City of Austin 2018

Staff Report on Bracted Twistflower (*Streptanthus bracteatus*)

Balcones Canyonlands Preserve Annual Report



Bracted Twistflower blooming at Gus Fruh Park
in Austin, Texas with powdery mildew visible on leaves (J. Scalise)

City of Austin, Austin Water
Wildland Conservation Division
Balcones Canyonlands Preserve

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Introduction

Bracted Twistflower (*Streptanthus bracteatus*) is a rare, annual plant in the Brassicaceae family. It was classified by U.S. Fish and Wildlife Service (USFWS) as a candidate for listing under the Endangered Species Act in 2011. There are few existing populations, many of which are located in rapidly urbanizing areas where colonies are being threatened by development. Other threats include recreational activities (mountain bikes and foot traffic), deer herbivory, and low genetic variation (Zippin 1997, Pepper 2010, USFWS 2013). Its known population is limited to just five counties in central Texas (Bexar, Hays, Medina, Travis, and Uvalde Counties; Poole et al. 2007), with a historical range of at least 8 counties (Damude and Poole 1990).

Bracted Twistflowers sprout in the fall and winter and develop an acaulescent rosette of waxy blue-green leaves. In spring, the plants begin bolting and display their showy lavender, four-petaled flowers along a stalk with clasping leaves. The fruits, called siliques, are long slender pods that later dehisce to release their seeds. The plants are commonly eaten by White-tailed Deer (*Odocoileus virginianus*) and other mammalian browsers (such as rabbits and squirrels) as well as by insects such as Falcate Orangetip (*Anthocharis midea*) and Checkered White (*Pontia protodice*) butterfly larvae (Zippin 1997, Leonard 2010). Leonard (2010) suggested that studies should be done on the potential detrimental effects of powdery mildew as this pathogen was noted on most plants in the field.

There are only 16 known colonies of Bracted Twistflower. Of those, eight are within Travis County and five exist entirely within or extend onto City of Austin (COA) Balcones Canyonlands Preserve (BCP) property. The COA signed a Memorandum of Agreement (MOA) with the USFWS and other members of the Bracted Twistflower Working Group in 2003 to manage and monitor those populations (USFWS et al. 2004). The populations that COA manages include Covert Park at Mt. Bonnell (Mt. Bonnell), Ullrich Water Treatment Plant (Ullrich), Barton Creek Greenbelt and Wilderness Park (Barton Creek), Gus Fruh Park (Gus Fruh), Bull Creek District Park (Valburn), and Vireo Research Area (Vireo Preserve) (Figure 1). The population at Vireo Preserve was established as part of an introduction study in 2009 (Fowler 2012) and was supplemented with more plants the following year by Walter Stewart.

COA staff have worked to protect plants from trampling by humans and browse by deer. Chain link fencing was installed along Loop 360 (Capitol of Texas Highway) and around the upslope and downslope entrances of an unauthorized trail that passed through an area with Bracted Twistflower. The goal of these fencing efforts was to reduce trampling and erosion from large numbers of people that were parking along Loop 360. A fence was also built around a section of plants at Barton Creek next to the Zippin research plot, by COA staff in 1998 (pers. comm. M. Sanders), to exclude deer from foraging on plants. In 2003, at Ullrich, a game fence was built to prevent deer browse of Bracted Twistflower. In winter of 2015, iron fencing was installed to reduce damage to plants from social trails along the cliff edge at Mt. Bonnell.

On COA property, plants tend to occur on hillsides in canopy openings, near canopy gaps, and in closed canopy typical of Ashe juniper-oak (*Juniperus ashei-Quercus sp.*) woodlands. The most common canopy

species that co-occur with Bracted Twistflower include Ashe Juniper, Plateau Live Oak (*Quercus fusiformis*), Shin Oak (*Quercus sinuata*), Texas Red Oak (*Quercus buckleyi*), and Texas Ash (*Fraxinus texensis*). The understory vegetation that commonly co-occurs with Bracted Twistflower includes Texas Mountain Laurel (*Dermatophyllum secundiflorum*), Elbow Bush (*Forestiera pubescens*), Mouse Ears (*Bernardia myricifolia*), Agarita (*Mahonia trifoliata*), Texas Persimmon (*Diospyros texana*), Shrubby Croton (*Croton fruticulosus*), Wafer Ash (*Ptelea trifoliata*), Shrubby Boneset (*Ageratina havanensis*), Silk Tassel (*Garrya ovata*), Texas Sacahuista (*Nolina texensis*), Twist-leaf Yucca (*Yucca rupicola*), Evergreen Sumac (*Rhus virens*), and Yaupon (*Ilex vomitoria*) (Zippin 1997, Fowler 2014, J. Scalise pers. obs.). Canopy closure has been considered one of the threats facing Bracted Twistflower (Fowler 2014). However, we examined historical aerials of all COA sites and found little to no change in canopy cover during the period from 1940 to present (Appendix A).

