FLOWER SEQUENCING IN THE FALL FOR PLANT SPECIES IN THE FARVIEW PRAIRIE AT THE FORT WORTH NATURE CENTER, FORT WORTH, TEXAS

by

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ABSTRACT

A study was completed at the Farview Prairie site at the Fort Worth Nature Center (FWNC), Fort Worth, Texas. The goal was to document the sequence of flowering for plants in the fall and collect type specimens for deposit in the Texas Christian University (TCU), the Botanical Research Institute of Texas (BRIT), and the FWNC herbaria. Three transects with 22 1 m2 plots were placed on the study area. Plants in flower were recorded weekly, noting species and number of plants in flower for each species. Data was recorded in a permanent field book and later transferred to an Excel spreadsheet. Four plants of each species were collected for pressing, drying, and mounting as type specimens. They are to be deposited as record into the herbaria of TCU, BRIT, and the FWNC. Ten species flowered during the study period. *Heliotropium tenellum* was dominant in the hot, dry beginning of the study period. *Palafoxia callosa*, *Gutierrezia amoena*, *Croton monanthogynus*, and *H. tenellum* were dominant in the final period. All species collected are native species indicating the prairie community is recovering from past farming and grazing disturbances. The data also provide a valuable benchmark for flower sequencing, as 2015 had twice the average annual precipitation for the region. Data from this study will aid management of the FWNC in their efforts to return ecosystems to a more natural state.

Introduction

The Site

The Fort Worth Nature Center (FWNC), located at 9601 Fossil Ridge Rd, Fort Worth, TX 76135, is 10 miles northwest of downtown Fort Worth, Texas. The northern arm of Lake Worth extends into the FWNC and encompasses 3,500 acres that includes the Grand Prairie and Cross Timbers ecosystems (Figure 1). The Fort Worth Nature Center was established in 1964 as a "wildlife sanctuary and nature preserve" and covered 360 acres of upper Lake Worth. The Audubon Society built a shelter house on the Greer Island and began paving trails (The Friends of the Fort Worth Nature Center and Refuge). Previously, this land was mainly used for ranching and farming and in some areas for mining sand and gravel. When leases ended in 1967, the City of Fort Worth enlarged the FWNC by 3,000 acres (Fort Worth Parks and Community Services Department, 2003). In 1972, buffalo were introduced and in 1977, a prairie dog town was created (FWPCSD, 2003, FFWNCR). In 2003, a new master plan was published (FWPCSD). The FWNC's goal is to educate and involve the community as well as preserve, restore, and conserve the unique ecosystems it houses (FWPCSD). It should be noted that the FWNC contains all 8 soil associations found in Tarrant County (FWPCSD, 2003). Each type supports different communities with their associated plant and animal populations. Invasive and non-native species are part of many FWNC communities. Restoration efforts, including prescribed burning and reseeding, are in place. Even though the Botanical Research Institute of Texas (BRIT) has collected samples, there is a continuing need for surveys of plant communities on the site

(FWPCSD, 2003). For example, surveys before and after prescribed burns can document the effectiveness of this process.

Figure 1: Map of the Fort Worth Nature Center

North Central Texas is located at 150-240 meters above sea level, and the climate is humid-subtropical and exhibits a wide annual temperature range (Natural History of North Central Texas, 2015). The summers are characterized as hot. July and August have the lowest average relative humidity, the highest percentage of sunshine, and the highest temperatures. In September, relative humidity increases and temperature decreases. Precipitation ranges from 8-10 cm a year. The annual average precipitation is 86 cm (NHNCT, 2015). In 2015, precipitation totaled to 159 cm. 43 of the 159.23 cm was precipitated in May. (National Weather Service Weather Forecast Office, 2016).

The Study

The study is located on the Farview Prairie site south of the bison range. According to *Flora of North Central Texas,* the Farview Prairie is one of two subdivisions of the Grand Prairie (Diggs, Lipscomb, and O'Kennon, 1999). When first acquired by the FWNC, the Farview site showed the effects of intense grazing pressure that all but destroyed vegetation on the upper slope, exposing the limestone substrate (S. Tuttle, personal communication, October 13, 1999). As a result, the ecosystem is undergoing secondary succession. In addition, the site has been exposed to several prescribed burns in an effort to "return nutrients to the soil, remove thatch, and control woody plants" (S. Tuttle, personal communication, October 13, 1999).

The goals of this study are 1) to determine the sequence of species-specific flowering from September 14, 2015 to November 23, 2015 after the first freeze, 2) to create a herbarium collection of the flowering plants, 3) to provide information not included in a study of this same location completed by MacKenzie (2003), and 4) to provide a database of information that will aid the FWNC staff in management of the Farview Prairie.

The study site is part of the Caprock ecosystem of the Fort Worth Prairie which is a component of the Grand Prairie (Diggs, Lipscomb, and O'Kennon, 1999). The Grand Prairie's substrate is limestone formed during the lower Cretaceous period. The Fort Worth Prairie component is treeless consisting of mostly dip plains. Most of the vegetation is *Andropogon gerardii* (big bluestem), *Schizachyrium scoparium* (little bluestem), and *Sorghastrum nutans* (Indian grass). The Fort Worth Prairie has survived well because of the shallow soils that are untillable and as result were used primarily for grazing. Two main factors have affected the Fort

Worth Prairie – fire suppression and woody species invasion (Diggs, Lipscomb, and O'Kennon, 1999).

Prairie grasses survive burning, droughts, and grazing animals through an adaptation known as the intercalary meristem (Anderson, 2012). This is the part of the plant that produces new stem and leaf tissue that is located under the soil surface. Also, plant species living in warm habitats have the C4 pathway of photosynthesis and are referred to as "warm season" plants (Anderson, 2012). Usually the temperature of a habitat determines whether a plant species is a C3 (cool season species) or a C4 (warm season species). C4 plants dominate when the temperature of the growing season above 30° C and there is adequate soil moisture. The dominant grasses of the Central Grasslands of North American are C4 grasses including *A. gerardii*, *S. scoparium*, and *S. nutans*. C4 plants are characterized by efficient water use, higher photosynthesis rates, ability to grow with low soil-water potential, and a sensitivity to stomatal water loss (Anderson, 2012). Apparently C3, woody plants are now invading prairie systems (McCarron, 2001). This has led to a new category of research to determine why C3, woody shrubs are out-competing the previously dominant native C4 grasses (McCarron, 2001).

