Title
UCSBlooms: Tracking the phenology of UCSB campus plants and using citizen science on a university campus

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ABSTRACT

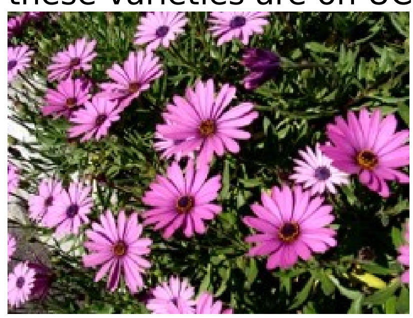
Phenology is becoming more important to study with human impacts on the environment including urbanization and climate change. The UCSBlooms project is a year-long blooms tracking project that began March 11, 2019 and concluded on March 17, 2020. This project uses the University of California Santa Barbara (UCSB) citizen scientists and the citizen science program iNaturalist to track the phenology of six species of plants found on the UCSB campus. Citizen scientists are much more likely to participate in organized events rather than an open-ended project. Citizen scientists are also more likely to observe species in flower than species that are not in bloom. Non-native species have less variation in phenostages at a single date than native species. The environmental cues used to determine movement through a species' phenology differs between families. There are many factors that affect the phenology of campus plants including urban heat islands, phylogeny, and native status.

INTRODUCTION

Plant phenology describes the life history of plant populations and the timing of these stages. The phenology of a plant tells us about the life history of a species, the health of an ecosystem, and the cues different species use for reproduction. Human impacts on the environment like climate change and the introduction of non-native species into ecosystems can disrupt these phenological cues, and are thus a danger to the health and function of ecosystems. More studies focused on phenology will give us a better understanding of ecosystem health in the context of these anthropogenic perturbations. However, there is also a lack of fine scale data on phenological research that would allow us to investigate these trends more locally. The UCSBlooms project uses citizen science and bloom tracking to collect phenological data on native and non-native species on the UCSB campus.

Below are the species of plants examined and documented by the UCSBlooms project

California brittlebush (*Encelia californica*) A perennial herbaceous shrub between 50-150 cm tall. This species is native to southern California and Baja California. The flowers are head	**California poppy (*Eschscholzia californica*)** An annual to perennial herb species. Native to the Western United States and Mexico. The flowers can close at night or in windy and cold weather.

inflorescences with yellow ray floret and yellow/purple disc florets. 	
Pride of Madeira (*Echium candicans*) A perennial shrub native to the island of Madeira. This shrub usually occurs 1.5-2.5 meters tall. It is drought tolerant and widely used as an ornamental plant in coastal climates. It is considered an invasive species in California. 	**Trailing African Daisy (*Dimorphotheca fruticosa)*** A perennial species native to South Africa. It grows up to 18 inches tall, the different varieties have ray flowers of white, pink, purple, and lavender, all of these varieties are on UCSB campus. 
Indian Hawthorn (*Rhaphiolepis indica*) A perennial shrub native to Southern China. It is grown as an ornamental species in California. It has small pink or white flowers and can grow in shrubs as tall as 4 meters. 	**Lemonade berry (Rhus integrifolia)** A perennial shrub that is native to southern coastal California, found mostly on dry slopes. It grows 1-8 meters tall. The flowers are rosy pink in color and the mature fruit is covered in a sticky substance. 

Collecting large amounts of accurate phenological data can be difficult given the relatively small-time frame of the bloom season and the vast number of species in an area. To address this, we decided to utilize citizen science, a growing branch of research that combines crowd-sourced data with community outreach. Citizen science is scientific research being conducted by community members who may or may not have formal scientific training. There are many websites dedicated to citizen science, where citizen scientists can participate in projects or upload natural observations. Project Budburst and the National Phenology Network are two national citizen science efforts to track blooms. Citizen science projects are good matches for urban habitats (Dickinson et al., 2010). Most projects have citizen scientists working with professional counterparts on projects that have been specifically designed or adapted to give amateurs a role (Silvertown, 2009). These types of projects have exploded recently due to increase accessibility through the internet (Silvertown, 2009). Research on citizen science has found that can provide reliable observations when following explicit protocols (Fuccillo et al., 2015). Training volunteers to will make information collected much more accurate (Dickinson et al., 2010; Barlow et al., 2015; Fuccillo et al., 2015). This project examines whether or not citizen science can be effectively used on a university campus with undergraduates working to take phenological observations, and to determine phenological stages of native and non-native plant species. Non-native plants are not indigenous to a particular region of interest – in this case California. Potential differences in phenology between native and non-native species could allow for certain species to respond better to phenological changes in climate. The UCSB campus has many non-native plants, most of which are ornamental. A few native species found on UCSB include the California brittlebush (*Encelia californica*) and the California poppy (*Eschscholzia californica*). A few non-native species include pride of madeira (*Echium candicans*), and trailing African daisy (*Dimorphotheca fruticosa).* Native and non-native plants come from distinct geographic areas where they may have certain phenological adaptations. Thus, phenology may be different for a native and exotic plants. In some cases, non-native species – particularly invasive species – have been shown to track changes in the climate and alter phenological patterns better than native species (Willis et al., 2010). This could indicate that native species and non-native species would actually have similar phenology. There could be more affecting phenostages than native status.