As part of a recent review of the Bracted Twistflower's Global/State Rank with the Bracted Twistflower working group, COA staff examined recent survey data to assess short-term population trends and determine whether relationships exist between weather variables and plant abundance.

Methods

COA staff organize and conduct annual surveys of Bracted Twistflower at all known populations on BCP lands. Surveys are scheduled during the peak blooming period for Bracted Twistflower, late April to early May. Survey areas are delineated in the field based on fencing and geographic landmarks, as well as with field maps and GPS units with previous plant locations. At Mt. Bonnell, the survey covers all accessible areas owned by COA. At Vireo Preserve, surveys are conducted at all planting sites. Surveys at Ullrich, Barton Creek, and Valburn only cover city property where plants are known to occur. To cover the survey areas, observers line up and move across the area while searching for plants, and double back as necessary. When a plant is found, a thorough search is done in the immediate area to locate more plants, and will continue to widen around the first plant found until no more new plants are found. This clump of plants will be assigned a unique group ID based on the site name, the search area, and the order in which it was found. Flagging is placed above each group of plants to avoid double counting. A GPS waypoint will be recorded from the center of this group, along with the GPS accuracy at the time the point was taken. The distance from the point to the furthest plant in that group is also recorded. Within this group, each plant is counted, and recorded as either in the rosette stage, bolting stage, or fruiting stage. Any plant that has only basal rosette leaves and no bloom stalk is counted as a rosette. If a plant has a blooming stalk and no siliques greater than 1 inch long, it is counted as a bolting plant. If a plant has any siliques greater than 1 inch in length, it is counted as a fruiting plant. The total number of siliques greater than 1 inch is counted and recorded for each group.

Since the effects of powdery mildew on Bracted Twistflower are not fully understood, we document how many plants within each group are afflicted with powdery mildew. Herbivory, both insect and deer, are also both known to have deleterious effects on individual plant fitness. We record the number of plants within each group that show signs of insect herbivory and deer (or mammalian) herbivory.

During the surveys, several observers are assigned to carry a GPS unit with tracking on, and these observers cover the outer edges of each transect that is walked. Their tracks are saved and loaded into ArcGIS, along with the locations of each plant group and a polygon is drawn to delineate the area surveyed and calculate its area in square meters. All field data is entered into Microsoft Excel by study site and search area and used to create a GIS shapefile of the plant locations.

These counts are performed about the same time each year to maintain consistency. Each site is only counted once a year, due to limited staff resources during this time. We recognize that these counts are static snapshots of the plant's status, and do not address the final reproductive output of each population.

For short-term trend analyses (10 years), counts from all plant stages (rosette, bolting, and fruiting) were pooled for each site, and graphed by year. Gus Fruh was treated as a separate population from Barton Creek as it was only discovered in 2014 and wasn't counted in years prior. COA counts at Valburn did not begin until 2015 as it was believed that the population was wiped out from housing development along Valburn Drive. The survey area at Valburn also varied greatly by year, as surveyors in earlier years were not aware of COA property limits. The population at Vireo Preserve was not included in this analysis as it is an experimental reintroduction population. Total plants from Barton Creek, Ullrich, and Mount Bonnell were pooled. We only examined trends from 2012-2018, as survey methods prior to 2012 were inconsistent.

To examine the relationship between population trends and climatic variables, we downloaded daily weather data from the Camp Mabry weather station (weatherunderground.com). We used the average daily temperature to determine a monthly average. We summed and pooled daily precipitation for weekly and monthly intervals. Since Bracted Twistflowers are annuals that germinate and grow in wet winter and spring months, amount of rainfall during this period has been hypothesized to be an important factor for plant abundance (Fowler 2012, Leonard 2010). To examine this hypothesis within our population, we binned rainfall totals by month as well as seasonally. We created graphs to compare the relationships between seasonal and monthly rainfall totals and total number of plants. We also examined the correlation coefficients between seasonal and monthly rainfall totals and total number of plants.

