains	La Salle	-99.1034	28.3266
South Texas Plains	La Salle	-99.0252	28.2015
South Texas Plains	La Salle	-98.8595	28.2021
South Texas Plains	La Salle	-98.8115	29.2093
South Texas Plains	Live Oak	-98.2551	28.6227
South Texas Plains	Live Oak	-98.2057	28.1023
South Texas Plains	Live Oak	-98.1829	28.5060
South Texas Plains	Live Oak	-98.1532	28.3786
South Texas Plains	Live Oak	-98.1069	28.2359
South Texas Plains	Live Oak	-98.0991	28.0924
South Texas Plains	McMullen	-98.6906	28.1739
South Texas Plains	McMullen	-98.5316	28.1285
South Texas Plains	McMullen	-98.3681	28.1047
South Texas Plains	Uvalde	-100.0081	29.2308
South Texas Plains	Uvalde	-99.8566	29.2014
South Texas Plains	Uvalde	-99.7566	29.1274
South Texas Plains	Val Verde	-100.7928	29.3701
South Texas Plains	Webb	-99.4909	27.6293
South Texas Plains	Webb	-99.4283	27.7755
South Texas Plains	Webb	-99.3976	27.8960
South Texas Plains	Webb	-99.3591	28.0279
South Texas Plains	Zavala	-99.6620	29.0045
South Texas Plains	Zavala	-99.6064	28.8663
South Texas Plains	Zavala	-99.5924	28.7670

Appendix II – Roadside Survey Nectar Species

Table 22. Species of nectaring plants identified for the spring in 2016, 2017, 2018. The black spaces indicate presence.

Species	Spring 2016	Spring 2017	Spring 2018
Abutilon fruticosum		■	
Abutilon parvulum		■	
Acalypha phleoides		■	
Acalypha radians		■	■
Achillea millefolium		■	■
Acleisanthes longiflora		■	
Allium canadense	■	■	■
Allium drummondii		■	■
Amblyolepis setigera		■	
Ambrosia psilotachya	■		
Amphiachyris dracunculoides	■		
Anagallis arvensis		■	■
Anemone berlandieri		■	■
Aphanostephus ramosissimus			■
Aphanostephus skirrhobasis	■	■	■
Argemone polyanthemos			■
Argythamnia humilis		■	
Asclepias asperula		■	■
Asclepias linearis			
Asclepias oenotheroides		■	
Asclepias viridis		■	■
Aster ericoides	■		
Astragalus nuttallianus			■
Astragulus lotiflorus	■		
Bellardia trixago		■	
Berlandiera texana	■		
Bifora americana	■		
Callirhoe alcaeoides		■	
Callirhoe involucrata		■	■
Callirhoe papaver		■	
Callirhoe pedata			■
Calylophus berlandieri		■	■
Calylophus hartwegii		■	■
Calylophus hartwegii var. maccarto			■
Calyptocarpus vialis		■	■
Castilleja indivisa		■	■
Castilleja purpurea	■		■
Castilleja sessiliflora			

Species	Spring 2016	Spring 2017	Spring 2018
Centaurea americana			
Centaurea melitensis			
Centaurium calycosum			
Centaurium texense			
Chaetopappa bellidifolia			
Chamaesaracha sordida			
Chromolaena odorata			
Cirsium texanum			
Commelina erecta			
Conium maculatum			
Convolvulus equitans			
Conyza canadensis			
Cooperia drummondii			
Coreopsis basalis			
Coreopsis lanceolata			
Coreopsis nuecensis			
Coreopsis tinctoria			
Croton sp.			
Cryptantha texana			
Cynosciadium digitatum			
Dalea aurea			
Dalea lasiathera			
Dalea nana			
Dalea pogonathera			
Daucus pusillus			
Delphinium carolinianum var. virescens			
Delphinium orientale			
Descurainia pinnata			
Desmanthus illinoensis			
Diodia teres			
Dracopis amplexicaulis			
Dyschoriste linearis			
Dyschoriste linearis var. linearis			
Engelmannia peristenia			
Engelmannia pinnatidida			
Engelmannia pinnatifida			
Erigeron modestus			
Erigeron philadelphicus			
Erigeron strigosus			
Erigeron tenuis			
Erodium cicutarium			
Erodium texanum			

Species	Spring 2016	Spring 2017	Spring 2018
Evolvulus alsinoides var. angustifolius			
Evolvulus nuttallianus			
Evolvulus sericeus			
Filago lutescens			
Gaillardia pinnatifida			
Gaillardia pulchella			
Gaillardia suavis			
Galium aparine			
Galium texense			
Galium virgantum			
Galium virgatum			
Geranium carolinianum			
Giliastrum incisum			
Glandularia bipinnatifida			
Glandularia pumila			
Gnaphalium obtusifolium			
Grindelia microcephala			
Hedeoma acinoides			
Hedeoma drummondii			
Hedeoma reverchonii			
Hedyotis nigricans			
Helenium amarum			
Heliotropium tenellum			
Heterotheca canescens			
Hymenopappus scabiosaeus			
Hymenoxys linearifolia			
Indigofera miniata			
Ipomea trichocarpa			
Ipomoea cordatotriloba			
Krameria lanceolata			
Krigia caespitosa			
Krigia virginica			
Lactuca serriola			
Lantana urticoides			
Lappula occidentalis			
Lathyrus hirsutus			
Latidens Mimosa			
Lesguerella argyraea			
Lesquerella argyraea			
Lesquerella gordonii			
Lesquerella recurvata			
Lindheimera texana			

Species	Spring 2016	Spring 2017	Spring 2018
Linum berlandieri			
Linum Berlandieri			
Linum pratense			
Linum rupestre			
Linum striatum			
Lithospermum incisum			
Lobelia spicata			
Lupinus texensis			
Lygodesmia texana			
Marshallia caespitosa			
Medicago lupulina			
Medicago minima			
Medicago polymorph			
Medicago polymorpha			
Melampodium cinereum			
Melampodium leucanthum			
Melilotus indicus			
Melilotus Indicus			
Menodora heterophylla			
Mimosa roemeriana			
Mimosa sp.			
Monarda citriodora			
Monarda clinopodioides			
Nothoscordum bivalve			
Oenothera berlandierii var. pinifolius			
Oenothera calcicola			
Oenothera curtiflora			
Oenothera filiformis			
Oenothera macrocarpa			
Oenothera patriciae			
Oenothera rosea			
Oenothera sinuosa			
Oenothera speciosa			
Oenothera suffrutescens			
Oenothera tetraptera			
Oenothera triangulata			
Oentothera calcicola			
Oxalis dillenii			
Oxalis stricta			
Packera tampicana			
Palafoxia texana			
Parthenium hysterophorus			