Closely related species may share similar responses to stimuli. Phenological responses to climate change are often shared among clades and families share different first flowering times, the date when the first flower is open on the plant (Davis et al., 2010; Mazer et al., 2013). Within phylogenetic families UCSB has both native and non-native plant species that share similar climates in their native region. Phylogenic and phenologic research show that local adaptation is more important than phylogeny (Davies et al., 2013; Lessard-Therrien et al., 2014). This could indicate that native and non-native species in the same family will have similar phenological patterns as they are adapted to similar climates and share genetic responses to the environment. Ecological factors can also influence responses to the environment.

To explore these areas of research for UCSB, I pursed the following questions:

- ◊ Can citizen science be used for phenological research on a university campus?
- ◊ What is the phenology of UCSB campus plants?
- ◊ Is the phenology of plants on campus different between native and non-native species?
- ◊ Is there a relationship between plant family and phenology on UCSB campus?

METHODS

STUDY SITE

To better understand phenology on the UCSB campus, we collected and categorized photographs of flowering plant species from March 2019 to March 2020. UCSB is a public university located on cliffs above the Pacific Ocean. The campus has a Mediterranean climate. The majority of the vegetation on UCSB campus has been chosen for ornamental value and because it would do well with the climatic conditions. The vegetation on the main campus is dominated by non-native plants receives patchy irrigation. The vegetation around the lagoon has been mostly restored to native dominated communities and receives no regular irrigation.

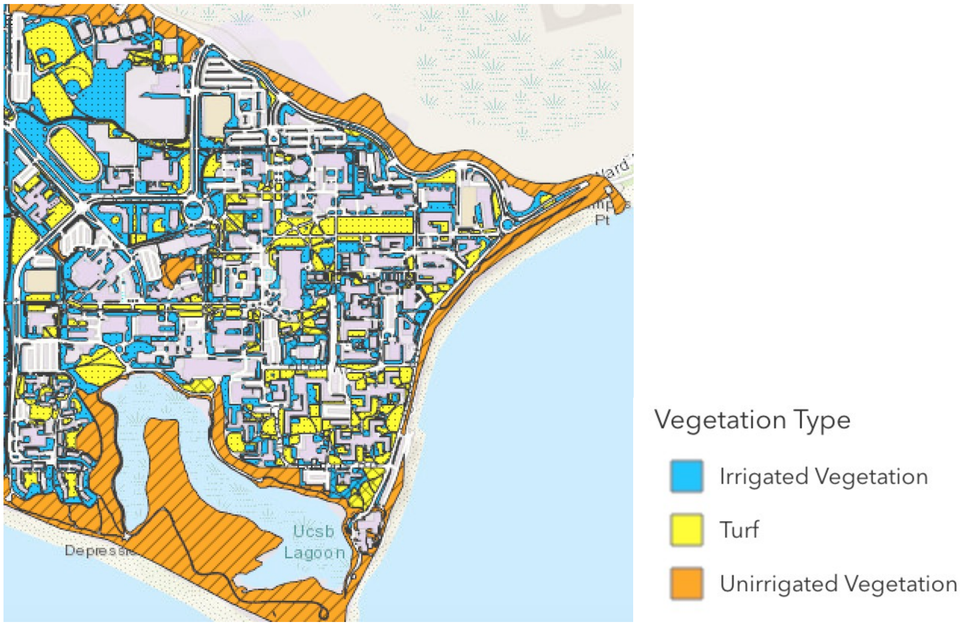


Figure 1: Map of vegetation on UCSB campus and its irrigation type. Source: UCSB Sustainable Irrigation