To document the levels of powdery mildew, deer herbivory, and insect herbivory, those three metrics were graphed for each year. Powdery mildew was also examined as a percent of total plants that had powdery mildew and graphed for each year to examine trends. To examine an aspect of the effects of deer herbivory over time, we graphed the relationship between the total number of plants found within the deer exclosure on the Barton Creek site, and the total number of plants found in the search area immediately next to the deer exclosure.

Results

Plant abundance varied greatly by year, with the highest numbers of plants recorded in 2012, 2014, 2016, and 2018 (Figure 2). The variation by year was consistent across sites with the exception of a higher than expected count at Ullrich in 2017 (Figure 2). While Barton Creek has the largest population of plants, there are two subpopulations within it that have had zero plants for several years. One subpopulation at Mt. Bonnell has also not had any plants detected for several years. Ullrich has an increasing trend while the others show no apparent increase or decrease in total number of plants over time due to the extreme variability by year.

Average monthly temperature trends for 2014, 2015, and 2018 were generally cooler and 2017 generally warmer (Figure 3). Rainfall was highest in 2016 (Figure 4), however, January of that year received less rainfall compared to January in all other years. The two months with the highest rainfall were October 2014 and October 2016 (Figure 3). We found a positive correlation between December rainfall and plant abundances in the following spring (0.84, Figure 7). Some years did not follow this pattern as closely. For example, 2018 saw about the same amount of October-December rainfall as 2017, but had more than twice as many plants. December rains were low in 2014, a year that had high plant totals, but 2014 had an

extremely high rainfall total in October (Figure 2). December rains in 2017 saw the opposite trend than 2014, in that there was high December rain, but nearly no October rain, which may partially explain the low plant totals in 2017.

The proportion of plants affected by powdery mildew and herbivory also varies greatly from year to year. Deer herbivory was low overall with the highest rates (18%) in 2015 while insect herbivory ranged from 22% to 56% across years (Figure 8). Powdery mildew varied from 6% to 47%. We did not find a correlation between the number of plants impacted by powdery mildew or herbivory and the plant abundance in the following year.

Figure 1. Bracted Twistflower survey locations on the Balcones Canyonlands Preserve in Travis County, Texas.