Materials and Method

Three transects were created at the site, starting from a common (master) plot on the southeast corner of the study site. Transect placement was established to sample the same areas of the site as a previous study (MacKenzie, 2003) to add new information to the study. Transects radiated downhill from the master plot. Easternmost transect 1 ran along a bearing of 0° N, transect 2 was 335° NNW, and transect 3 was 295° WNW. One m^2 sample plots were placed at 10 m intervals along each transect. A pink marker flag with the plot ID written on it in

permanent marker was place on the northwest corner of each plot. GPS coordinates were established for each plot (appendix A) using a Garmin eTrex Vista Cx GPS receiver.

Table 1: GPS coordinates for each sample plot for each transect.

	Transect 1	Transect 2	Transect 3
Plot 1	N 32° 50.191’ W 097° 28.751’	N 32° 50.191’ W 097 28.753’	N 32° 50.189’ W 097 28.756’
Plot 2	N 32° 50.196’ W 097° 28.752’	N 32° 50.196’ W 097 28.756’	N 32° 50.192’ W 097 28.761’
Plot 3	N 32° 50.202’ W 097° 28.753’	N 32° 50.201’ W 097 28.758’	N 32° 50.195’ W 097 28.767’
Plot 4	N 32° 50.207’ W 097° 28.753’	N 32° 50.206’ W 097 28.760’	N 32° 50.199’ W 097 28.773’
Plot 5	N 32° 50.214’ W 097° 28.753’	N 32° 50.211’ W 097 28.763’	N 32° 50.202’ W 097 28.778’
Plot 6	N 32° 50.220’ W 097° 28.751’	N 32° 50.217’ W 097 28.734’	N 32° 50.206’ W 097 28.782’
Plot 7	N 32° 50.224’		

	W 097° 28.754’		
Plot 8	N 32° 50.229’ W 097° 28.756’		
Plot 9	N 32° 50.235’ W 097° 28.754’		
Plot 10	N 32° 50.240’ W 097° 28.753’		

Weekly sampling was conducted on Mondays from September 14, 2012 to November 23, 2015. Exceptions occurred during week 5 and week 10 of the study. Week 5 sampling took place on Tuesday, October 13, 2015. No sampling occurred during week 10 of November 16, 2015. Sampling of each plot was accomplished by placing a 1 m^2 quadrat on each plot so that the northwest corner of the quadrat touched the base of the pink marker flag. The quadrat, made from PVC pipe, defined the area to be sampled. A total of 22 plots were sampled. Each species in flower was described in writing, counted, photographed, and identified to species using Shinner’s and Mahler’s *Flora of North Central Texas* (Diggs, Lipscomb, and O’Kennon, 1999). Verification of plant identification was provided by Barney Lipscomb at the Botanical Research Institute of Texas (BRIT). All data was recorded in a permanent field book. Data was later transferred to an Excel spreadsheet.

On the first Monday of each month during the course of the study, images were recorded of each of the 22 plots. Four specimens of each plant species in flower were collected from an area adjacent to the sample plot. Each was removed from the soil so that the root system remained intact. They were pressed and dried for 48 hours, placed in a freezer for 48 hours, and mounted on herbarium paper stock with an appropriate label. These mounts will be deposited with the FWNC, BRIT, and Texas Christian University.

In addition, precipitation data was acquired from the National Weather Service Forecast Office's online site. These data were compiled at the Dallas-Fort Worth International Airport, 32.0 miles from the FWNC. In 2015, precipitation totaled to 159.029 cm. 43.0784 of the 159.23 cm was precipitated in May (NWSWFO, 2016). The precipitation for 2015 was twice the yearly average for North Central Texas which is 71.12 to 81.28 cm. This could potentially influence flowering patterns on the site.

Table 2: Monthly precipitation data (cm) from the National Weather Service Forecast Office for 2015.

Month	Centimeters of Rain
January	9.1948
February	7.5184
March	6.4262
April	14.1224
May	43.0784

June	10.033
July	2.3368
August	1.1684
September	5.4356
October	24.9428
November	25.0444
December	9.7282
TOTAL for 2015	159.029

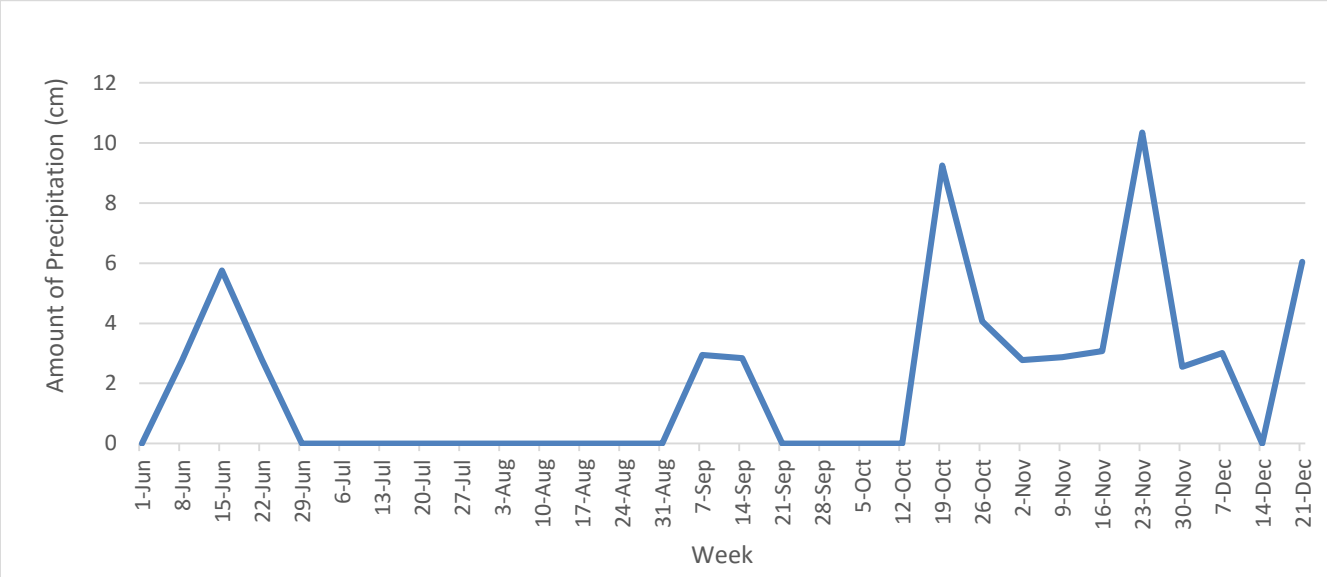

Figure 2: Amount of precipitation from the week of June 1, 2015 through the week of December 21, 2015 from the National Weather Service Forecast Office.