COLLECTING OBSERVATIONS

Making Observations

Photographs of campus plants, which we refer to as observations, were made in two different ways for the overall UCSBlooms project database: BioBlitzes and casual observations. Eight times throughout the project I hosted a BioBlitz. A BioBlitz is an organized event where citizen scientists gather together to make biological observations. The BioBlitzes occurred once a month, excluding December, July, August, and September. Each BioBlitz lasted for one hour where anyone in the UCSB community was invited to participate. Participants spread out over campus to collect as many observations as they could of campus vegetation in one hour. Any time outside of a BioBlitz UCSB citizens were asked to take observations of campus vegetation and upload those to the online project database. A person could make observations whenever they desired. These observations were grouped by the month they were collected. The observations from BioBlitz events and open month long projects are treated the same in the UCSBlooms project database in iNaturalist for identification and phenostage assignments.

iNaturalist

The UCSBlooms projects collects all images uploaded to any UCSBlooms titled project in iNaturalist. iNaturalist is owned by the California Academy of Sciences and was developed for the purpose of mapping and sharing observations of biodiversity across the globe. I created the UCSBlooms project in iNaturalist. The UCSBlooms project collects all of the observations uploaded by UCSB campus citizens into smaller specific projects that were created based on date and effort, a BioBlitz or casual observations. Each observation was instructed to include a photo of the whole individual, a leaf, and any reproductive structure. The species are identified by the larger iNaturalist community. With other trained undergraduate students, I have verified the identifications made and have identified observations that crowdsourcing did not.

CHOOSING SPECIES

At the outset of the project examples of species occurring often on campus were shared with participants to focus on. Part way through the study the most consistently observed species, whether a part of the original list or not were set as the focus species of this project. Over 200 plant species were observed on the UCSB campus by the end of the study. This number is too large for all identified species to be analyzed so only a select few were chosen to be included in this study. 6 species, 3 California native and 3 California non-native, were chosen. I chose these 6 species because they had the top 3 highest number of observations collected at the four month mark of the project in their category. I chose the species with the largest number of individuals assuming that the species with the most observations were most abundant on campus so a better sample size of each species, also because more data points will produce more accurate analyses. Once added to the project, observations from these 6 species needed to be assigned specific phenostages.

ASSIGNING PHENOSTAGES

In order to assign one of the seven phenostages to every observation, I trained a group of undergraduate student volunteers to recognize the different reproductive structures and what each stage looks like on all six of key species. This classification system was created for this project in order to achieve greater detail of a plant’s phenology than either in-bloom or not-in-bloom. Seven phenostages were established as a stage that an observation could be in: 1. Not in bloom, 2. Budding, 3. Leading bloom, 4. Peak bloom, 5. Trailing bloom, 6. Very trailing bloom, 7. End of bloom (Figure 1). I trained each citizen scientist on what each phenostage looked like on all of the species. Multiple stages can occur on a plant individual at a single time, so I instructed volunteers to average the phenostages they identified on a species. For example if the individual was 50% budding and 50% showing full big open flowers, that observation would be rated as leading bloom.

A minimum of 3 citizen scientists gave their rating to a single observation. I averaged the ratings of the citizen scientists to give a single rating to each individual observation. The averaging was done by hand to ensure that observations rated as stage 7 and 1 would average to stage 7 or 1 and not stage 4 and extreme outliers were dropped from the averaging.

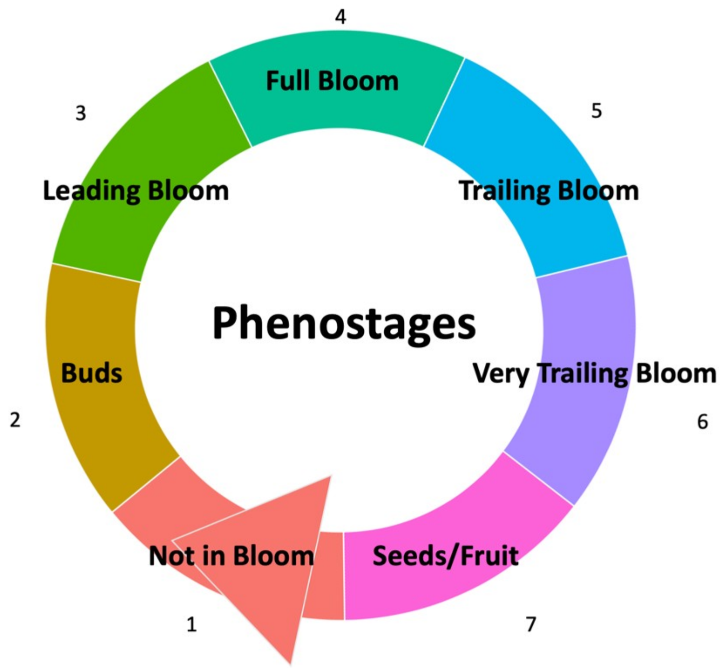


Figure 2: The phenostages and corresponding stage number

ANALYSIS

All analyses were run using RStudio1.1.463.