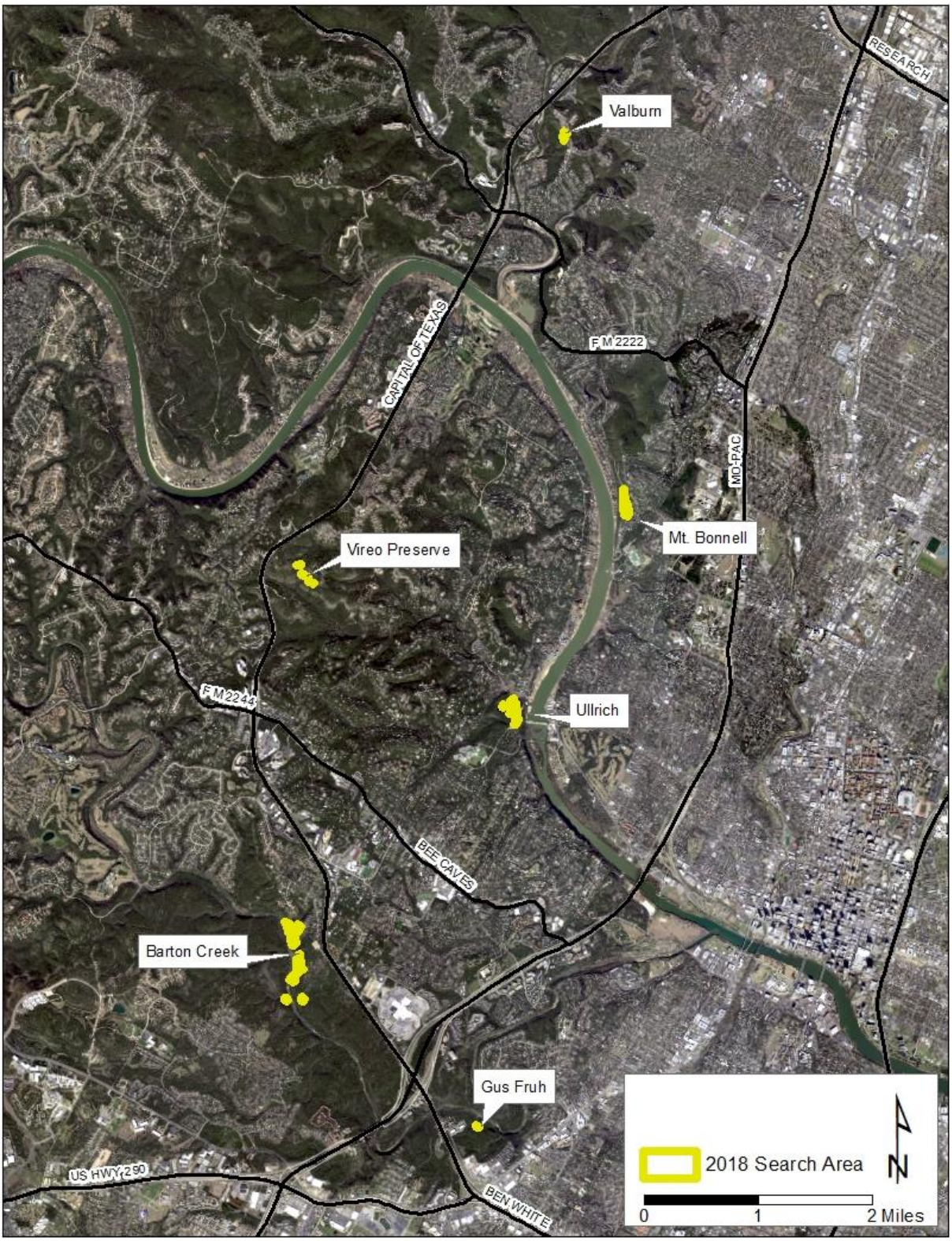


Figure 2. Total plants per site from 2012 – 2018 in Travis County, Texas.

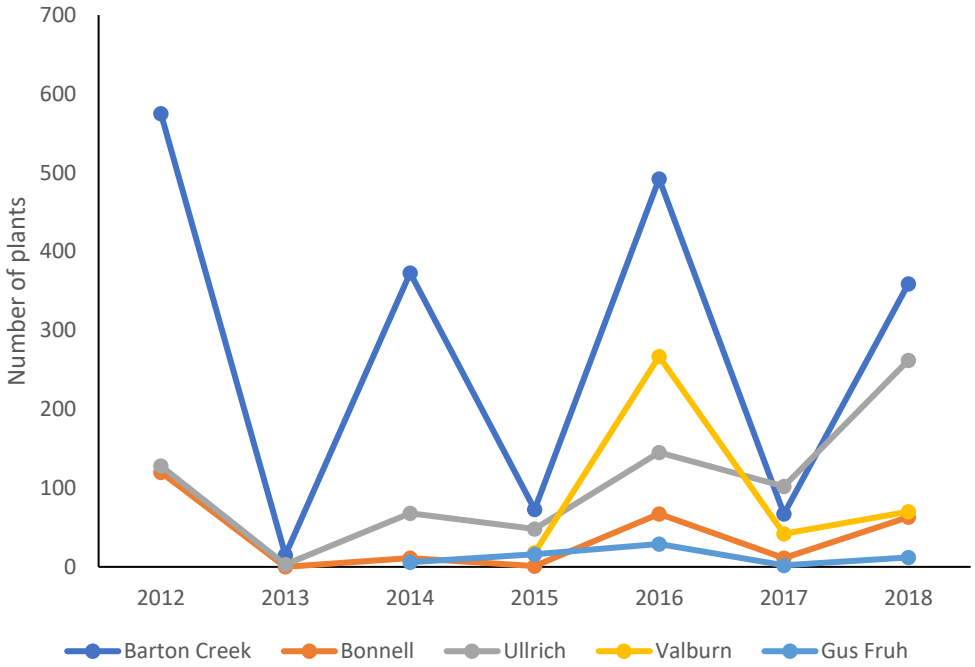


Figure 3. Average monthly temperature per year from 2012 - 2018 in Travis County, Texas.