Species	Spring 2016	Spring 2017	Spring 2018
Pediomelum rhombifolium			
Penstemon cobaea			
Phacelia congesta			
Phacelia patuliflora			
Phacelia patuliflora var. austrotexana			
Phlox divaricata			
Phlox drummondii			
Phlox pilosa			
Phyla nodiflora			
Phyla nudiflora			
Physalis cinerascers var.cinerascens			
Physalis viscosa			
Physostegia digitalis			
Physostegia pulchella			
Pinaropappus parvus			
Pinaropappus roseus			
Plantago helleri			
Plantago rhodosperma			
Plantego aristada			
Polygala alba			
Polytaenia texana			
Prunella vulgaris			
Psoralea tenuiflora			
Ptilimnium capillaceum			
Ptilimnium nuttallii			
Pyrrhopappus multicaulis			
Pyrrhopappus pauciflorus			
Rapistrum perenne			
Rapistrum rugosum			
Ratibida columnifera			
Rhynchosia americana			
Rhynchosida physocalyx			
Richardia tricocca			
Rudbeckia hirta			
Ruellia humilis			
Sabatia campestris			
Salvia ballotiflora			
Salvia farinacea			
Salvia lyrata			
Salvia texana			
Scandix pecten-veneris			
Scandix Pecten-Veneris			

Species	**Spring 2016**	**Spring 2017**	**Spring 2018**
Schoenocaulon texanum		■	
Scutellaria drummondii		■	■
Scutellaria ovata		■	
Scutellaria parvula			■
Scutellaria wrightii		■	■
Sedum nuttallianum		■	■
Senecio vulgaris			■
Senna roemeriana		■	
Sherardia arvensis	■		
Sida abutifolia		■	■
Simsia calva		■	■
Sisrinchium ensigerum	■		
Sisyrinchium angustifolium		■	■
Sisyrinchium chilense			■
Sisyrinchium langloisii			■
Solanum elaeagnifolium		■	■
Sonchus asper		■	■
Sonchus oleraceus	■	■	■
Stachys crenata			■
Stenaria nigricans		■	■
Stillingia texana		■	
Stylosanthes biflora		■	
Taraxacum officinale			■
Tetraneuris linearifolia			■
Tetraneuris scaposa		■	■
Teucrium cubense			■
Teucrium laciniatum		■	
Thelasperma filifolium		■	
Thelesperma filifolium			■
Thelesperma simplicifolium		■	■
Thymophylla pentachaeta		■	
Thymophylla pentacheta			■
Thymophylla tenuiloba		■	■
Thymophylla tenuiloba var. wrightii		■	
Tinantia anomala			
Torilis arvensis		■	■
Torilis nodosa		■	
Torillas arvensis	■		
Tradescantia ohiensis		■	■
Trepocarpus aethusae			■
Trifolium aureum	■		
Trifolium campestre		■	

Species	Spring 2016	Spring 2017	Spring 2018
Trifolium carolinianum			■
Trifolium incarnatum		■	
Triodanis biflora		■	■
Tuberous vervain			■
Valerianella stenocarpa			■
Valerianella amarella	■	■	
Valerianella radiata			■
Verbena bracteata			■
Verbena brasiliensis			■
Verbena canescens		■	■
Verbena halei		■	■
Verbena hastata		■	
Verbena officinalis			■
Verbena rigida		■	■
Vicia americana		■	
Vicia ludoviciana	■	■	■
Vicia sativa	■		
Vicia villosa			■
Viguiera dentata		■	
Wedelia acapulcensis var. hispida			■
Yucca treculeana	■		
Zexmenia hispida	■		

Table 23. Species of nectaring plants identified for the fall in 2015, 2016, 2017. The black spaces indicate presence.

Species	Fall 2015	Fall 2016	Fall 2017
Acalypha Lindheimeri		■	
Agalinis edwardsiana		■	■
Agalinis heterophylla			■
Allium canadense	■		
Ambrosia psilotachya	■		
Amphiachyris amoena			■
Amphiachyris dracunculoides	■	■	■
Aphanostephus ramosissimus			■
Aphanostephus skirrhobasis			■
Aster ericoides	■		
Aster texanus		■	
Calylophus berlandieri	■	■	■
Calyptocarpus vialis		■	■
Chamaesaracha villosa			■
Chamaesyce nutans		■	
Chromolaena odorata			■
Commelina erecta		■	
Cooperia drummondii			■
Coreopsis grandiflora			■
Croptilon divaricatum		■	
Croton sp.	■	■	
Desmanthus illinoensis	■		
Desmanthus leptolobus	■		
Desmanthus virgatus	■		
Dyschoriste linearis			■
Engelmannia pinnatidida	■		
Erigeron strigosus		■	
Erodium texanum	■		
Evolvulus alsinoides			■
Gaillardia pulchella		■	■
Galphimia angustifolia			■
Geranium carolinianum	■		
Gutierrezia sarothrae		■	
Gymnosperma glutinosum		■	■
Hedeoma drummondii		■	
Hedyotis nigricans	■		
Helenium amarum		■	
Helianthus augustifolius			■