Results

Ten plant species flowered during the study period. Numbers of plants flowering per species for each sample period are presented in Table 3. The flowering pattern of each species over the course of the 12 week study was tracked (Figure 1). Flowering patterns of all species were graphed (Figures 2-14). Images for each species is also included as part of the data collection.

Table 3: The number of flowering plants for each species for each weekly sample during the study.

Week	1	2	3	4	5	6	7	8	9	11	12
Heliotropium tenellum	286	126	19	8	1	2	2	120	73	0	0
Palafoxia callosa	7	13	25	29	25	23	18	33	86	0	0
Croton monanthogynus	34	16	4	0	0	0	22	28	27	0	0
Chamaesyce missurica	5	16	12	14	2	4	5	0	0	0	0
Paronychia virginica	2	1	3	3	3	3	1	3	3	0	0
Gutierrezia amoena	0	1	6	15	16	41	53	38	43	7	5
Dalea hallii	0	2	2	1	0	0	0	0	0	0	0
Liatris mucronata	0	0	5	15	9	1	0	0	0	0	0
Ambrosia psilostachya	0	0	0	5	0	0	0	0	0	0	0
Nothoscordum bivalve	0	0	0	0	0	0	0	1	2	0	0

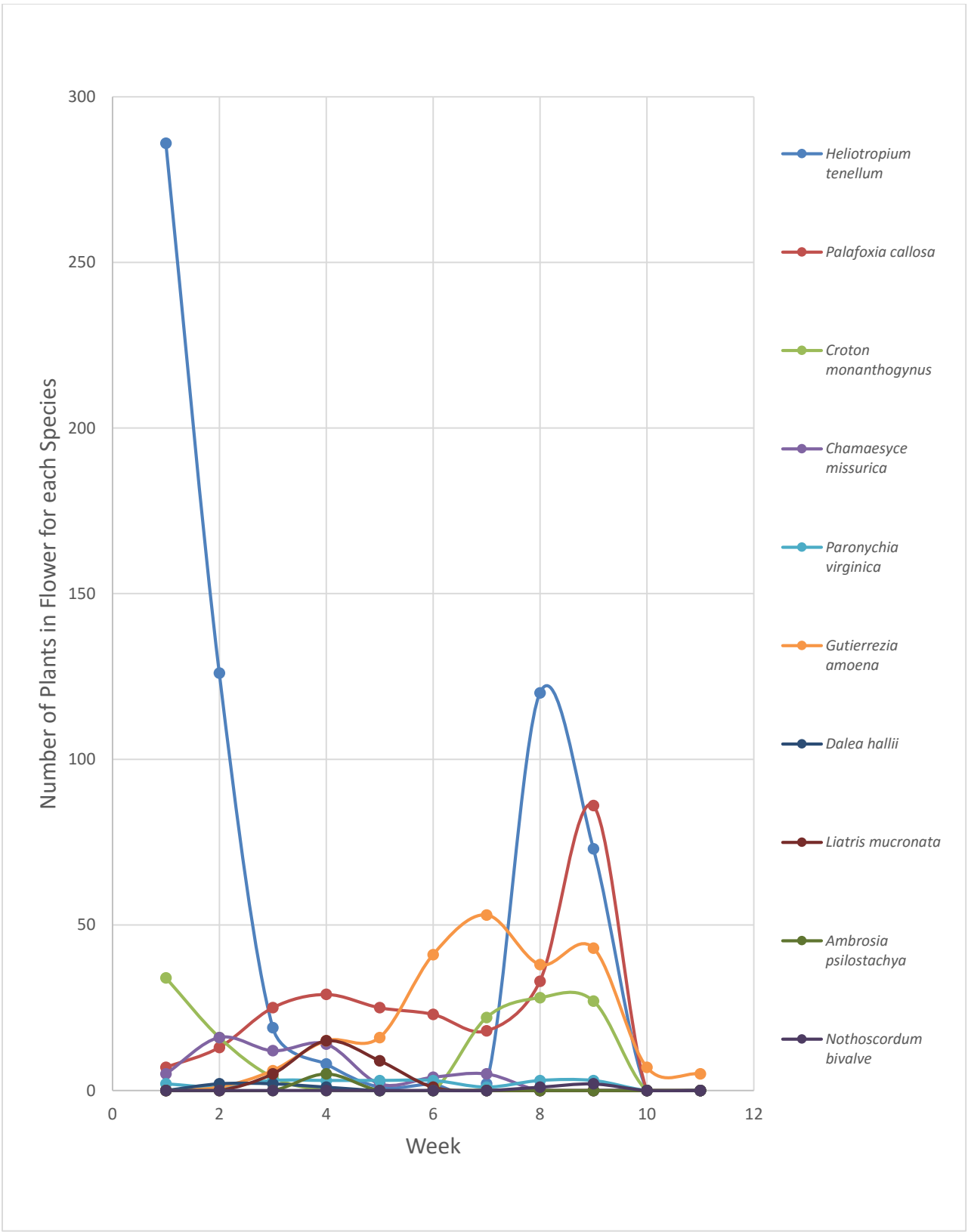
300
250
200
150
100
50
0
Number of Plants in Flower for each Species
0
2
4
6
8
10
12
Week
Heliotropium tenellum
Palafoxia callosa
Croton monanthogynus
Chamaesyce missurica
Paronychia virginica
Gutierrezia amoena
Dalea hallii
Liatris mucronata
Ambrosia psilostachya
Nothoscordum bivalve

Figure 3: Change in the number of flowering plants for each species throughout the study.