To statistically compare the mean date and variance across species of peak bloom, we used ANOVA tests to compare the variance of peak bloom (stage 4) phenostages across species.

For this project, we binned the bloom categories to refer to the potential number of blooms present on an individual ranging from 1-4. Thus, peak bloom, when an individual is said to be in the “4” phenostage, refers to the highest possible number of reproductive structures in flower. An individual will ascend into peak bloom from stages “1” not in bloom, “2” buds where the majority of reproductive structures on the individual are buds, “3” leading blooms the stage between buds and peak blooms. After peak bloom the phenostage will descend from “3” trailing bloom, “2” very trailing blooms, and “1” seeds/fruit where there are no flowers on an individual.

RESULTS

The UCSBlooms project began March 11, 2019 and ended March 17, 2020. In the iNaturalist project 3,590 observations were uploaded from 36 different observers. 200 different plant species were observed and identified in this project.

CITIZEN SCIENCE

The number of observations taken was greatest in the beginning of the project. The number of observations added to the project is dramatically lower in the summer and fall months. The number of observations increased in the winter but not to the same number per month as experienced the beginning of the project.

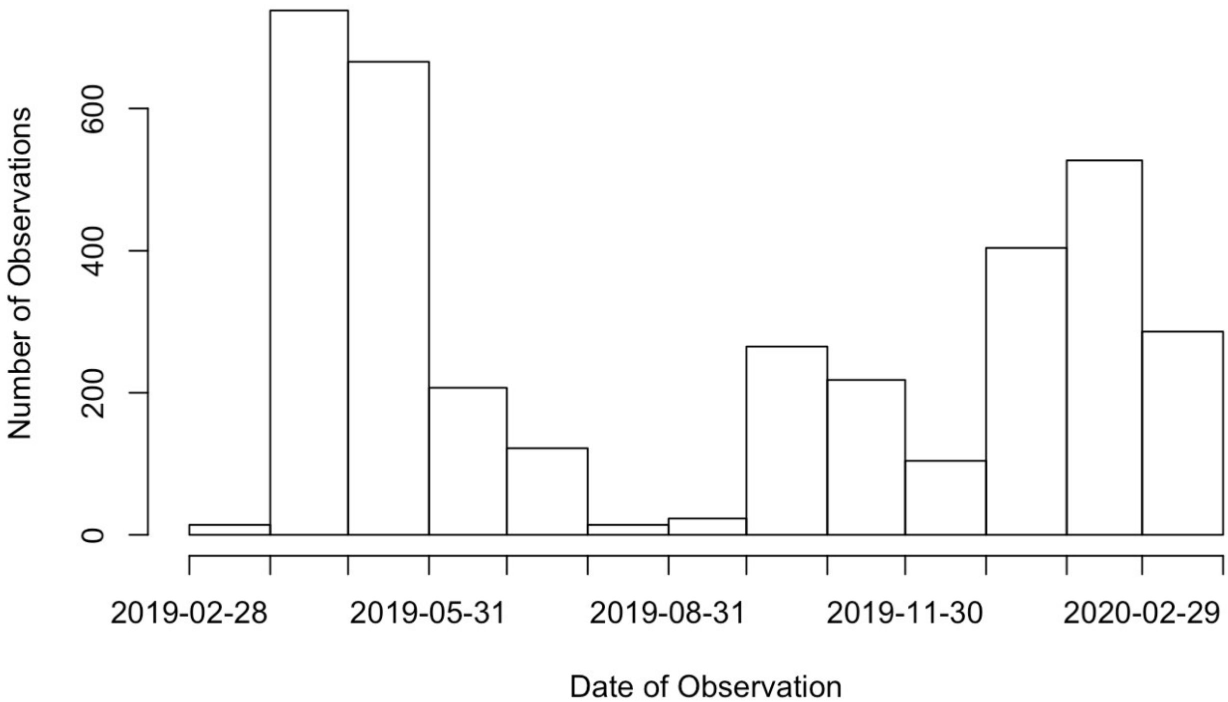


Figure 3: Histogram of when observations were taken for the UCSBlooms project by date.

BioBlitz and Non-BioBlitz Observations

The numbers of participants in the UCSBlooms project changed overtime. Overall 27 observers participated in a BioBlitz event while only 18 observers participated in the project outside of a BioBlitz (table 1&2).

Table 1: The date of each BioBlitz for UCSBlooms and the number of observers for each event.