Species	Fall 2015	Fall 2016	Fall 2017
Helianthus maximilian			■
Helianthus tuberosus			■
Heterotheca canescens	■	■	■
Heterotheca subaxillaris		■	■
Indigofera miniata	■		
Ipomea trichocarpa	■		
Ipomoea cordatotriloba		■	■
Ipomoea lindheimeri		■	
Justicia pilosella		■	
Lespedeza texana			■
Liatris elegans			■
Liatris punctata			■
Liatris punctata var. mucronata		■	
Linum Berlandieri	■		
Linum rupestre		■	■
Lygodesmia texana	■		■
Medicago polymorph	■		
Melampodium leucanthum		■	■
Melochia pyramidata			■
Mentzelia oligosperma		■	
Mimosa Borealis			■
Mirabilis albida			■
Mirabilis hirsuta		■	
Nothoscordum bivalve		■	■
Nyctaginia capitata		■	
Oenothera calcicola			■
Oenothera speciosa			■
Oenothera suffrutescens		■	
Oxalis dillenii	■	■	■
Palafoxia callosa		■	■
Palafoxia texana			■
Parthenium hysterophorus		■	■
Phyla nodiflora		■	■
Phyla nudiflora	■		
Physalis longifolia		■	
Polygala alba		■	■
Psilostrophe tagetina		■	
Ratibida columnifera	■	■	
Ratibida peduncularis			■
Rayjacksonia phyllocephala		■	
Ruellia humilis		■	
Salvia farinacea			■

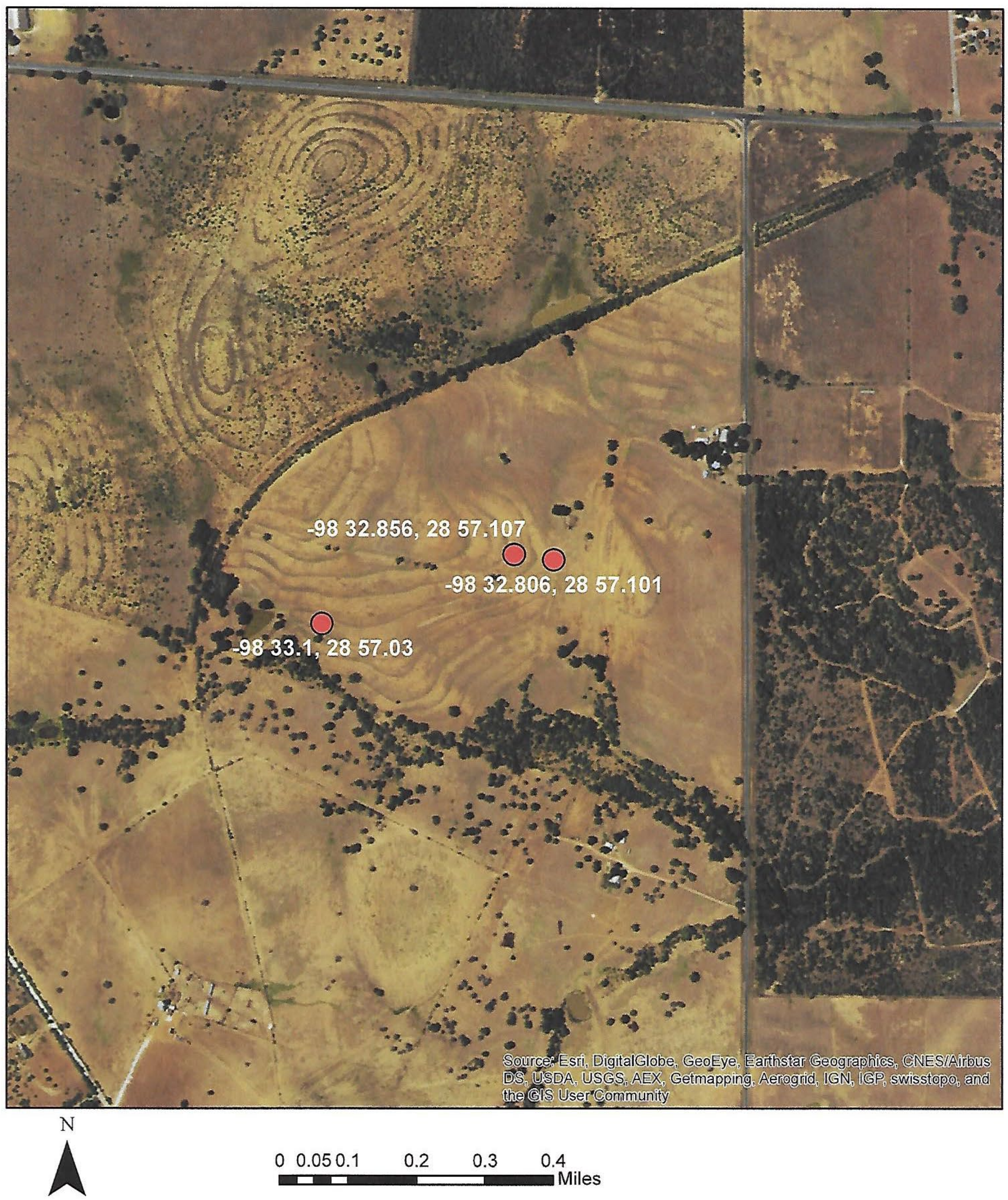
Species	Fall 2015	Fall 2016	Fall 2017
Scutellaria drummondii		■	■
Senecio ampullaceus		■	
Sida abutafolia			■
Sida abutifolia		■	
Sida lindheimeri			■
Sida rhombifolia		■	
Sphaeralcea angustifolia		■	
Sphaeralcea lindheimeri			■
Spiranthes cernua			■
Stenaria nigricans			■
Stenaria nigricans var. nigricans		■	
Strophostyles leiosperma		■	
Symphyotrichum ericoides		■	
Symphyotrichum ericoides var. ericoides			■
Symphyotrichum lateriflorum			■
Symphyotrichum oblongifolium			■
Symphyotrichum patens var. patens			■
Symphyotrichum subulatum		■	
Tetraneuris linearifolia		■	■
Tetraneuris scaposa var. scaposa			■
Teucrium cubense		■	
Thelesperma filifolium		■	
Thelesperma nuecense			■
Thelesperma simplicifolium		■	■
Thymophylla pentachaeta		■	■
Thymophylla tenuiloba		■	
Tinantia anomala			■
Torillas arvensis	■		
Verbena bracteata		■	
Verbena brasiliensis			■
Verbena canescens		■	■
Verbena halei		■	■
Verbena rigida		■	■
Verbena sp.			■
Vernonia Lindheimeri		■	
Wedelia acapulcensis var. hispida			■
Wedelia acapulcensis var. hispida			■
Zexmenia hispida	■		