Four species of the Asteraceae family flowered during our observation period.

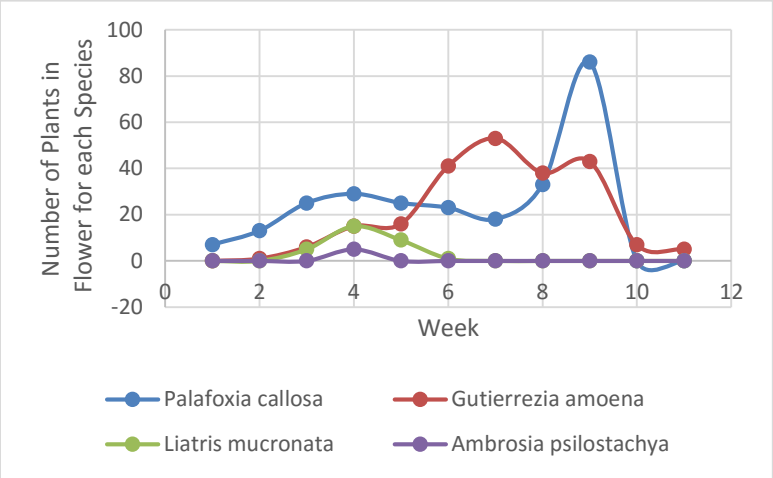

Figure 4: The number of plants in flower for species in the Asteraceae Family over time.

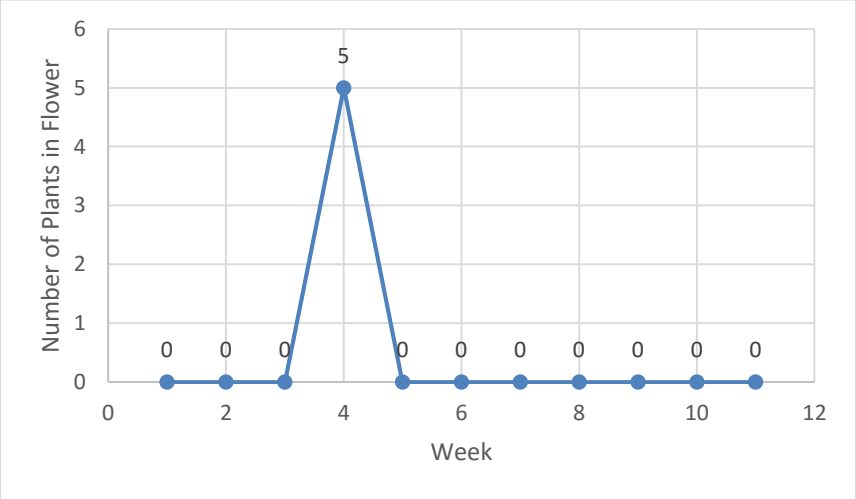

Figure 5: The number of *Ambrosia psilostachya* plants in flower over time. (Asteraceae)

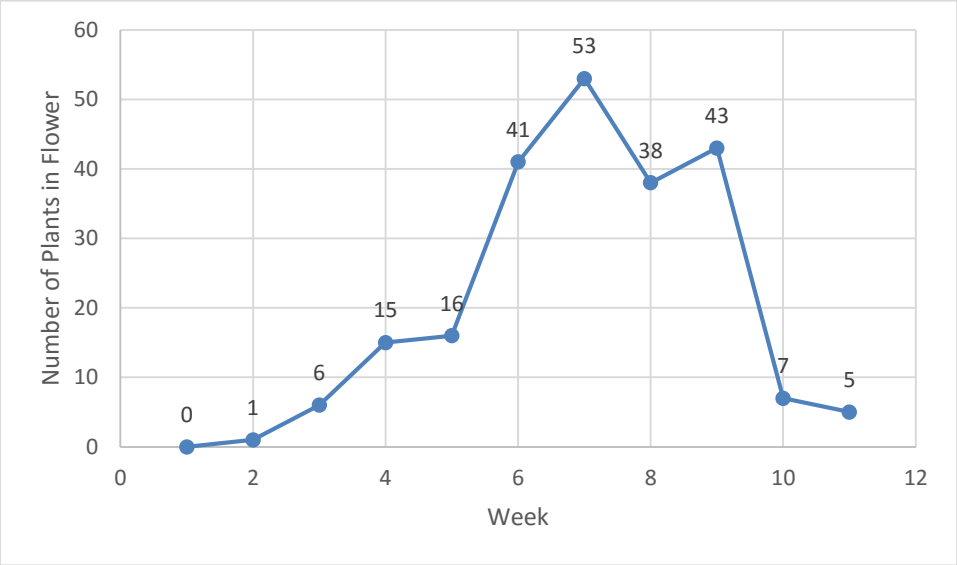

Figure 6: The number of *Gutierrezia amoena* plants in flower over time. (Asteraceae)

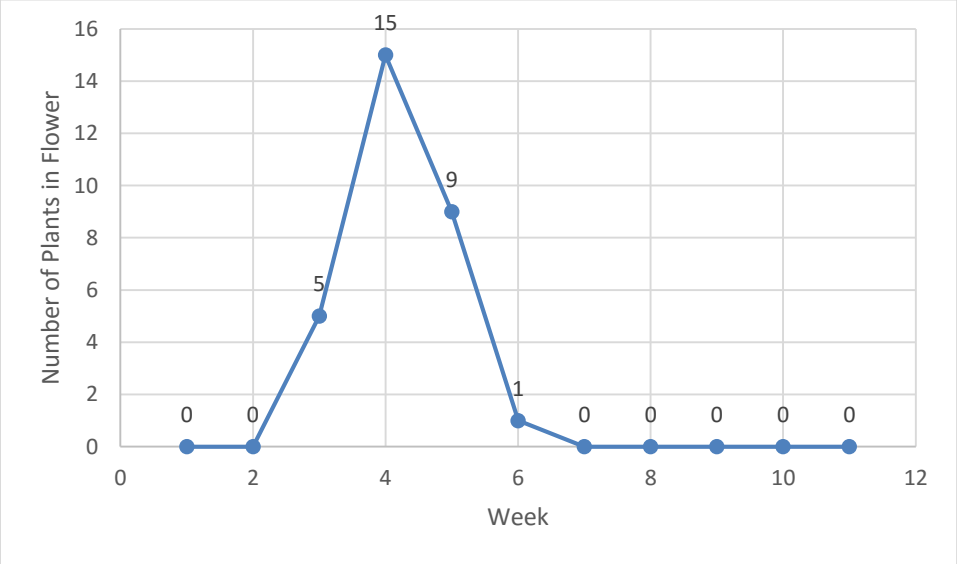

Figure 7: The number of *Liatris mucronata* plants in flower over time. (Asteraceae)