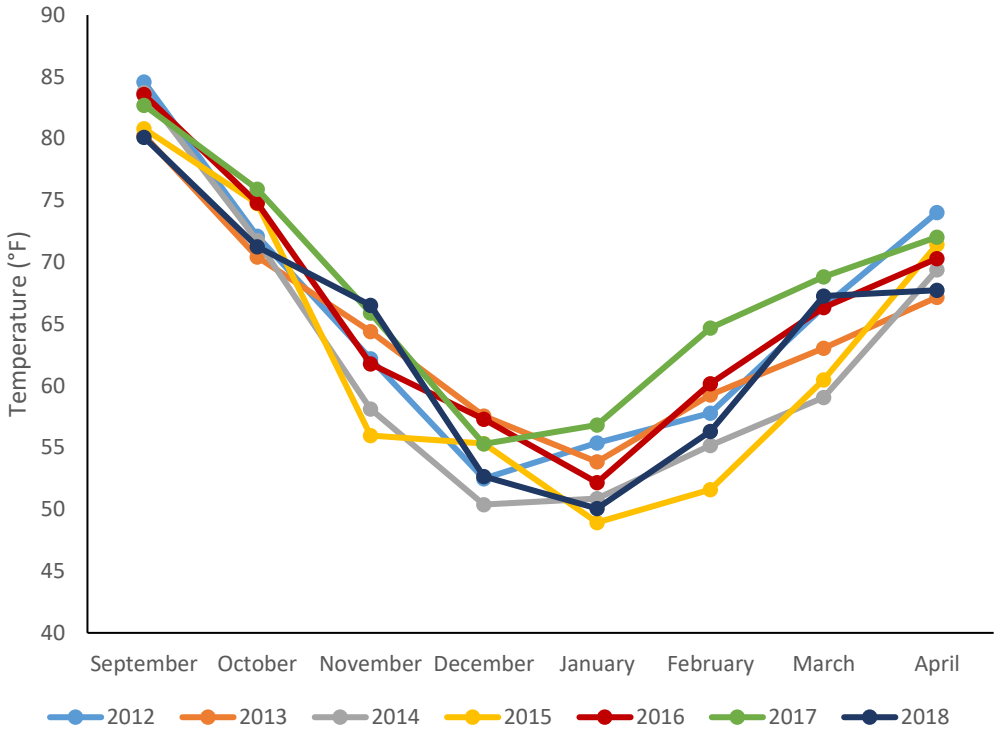


Figure 4. Average rainfall by month from 2012 - 2018 in Travis County, Texas.

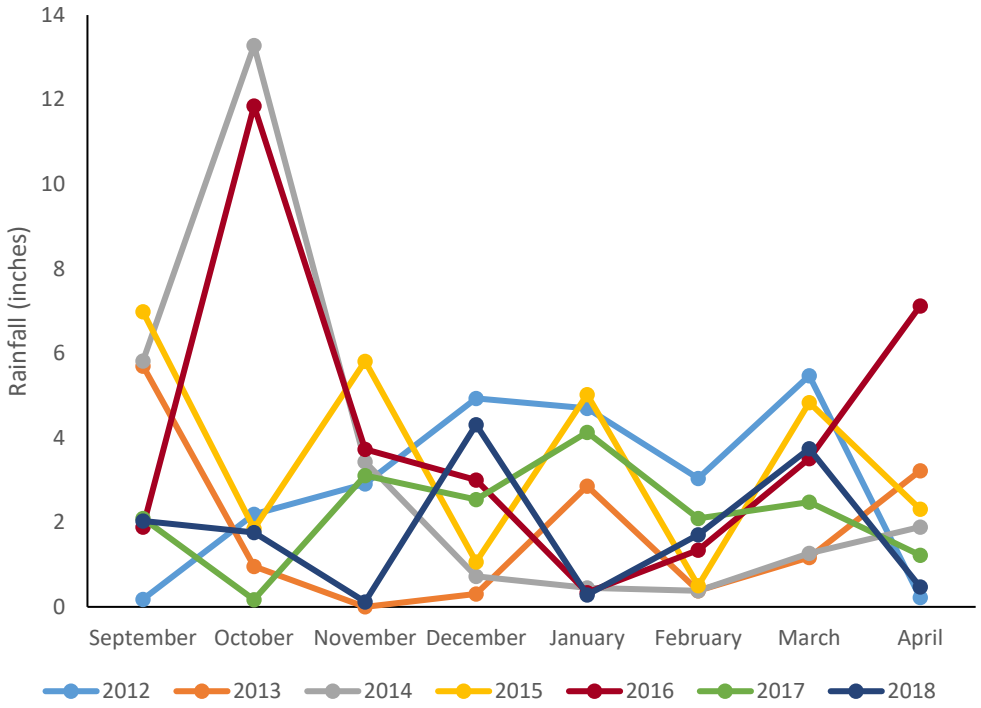


Figure 5. Total rainfall binned by month from 2012 - 2018 in Travis County, Texas.