Appendix III– Site Specific Locations

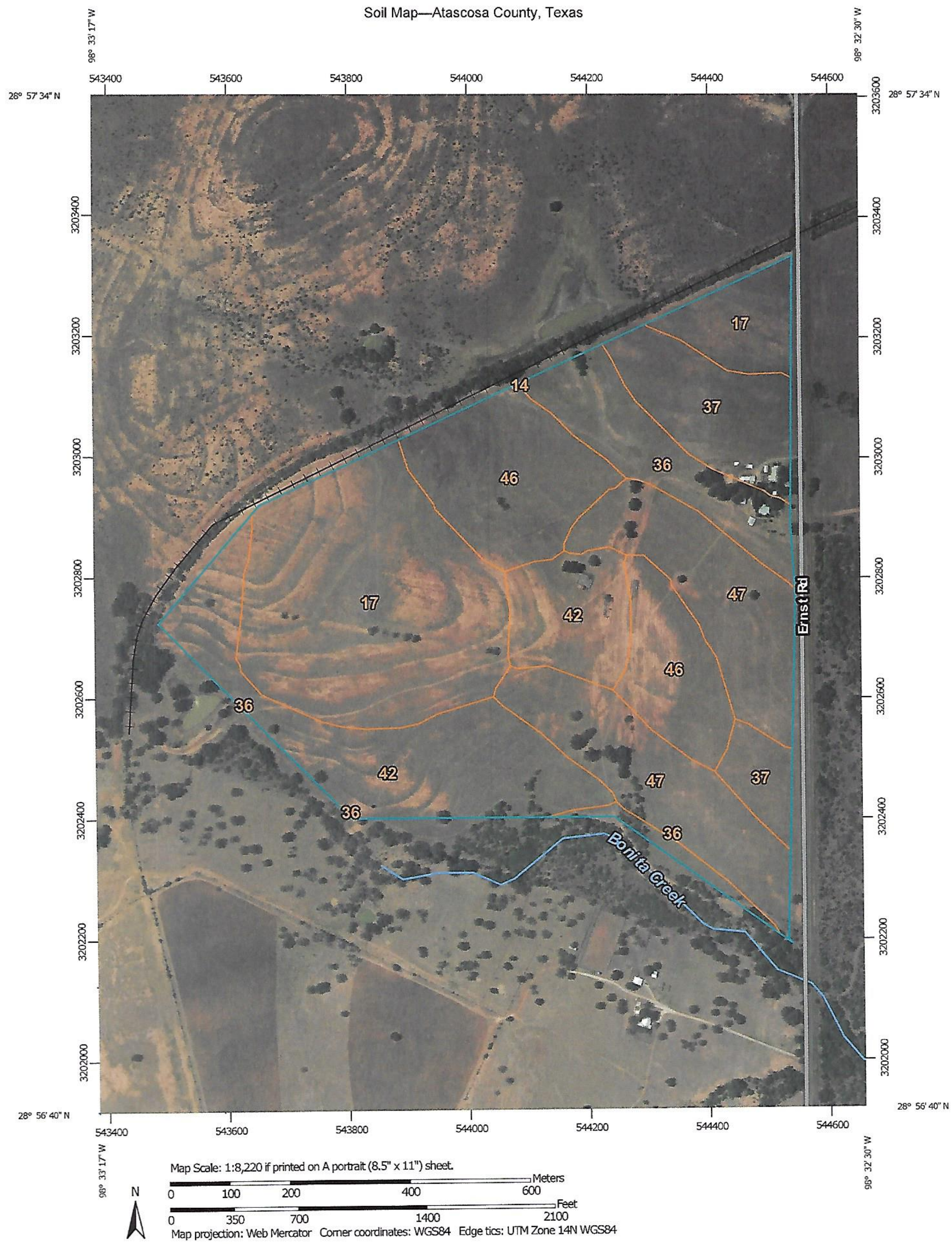
Atascosa County, Texas

Atascosa County, Texas
Site Data

Date: 5/18/16



Soil Map—Atascosa County, Texas



Map Unit Legend

Atascosa County, Texas (TX013)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
14	Floresville fine sandy loam, 1 to 3 percent slopes	0.1	0.0%
17	Hanis sandy clay loam, 1 to 3 percent slopes	45.9	26.7%
36	Poteet soils, occasionally flooded	14.6	8.5%
37	Poth loamy fine sand, 0 to 3 percent slopes	16.1	9.4%
42	Webb fine sandy loam, 1 to 3 percent slopes	34.6	20.2%
46	Wilco loamy fine sand, 0 to 3 percent slopes	26.7	15.5%
47	Wilco loamy fine sand, 3 to 5 percent slopes	33.9	19.7%
Totals for Area of Interest		**171.8**	**100.0%**