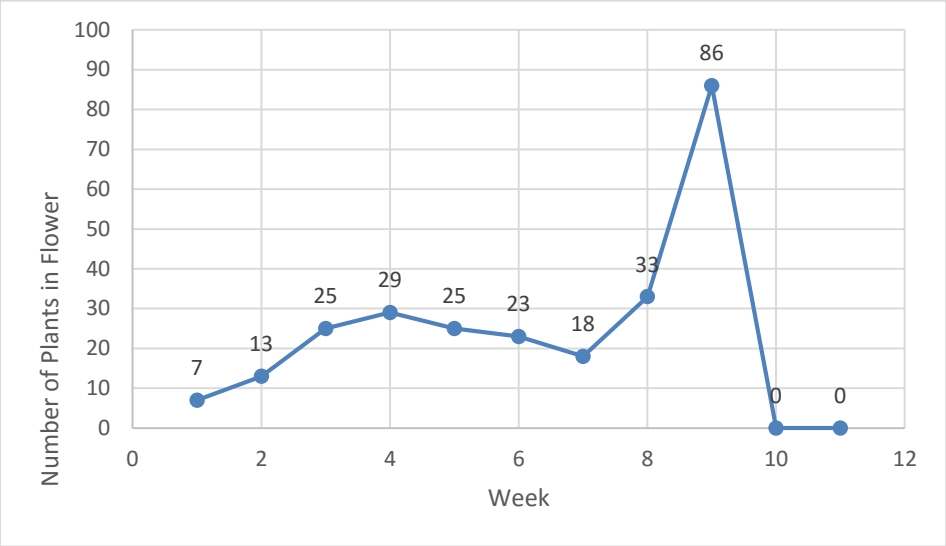

Figure 8: The number of *Palafoxia callosa* plants in flower over time. (Asteraceae)

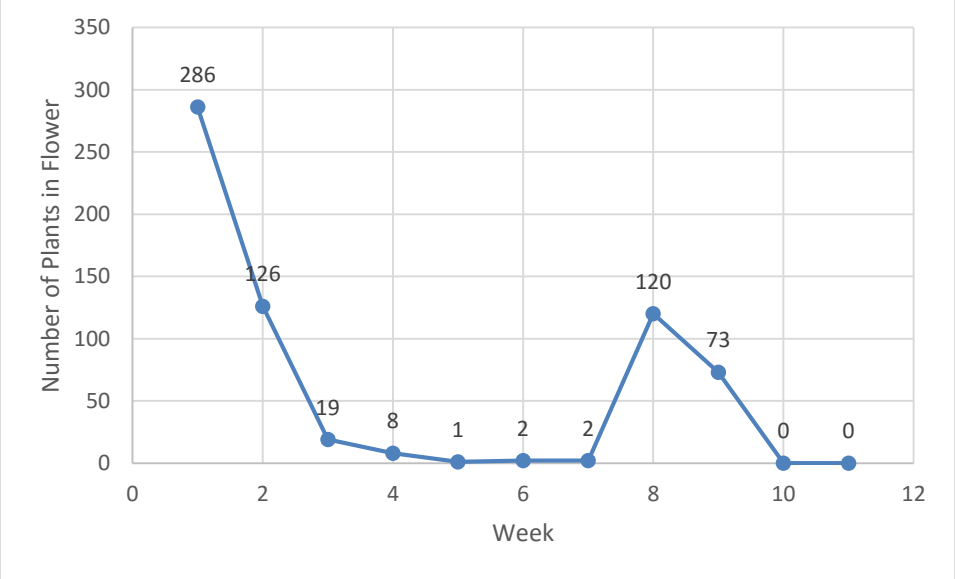

Figure 9: The number of *Heliotropium tenellum* plants in flower over time. (Boraginaceae)

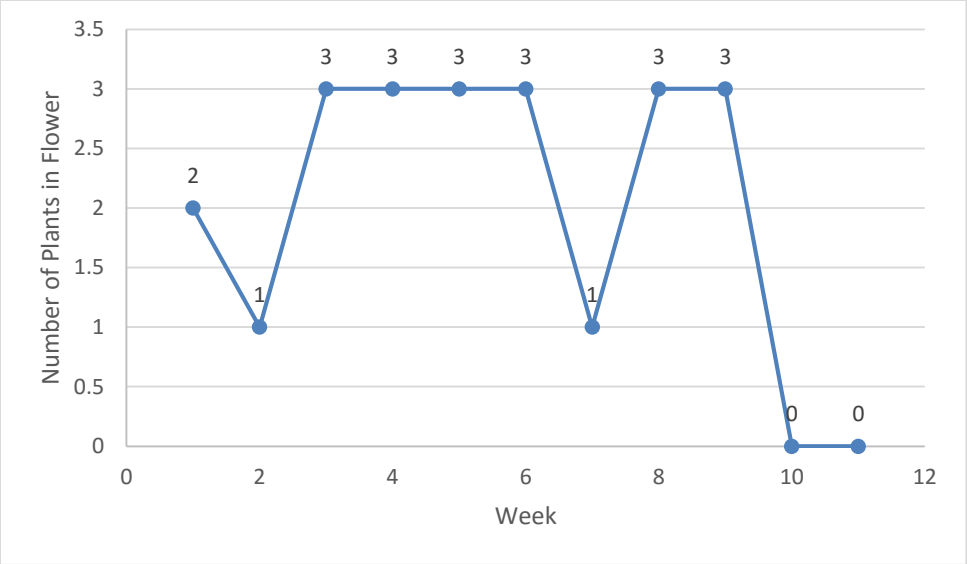

Figure 10: The number of *Paronychia virginica* plants in flower over time. (Caryophyllaceae)