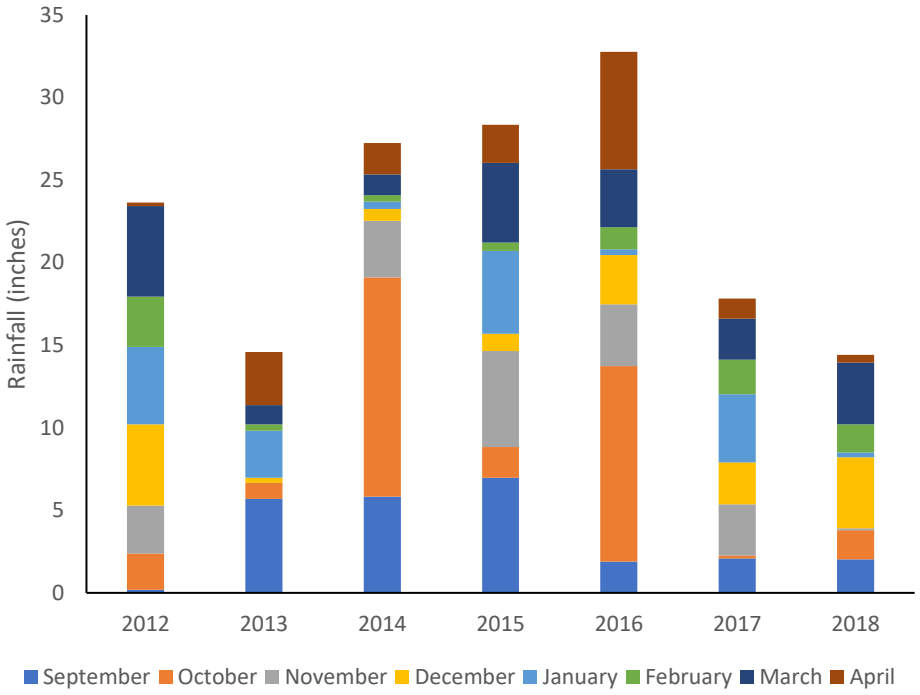


Figure 6. Total rainfall from October to December and corresponding number of plants per year from 2012 – 2018 in Travis County, Texas.

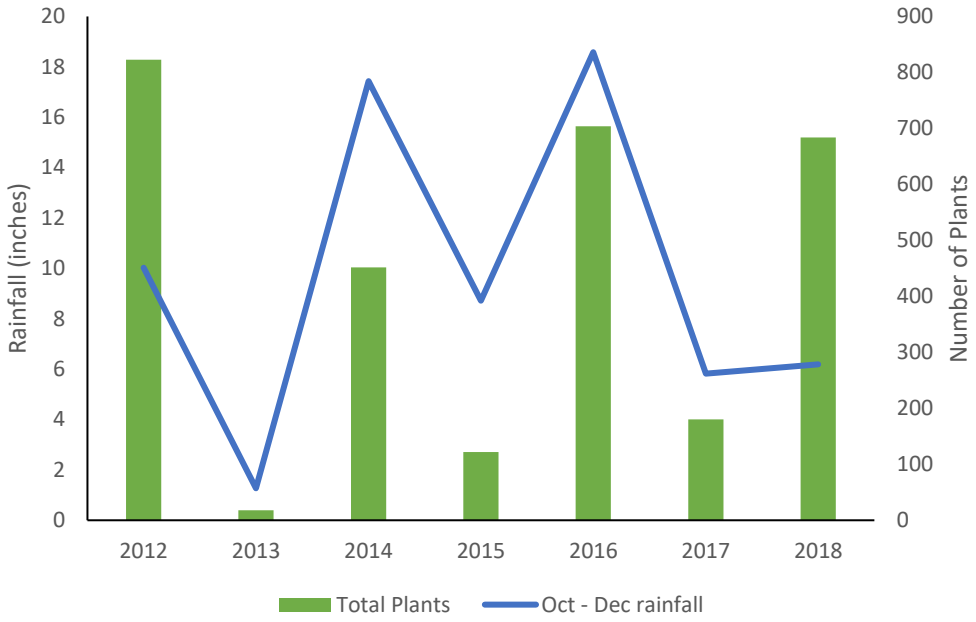


Figure 7. Total December rainfall and corresponding plants per year from 2012 – 2018 in Travis County, Texas.