Bastrop County, Texas

Billig Ranch
UTSA Monarch and Milkweed
Survey Locations

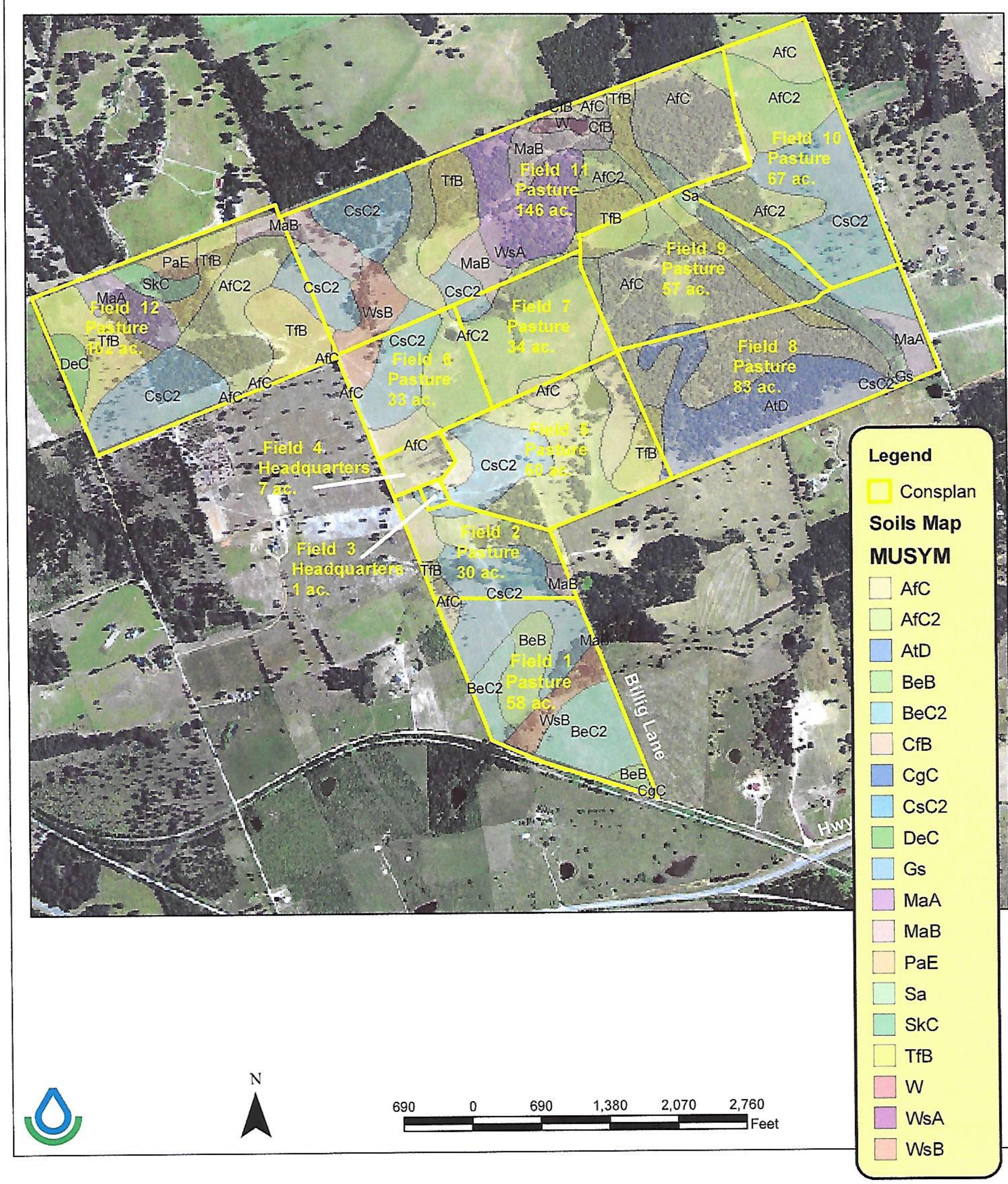
Date: 5/17/2016

Soils Map

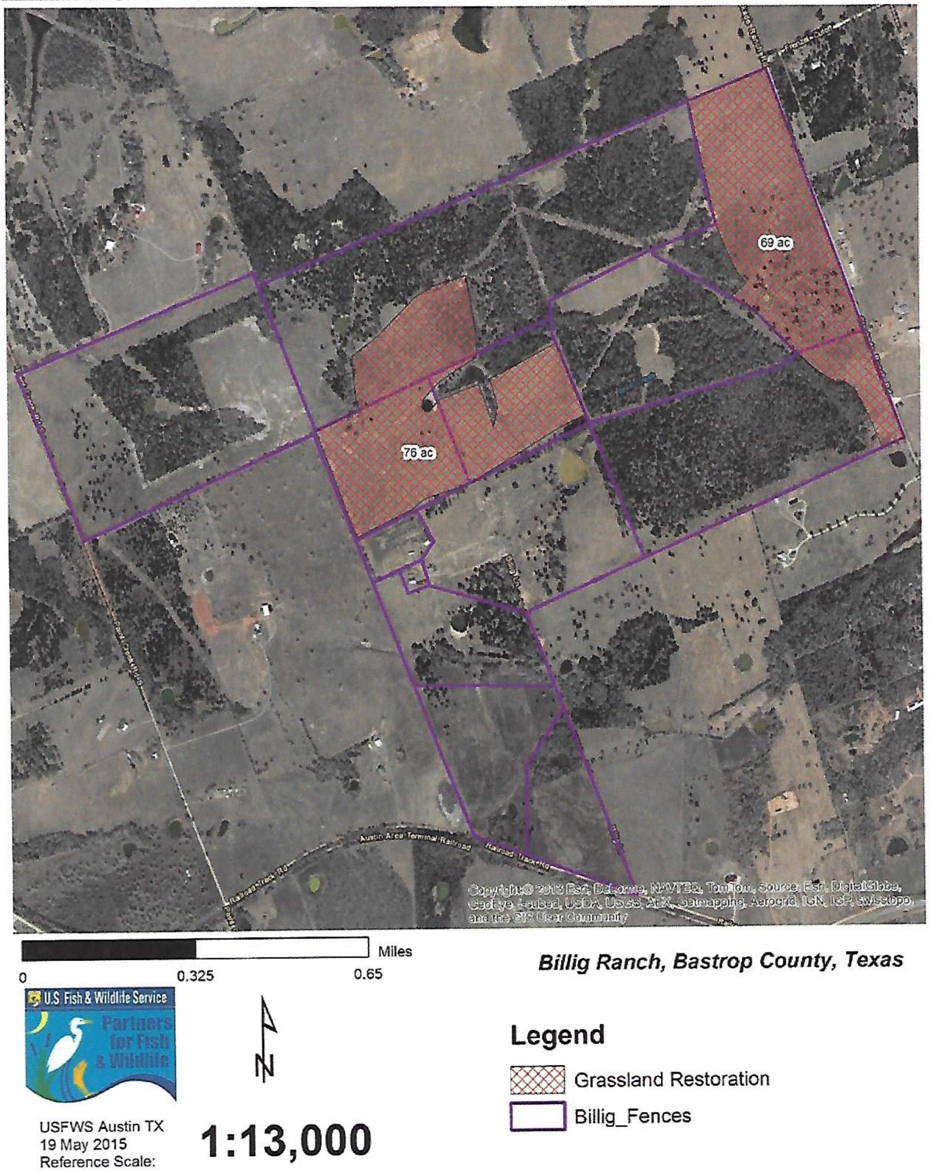
Date: 8/12/2009

Customer(s): PINES AND PRAIRIES LAND TRUST
District: BASTROP COUNTY SOIL & WATER CONSERVATION DISTRICT
Approximate Acres: 675