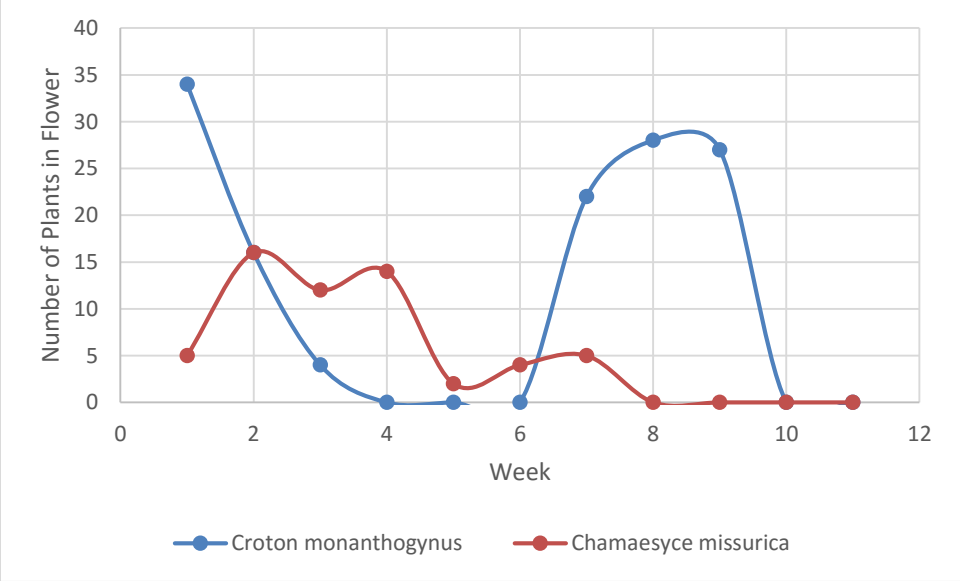

Figure 11: The number of plants in flower for species in the Euphorbiaceae Family over time.

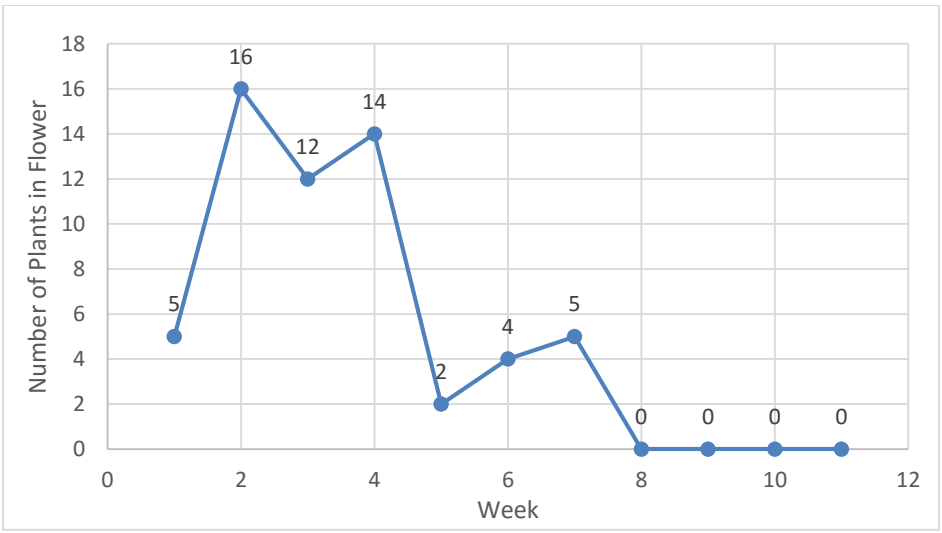

Figure 12: The number of *Chamaesyce missurica* plants in flower over time. (Euphorbiaceae)

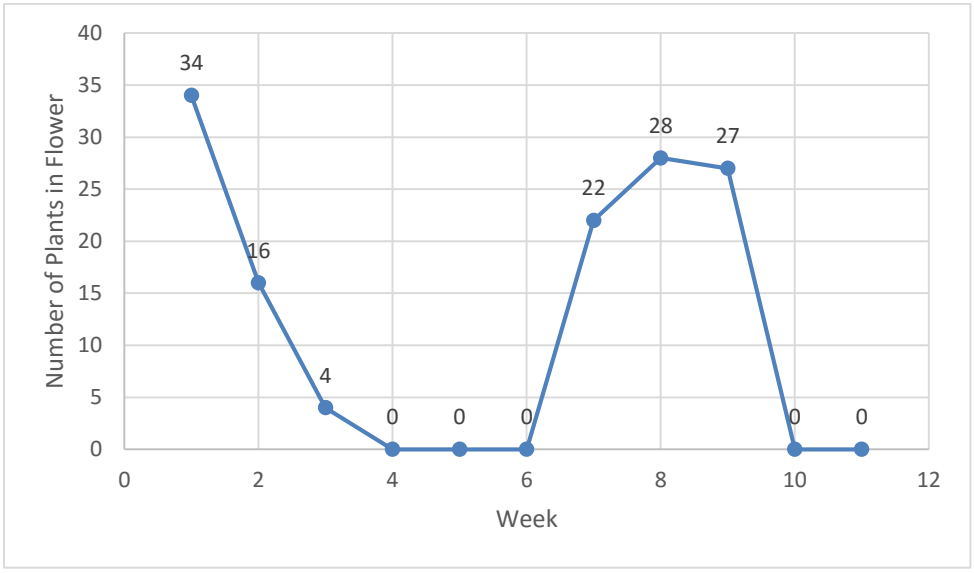

Figure 13: The number of *Croton monanthogynus* plants in flower over time. (Euphorbiaceae)