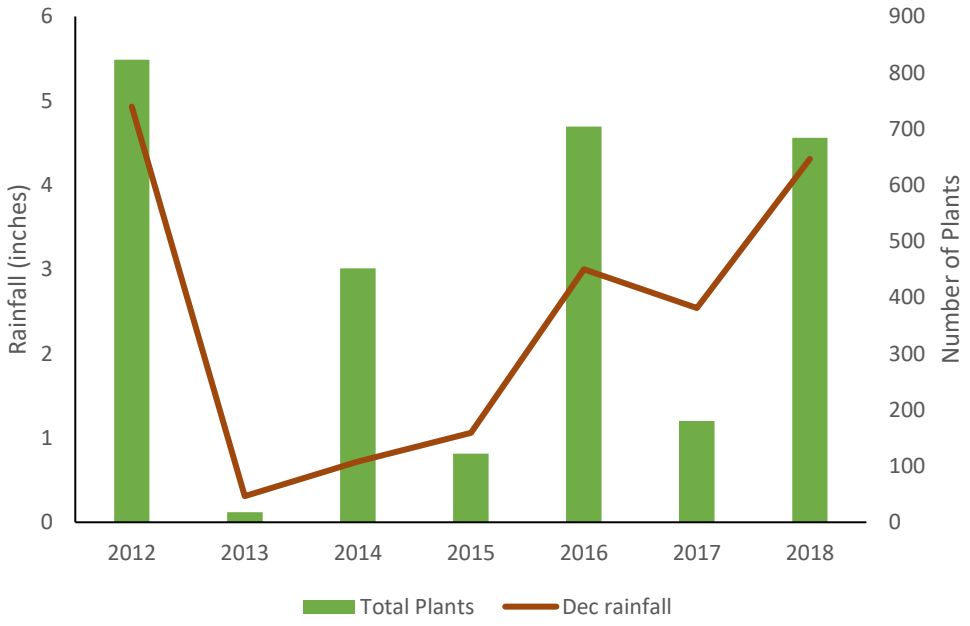
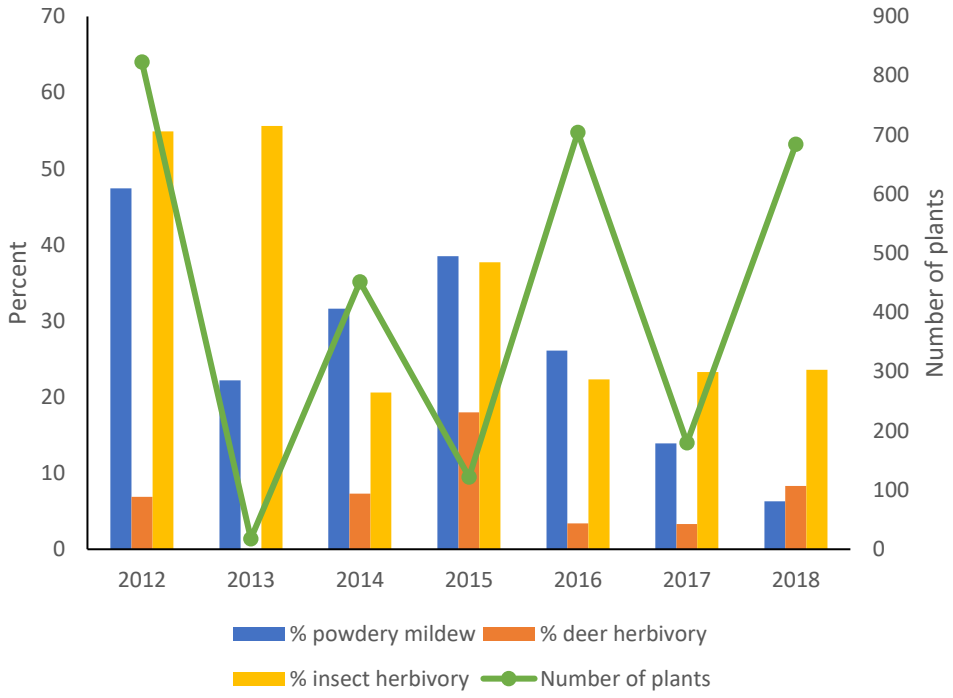


Figure 8. Percent of plants showing evidence of powdery mildew, insect herbivory, and deer herbivory from 2012 – 2018 in Travis County, Texas.