Field Office: BASTROP SERVICE CENTER
Agency: USDA-NRCS
Assisted By: Morris, Jason C

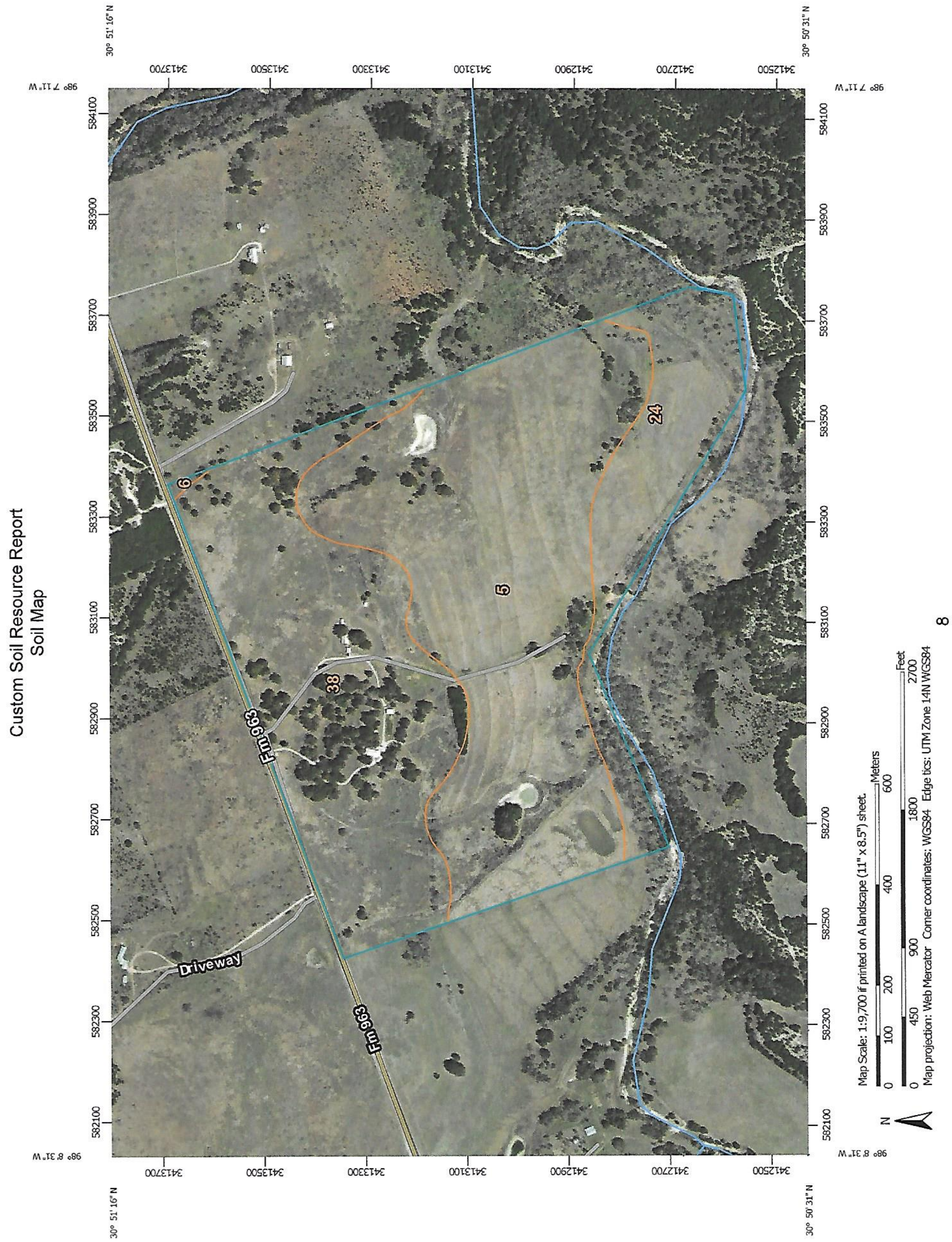


Project Map 1. Proposed treatment areas (Red) over imagery (145 acres).



Burnet County, Texas

Burnet County
Site Data


Custom Soil Resource Report
Soil Map
Fm 963
Fm 963
Driveway
5
6
24
38
30° 51' 16" N
30° 50' 31" N
98° 7' 11" W
98° 8' 31" W
Map Scale: 1:9,700 if printed on A landscape (11" x 8.5") sheet.
Meters
0 100 200 400 600
Feet
0 450 900 1800 2700
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84
8

Map Unit Legend

Blanco and Burnet Counties, Texas (TX601)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
5	Bolar clay loam, 3 to 5 percent slopes	106.6	48.9%
6	Brackett association, 1 to 8 percent slopes	0.4	0.2%
24	Krum clay, 1 to 3 percent slopes	31.3	14.3%
38	Purves association, undulating	79.7	36.6%
Totals for Area of Interest		**218.0**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that

DeWitt County, Texas

Smiley, Texas
Site Data

Soil Map—DeWitt County, Texas
(Dewitt Co. - Jackson Property)

Map Scale: 1:3,580 if printed on A landscape (11" x 8.5") sheet.