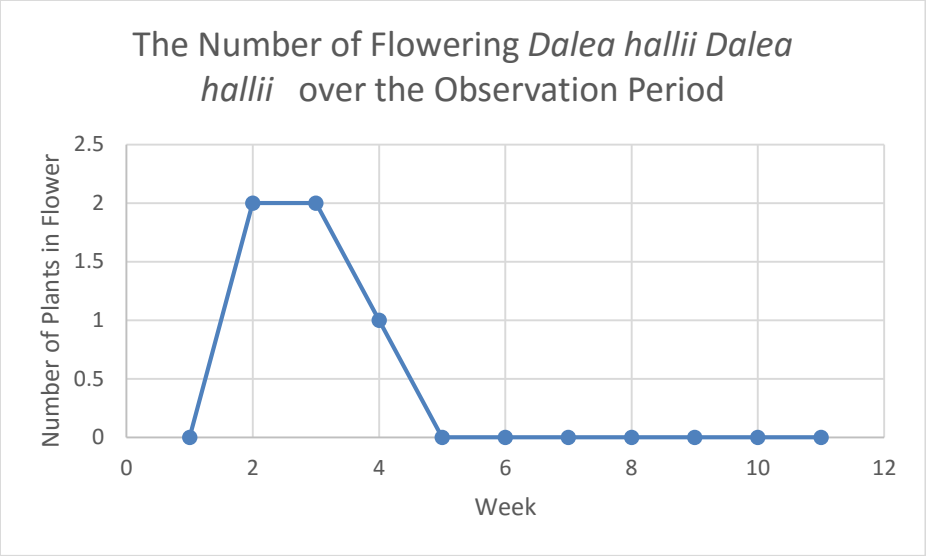

Figure 14: The number of *Dalea hallii* plants in flower over time. (Fabaceae)

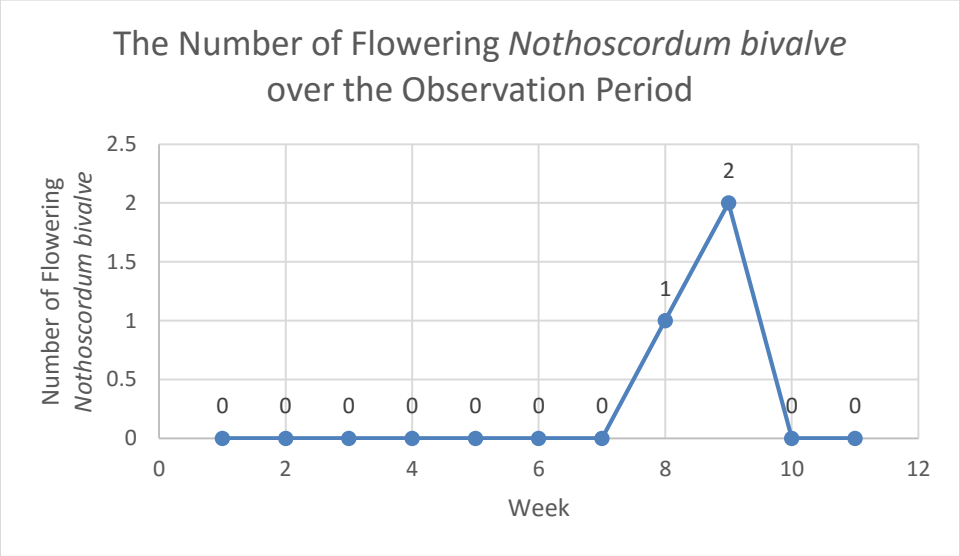

Figure 15: The number of *Nothoscordum bivalve* plants in flower over time. (Liliaceae)

Discussion

The Asteraceae family is a large flowering family with over 21,000 species world-wide (Diggs, Lipscomb, and O'Kennon, 1999). It is the largest plant family in Texas, contributing 620 species (13% of all species in Texas). There are some economically important species such as

lettuce and artichoke and many ornamental species such as sunflowers and marigolds. Ragweed can cause severe hay fever (Diggs, Lipscomb, and O'Kennon, 1999). Our samples included 4 species in this family - *Palafoxia callosa* (palafoxia), *Gutierrezia amoena* (broomweed), *Liatris mucronata* (gayfeather), and *Ambrosia psilostachya* (western ragweed).

Palafoxia callosa is commonly found in calcareous soils or in disturbed habitats of east Texas, west to the rolling plains and south to the Edwards plateau (Diggs, Lipscomb, and O'Kennon, 1999). It flowered from August to until the first freeze in November (Figure 8) which is consistent with the literature (Diggs, Lipscomb, and O'Kennon, 1999).

Gutierrezia amoena is commonly found on calcaeous soils on or near limestone outcrops in the rocky prairies of central and north central Texas as well as in west Texas (Diggs, Lipscomb, and O'Kennon, 1999). Our study indicates flowering from late September to October (Figure 6) which is in agreement with the literature (Diggs, Lipscomb, and O'Kennon, 1999).

Liatris mucronata is identified by the spike-like plant structure that becomes covered in purple corollas (Diggs, Lipscomb, and O'Kennon, 1999). *L. mucronata* is most commonly found in calcareous soils, in North Central Texas prairies such as the Blackland and Grand Prairies, and in southeast and east Texas (Diggs, Lipscomb, and O'Kennon, 1999). In our study, *L. mucronata* flowered from the 3rd to the 5th week starting in late September to mid-October (Figure 7). In the literature, *L. mucronata* is recorded as flowering from August until November.

The remaining member of the Asteraceae to flower in the study was *Ambrosia psilostachya* (western ragweed), known to cause hay fever. *A. psilostachya* was used by Native Americans in tea as a medicinal treatment (Diggs, Lipscomb, and O'Kennon, 1999). It uses allelopathy to inhibit the growth of other, select organisms. Western ragweed is most common in

disturbed areas and is abundant throughout Texas (Diggs, Lipscomb, and O'Kennon, 1999). In our study, *A. psilostachya* flowered from the 3rd to the 5th week (Figure 5), the same pattern as with *L. mucronata.* The flowering time of *A. psilostachya* has not been reported in the literature for the Fort Worth prairie.