Discussion and management implications

While it is impossible to tease out a causal mechanism for higher plant abundances with this observational study, our data do show that the amount of rainfall from October through December correlated with a higher abundance of plants the following spring (Figure 7). Given that canopy cover and light amounts did not vary across this time period, this suggests that climate factors may have had an impact on Bracted Twistflower populations in the BCP. While we did examine correlations between average monthly temperature and plant abundance, we do not think this is a useful metric for examining trends in plant populations, as the extreme hot and cold events were lost by averaging. There could be an interaction between rainfall and temperature that we were unable to account for. The timing of rainfall events and the length of time between them, particularly during periods of hot weather, may play a role in plant survival. Soil temperature and soil moisture may be better indicators, but are difficult metrics to obtain.

It is interesting to see such a wide variation in plant numbers from year to year, which suggests that this species is resilient and capable of recovering from very low population numbers. However, there may be a limit to what they are able to recover from, as we have observed some of the subpopulations appear to be extirpated and have not recovered in several years. Examples of this are noted at Barton Creek, where two subpopulations have not had any plants detected since 2015. When populations drop to low numbers, there is also a risk of losing genetic variation that can eventually result in inbreeding, reduced effective population size, and reduced adaptive potential (Reed and Frankham 2003, Pepper 2010, Traill et al. 2010, Flather et al. 2011).

We did not find evidence that powdery mildew or herbivory impacted plant abundance in the following year, however these data may be influenced by observer bias. Powdery mildew and insect herbivory can both exist in a spectrum from 0-100%, but are measured as either present or absent. Tiny amounts of mildew or herbivory may have no significant negative effects on the plants. On the opposite end of the spectrum, plants can be rendered unable to reproduce or even be killed by these problems. Observers may detect these problems and not record them at the lower end of the spectrum. At the higher end of the spectrum, herbivory could render the plants unrecognizable and therefore they would go uncounted. When plants are covered with powdery mildew they tend to become more obvious to observers and could even help observers count plants that may have otherwise been missed. Since there is a spectrum of possible levels of mildew and herbivory and the effects on plants is variable, efforts should be made to standardize how this is measured in future surveys so that the entire spectrum of impacts can be measured more accurately.

Another limitation of our dataset is that it is just a single snapshot during the life cycle of these plants. Plants that were counted and considered healthy during the survey may later see levels of powdery mildew or herbivory that reduce or eliminate their ability to set seed for the year. Studies have noted that deer herbivory is likely to eliminate the ability of a plant to set seed (Zippin 1997). Alternatively, plants could be doing much better in periods after surveys and our surveys may be an underestimate of plant fitness. Fowler (2014) found that plants with powdery mildew had siliques that were on average 4.1cm longer than on plants without powdery mildew.

Based on short term trends, it appears that populations on BCP may be reliant on fall and winter rainfall, and that years with drier fall and winter months will have low plant totals the following spring. Based on this knowledge, efforts for seed collecting, establishing new colonies, or supplementing genetically poor populations can be planned in advance for years when there are more likely to be high numbers of plants or years with good germination. Efforts to find previously undocumented colonies could be focused on years that would be predicted to have more plants, to increase the likelihood of finding any such colony.

For example, there are records of seeds being scattered at sites like Emma Long Park, Zilker Preserve, and Mayfield Park and it would be more strategic to do searches of these areas in years following wet fall and winter months.

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Appendix A. Historical Aerials and Canopy Cover.

The images below are aerial photography of the Ullrich Bracted Twistflower population in 1940 and 2017. We examined historical aerial photography for our four naturally-occurring plant populations (Barton Creek, Mt. Bonnell, Ullrich, and Valburn) from the years 1940, 1951, 1965, 1980, 1996, and 2008. One observable trend is the relatively consistent canopy cover during this period where plants have been found in recent years (as depicted by purple stars). Some white patches in 1940 imagery are an overlay and do not represent actual canopy openings.



Appendix A. Historical Aerials and Canopy Cover, continued.