N

0 50 100 200 300 Meters

0 150 300 600 900 Feet

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

USDA Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

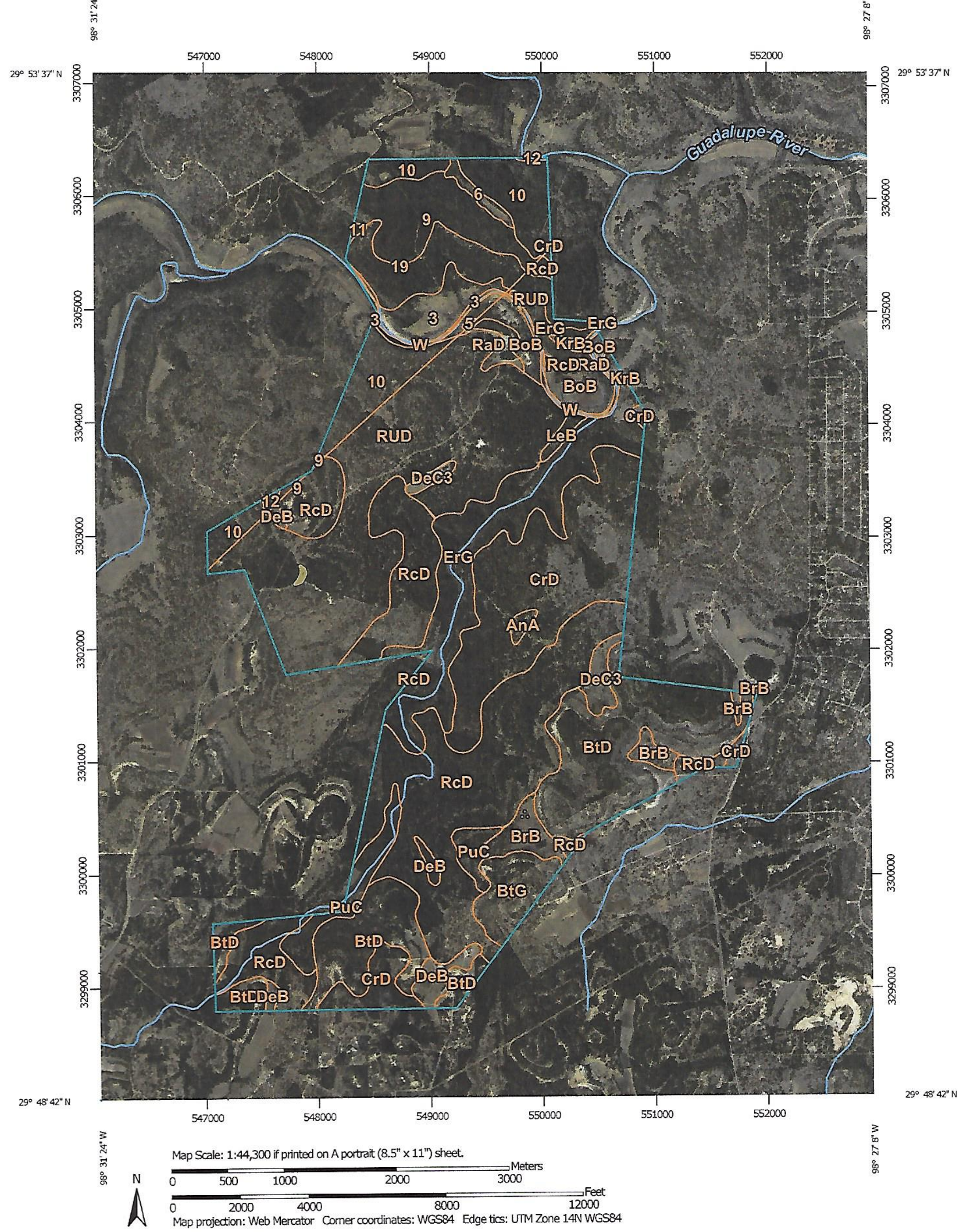
5/26/2016
Page 1 of 3

Map Unit Legend

DeWitt County, Texas (TX123)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
HeB	Heiden clay, 1 to 3 percent slopes	4.8	15.2%
LmC	Leming loamy fine sand, 0 to 5 percent slopes	0.0	0.2%
Me	Meguin silty clay loam, occasionally flooded	4.2	13.4%
MgC	Miguel fine sandy loam, 3 to 5 percent slopes	17.8	56.2%
SaB	Sarnosa fine sandy loam, 1 to 3 percent slopes	4.7	15.0%
Totals for Area of Interest		**31.7**	**100.0%**

Guadalupe County, Texas

Soil Map—Comal and Hays Counties, Texas, and Kendall County, Texas



USDA Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

6/9/2016
Page 1 of 4

Map Unit Legend

Comal and Hays Counties, Texas (TX604)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
AnA	Anhalt clay, 0 to 2 percent slopes	10.2	0.2%
BoB	Boerne fine sandy loam, 1 to 3 percent slopes, rarely flooded	99.5	2.1%
BrB	Bolar clay loam, 1 to 3 percent slopes	75.1	1.6%
BtD	Brackett-Rock outcrop-Comfort complex, 1 to 8 percent slopes	626.6	13.2%
BtG	Brackett-Rock outcrop-Real complex, 8 to 30 percent slopes	94.2	2.0%
CrD	Comfort-Rock outcrop complex, 1 to 8 percent slopes	561.1	11.9%
DeB	Denton silty clay, 1 to 3 percent slopes	53.5	1.1%
DeC3	Denton silty clay, 1 to 5 percent slopes, eroded	44.3	0.9%
ErG	Eckrant-Rock outcrop complex, 8 to 30 percent slopes	388.8	8.2%
KrB	Krum clay, 1 to 3 percent slopes	7.7	0.2%
LeB	Lewisville silty clay, 1 to 3 percent slopes	13.5	0.3%
PuC	Purves clay, 1 to 5 percent slopes	104.8	2.2%
RaD	Real gravelly loam, 1 to 8 percent slopes	28.2	0.6%
RcD	Real-Comfort-Doss complex, 1 to 8 percent slopes	1,008.5	21.3%
RUD	Rumple-Comfort association, 1 to 8 percent slopes	864.7	18.3%
W	Water	19.8	0.4%
Subtotals for Soil Survey Area		**4,000.5**	**84.5%**
Totals for Area of Interest		**4,734.8**	**100.0%**

Kendall County, Texas (TX259)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
3	Boerne fine sandy loam, 0 to 3 percent slopes, occasionally flooded	98.8	2.1%
5	Brackett-Real association, 10 to 30 percent slopes	1.3	0.0%