During the course of the study, *Heliotropium tenellum* (pasture heliotrope) in the Boraginaceae family was sampled. The Boraginaceae family consists of temperate and subtropical plants ranging from herbs to trees to shrubs to vines (Diggs, Lipscomb, and O'Kennon, 1999). Some species in this family are used medicinally or for flavoring. Common Boraginaceae plants include borage, forget-me-nots, and Virginia bluebells. *H. tenellum*, the species sampled in our study, has white corollas and a yellow center. *H. tenellum* is commonly found in limestone based soils and in the most eastern half of Texas. According to MacKenzie's study (2003), this species is a dominant plant at our study site. It does well in hot, dry weather and flowers from May to October (Diggs, Lipscomb, and O'Kennon, 1999). Flowering was depressed during the rainy period of our study (Figure 9).

Another species sampled at the study site was *Paronychia virginica* (broom nailwort) in the Caryophyllaceae (Pink) family. The Caryophyllaceae family contains mostly herbs (Diggs, Lipscomb, and O'Kennon, 1999). This family is found in the temperate or warm northern hemisphere. An identifying characteristic of this family is the notched petals that look as if pinking shears created them; hence the phrase "pink family." The colorful carnation is a member of the Caryophyllaceae family. *P. virginica* of the Caryophyllaceae family is a perennial consisting of a woody base. It was sampled at our study and is commonly found in limestone based soils such as the Blackland and Grand Prairies (Diggs, Lipscomb, and O'Kennon, 1999).

Our data showed *P. virginica* flowers from August to October (Figure 10) which matches the literature (Diggs, Lipscomb, and O'Kennon, 1999).

Two plant species in the Euphobriaceae family were sampled in the study, *Chamaesyce missurica* (Missouri spurge) and *Croton monanthogynous* (one seed croton). The Euphorbiaceae consists of tropical plants varying from shrubs and herbs to trees and succulents (Diggs, Lipscomb, and O'Kennon, 1999). They have specialized cells that secrete the milky or colored latex sap. Economically important family members include poinsettia, rubber tree, tapioca, and tung oil tree. Some Euphobriaceae are poisonous due to the presence of alkaloids and cyanogenic glycosides (Diggs, Lipscomb, and O'Kennon, 1999).

Chamaesyca missurica (Missouri spurge), an annual plant, was sampled in our plots. It is commonly found in limestone based soil or loose sandy soils throughout Texas east of the Trans-Pecos River (Diggs, Lipscomb, and O'Kennon, 1999). It is reported that C. *missurica* flowers from May to October (Diggs, Lipscomb, and O'Kennon, 1999). At our study site, flowering decreased notably after the rain in October (Figure 12).

Croton monanthogynus (one seed croton) is commonly found throughout most of Texas in a variety of places such as roadsides, waste sites, rocky ground, or eroding ground (Diggs, Lipscomb, and O'Kennon, 1999). It is especially found in calcium-rich soils. Records show that *C. monanthogynus* flowers from June to November (Diggs, Lipscomb, and O'Kennon, 1999). At our site, flowering was high except during the October rains and after the first freeze (Figure 13).

The Fabaceae (bean) family varies from herbs to rain forest canopy trees (Diggs, Lipscomb, and O'Kennon, 1999). This family is the third largest angiosperm family and the third largest plant family in North Central Texas. They are especially important ecologically because their roots are associated with nitrogen-fixing bacteria, *Rhizobia.* Important, protein-rich,

Fabaceae plants include peanuts, beans, chick-peas, soybeans, and lentils. Some Fabaceae plants such as *Sophora secundiflora* contain alkaloids making them poisonous (Diggs, Lipscomb, and O'Kennon, 1999).

Our sampling only identified two individual plants in the Fabaceae family. Both of these two plants were the species *Dalea hallii* (Hall's Dalea) (Diggs, Lipscomb, and O'Kennon, 1999). *D. hallii* is endemic to Texas and is most commonly found in the Blackland and Grand Prairies of south and central Texas (Diggs, Lipscomb, and O'Kennon, 1999). Our two individuals were in flower until mid-September (Figure 14). The normal flowering period for this species is from late May to June (Diggs, Lipscomb, and O'Kennon, 1999).

The Liliaceae (lily) family consists of perennial herbs with a bulb or rhizome (Diggs, Lipscomb, and O'Kennon, 1999). Lilies and Tulips are major landscape plants. Some of the Liliaceae plants are edible while others contain alkaloids which are poisonous (Diggs, Lipscomb, and O'Kennon, 1999). *Nothoscordum bivalve* (crow poison) appear in our study plots at the end of the study in November. Flowers of *N. bivalve* have white petals with a yellow base inside and lavender to purple-red midribs (Diggs, Lipscomb, and O'Kennon, 1999). This species is one of the most abundant and widespread of the native species. It is commonly found in disturbed areas, open woods, or prairies, and it is found throughout Texas. It has two flowering seasons – March through late May and late September to October (Diggs, Lipscomb, and O'Kennon, 1999). Our plants flowered from the end of September through the first freeze in November (Figure 15).

Although our experimental design was implemented to sample the same areas as MacKenzie's 2003 study, it missed at least one other species that flowered during the time frame of our study. *Eryngium leavenworthii* (Eryngo) in the Apiaceae (carrot) family was observed flowering to the east of transect 1. No data was collected for this species as it did not fall within

any of our plots. However, it was photographed, collected, pressed, and mounted this species. *E. leavenworthii* is commonly found in prairies and woody areas (Diggs, Lipscomb, and O'Kennon, 1999). The forb is a native to prairies and is associated with calcareous soils typical of the Fort Worth Prairie (Engle, et al., 2000).

Conclusion

A database was created tracking the sequence of flowering plants from September 14, 2015 to November 23, 2015 (Figure 3). Also, type specimens were collected to document the species that flowered. Digital images for each plot were taken at the beginning of each month, and these series of three images for each plot can be placed in a digital flip book application to see the progression of the Caprock Prairie. Data from this study is valuable for comparative purposes as the precipitation for 2015 was twice that of the average precipitation per year for the region. All the species that flowered during the study are native (Diggs, Lipscomb, and O'Kennon, 1999). The presence of cryptogrammic soil indicates the prairie is healthy (United States Department of Agriculture, 1997). This indicates the FWNC's efforts to restore the prairie to a more natural state might be successful.

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