Kendall County, Texas (TX259)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
6	Denton silty clay, 1 to 3 percent slopes	18.9	0.4%
9	Doss-Brackett association, undulating	178.5	3.8%
10	Eckrant-Comfort association, gently undulating	274.2	5.8%
11	Eckrant-Rock outcrop association, steep	3.1	0.1%
12	Krum silty clay, 1 to 3 percent slopes	5.9	0.1%
19	Tarpley-Comfort association, gently undulating	139.9	3.0%
W	Water	13.8	0.3%
Subtotals for Soil Survey Area		**734.3**	**15.5%**
Totals for Area of Interest		**4,734.8**	**100.0%**

Parker County, Texas

Map Unit Legend

Parker County, Texas (TX367)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
ALE	Aledo-Bolar association, 1 to 8 percent slopes	1,272.3	49.3%
BcC	Bolar clay loam, 3 to 5 percent slopes	4.0	0.2%
BcD	Bolar clay loam, 5 to 8 percent slopes	10.6	0.4%
DeB	Denton clay, 1 to 3 percent slopes	54.1	2.1%
Fc	Frio clay loam, 0 to 1 percent slopes, occasionally flooded	69.2	2.7%
Ff	Frio clay loam, 0 to 1 percent slopes, frequently flooded	74.4	2.9%
KcA	Krum clay, 0 to 1 percent slopes	3.4	0.1%
KcB	Krum clay, 1 to 3 percent slopes	709.9	27.5%
PcB	Purves clay, 1 to 3 percent slopes	7.8	0.3%
PcC	Purves clay, 3 to 5 percent slopes	49.4	1.9%
VeB	Venus loam, 1 to 3 percent slopes	6.8	0.3%
VeC	Venus loam, 3 to 5 percent slopes	226.5	8.8%
VeD	Venus clay loam, 5 to 8 percent slopes	83.7	3.2%
W	Water	6.8	0.3%
Totals for Area of Interest		**2,578.9**	**100.0%**

Appendix IV – Site Specific Nectaring Plants

Table 24. Species of nectaring plants identified for site specific areas. The black spaces indicate presence.

Species	Spring 2017	Fall 2017	Spring 2018
Acacia farnesiana			■
Agalinis edwardsiana		■	
Agalinis heterophylla		■	
Amphiachyris dracunculoides		■	
Anagallis arvensis	■		
Aphanostephus skirrhobasis	■	■	
Ascelpias virdis			■
Asclepias asperula	■		■
Asclepias oenotheroides			■
Asclepias viridiflora			■
Asclepias viridis			■
Astragulus lotiflorus			■
Bifora americana	■		■
Callirhoe involucrata	■		■
Calylophus hartwegii			■
Calyophus berlandieri ssp berlandieri	■		
Castilleja indivisa	■		■
Centaurium calycosum	■		
Chaetopappa bellidifolia	■		
Chamaecrista fasciculata	■		
Commelina erecta		■	
Coreopsis tinctoria	■		
Daucus carota	■		
Daucus pusillus	■		■
Dracopis amplexicaulis	■		
Dyschoriste linearis		■	
Dyssodia pentachaeta	■		■
Engelmannia pinnatifida	■		
Erigeron modestus	■		■
Erigeron philadelphicus	■		
Erigeron strigosus			■
Evax verna	■		■
Evolvulus sericeus	■		
Gaillardia suavis			■
Gaillarida pulchella	■		

Species	Spring 2017	Fall 2017	Spring 2018
Gaura coccinea	■		■
Geranium carolinianum	■		■
Geranium maculatum			■
Giliastrum incisum			■
Giliastrum rigidulum	■		
Glandularia bipinnatifida	■	■	■
Grindelia sp.	■		
Grindelia lanceolate		■	
Grindelia squarrosa			■
Hedeoma acinoides	■		■
Helenium amarum	■	■	■
Herbertia lahue	■		■
Heterotheca subaxillaris		■	
Hymenopappus scabiosaeus	■		■
Krameria lanceolata	■		
Krigia caespitosa			■
Liatris punctata		■	
Linaria texana			■
Linum berlandieri			■
Linum hudsonioides	■		■
Linum rigidum var. berlandieri			■
Lithospermum incisum			■
Lupinus texensis	■		■
Medicago polymorpha	■		
Melampodium leucanthum	■	■	■
Melilotus indicus			■
Melilotus officinalis			■
Mimosa borealis			■
Mimosa sp.	■		
Monarda citriodora	■		
Monarda clinopodioides			■
Nothoscordum bivalve	■	■	■
Oenothera speciosa	■		■
Oenothera suffrutescens			■
Oenothera suffulta			■
Oenothera triloba	■		
Opuntia sp.	■		
Oxalis dillenii	■	■	■
Palafoxia callosa		■	
Phlox cuspidata			■
Plantago aristata	■		
Plantago helleri	■		■

Species	Spring 2017	Fall 2017	Spring 2018
Polygala alba	■		■
Polygala lindheimeri	■		
Polygala verticillata		■	
Pyrrhopappus carolinianus			■
Pyrrhopappus pauciflorus	■		■
Rapistrum rugosum	■		■
Rudbeckia hirta	■		
Rudbeckia triloba	■		
Rumex sp.	■		
Sabatin campestris	■		
Salvia engelmannii			■
Salvia texana	■		■
Scandix pecten-veneris			■
Scutellaria drummondii	■	■	■
Scutellaria resinosa	■		
Senecio ampullaceus	■		
Senecio imparipinnatus	■		
Sida abutifolia	■		
Sida ciliaris		■	
Sisyrinchium angustifolium	■		
Sisyrinchium chilense			■
Sisyrinchium minus	■		
Solanum elaeagnifolium	■		
Sphaeralcea angustifolia	■		
Stenaria nigricans	■	■	
Symphyotrichum drummondii		■	
Symphyotrichum ericoides		■	
Tetraneuris linearifolia			■
Tetraneuris scaposa	■		■
Thelesperma filifolium	■		■
Thelasperma simplicifolium	■	■	
Thymophylla pentachaeta		■	■
Torilis arvensis	■		
Trepocarpus aethusae			■
Triodanis biflora	■		
Triodanis perfoliata			■
Verbena canescens	■		
Verbena halei	■	■	
Verbena hastata		■	
Vicia ludoviciana	■		
Wedelia acapulcensis	■	■	