BioBlitz	Number of Observers
April 6, 2019	14
May 5, 2019	13
June 7,2019	5

October 19, 2019	11
November 16, 2019	6
January 11, 2020	6
February 9, 2020	9
March 7, 2020	7
Overall	27

Table 2: The number of observers for each month of the project excluding BioBlitz events

Non-BioBlitz	Number of Observers
March 2019	3
April 2019	5
May 2019	7
June 2019	2
July 2019	8
August 2019	2
September 2019	1
October 2019	5
November 2019	3
December 2019	4
January 2020	2
February 2020	2
March 2020	3
Overall	18

The total number of observations collected in the project can be separated into two categories, collected during a BioBlitz and not collected during a BioBlitz (figures 2 &3). Eight BioBlitzes were held and 1908 observations were collected during that time. Outside of a BioBlitz 1680 observations were taken.

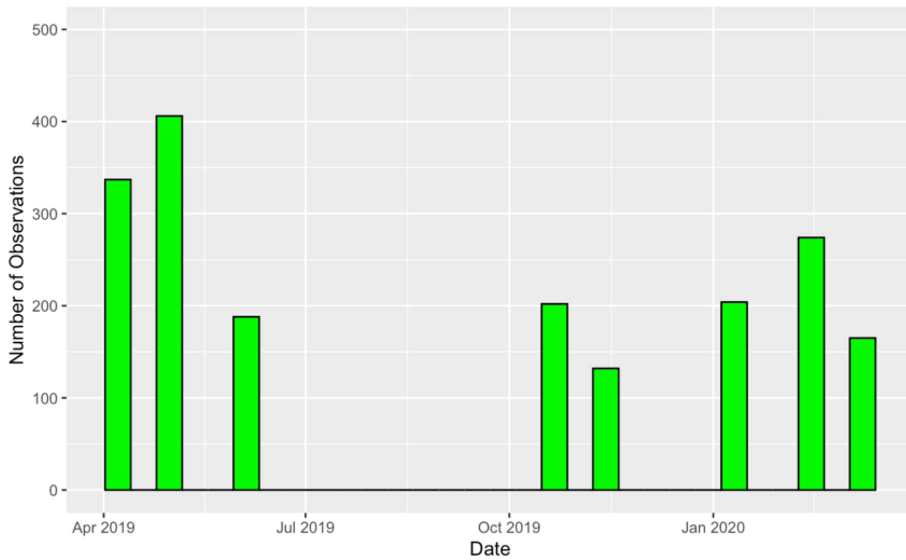


Figure 4: The number of observations taken during an organized BioBlitz for the UCSBlooms project

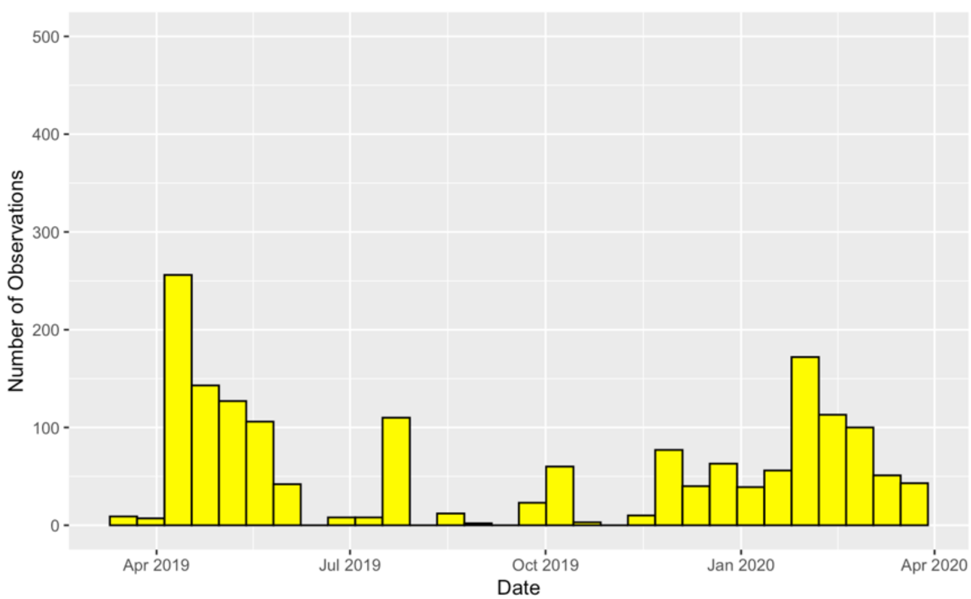


Figure 5: The number of observations taken for the UCSBlooms project outside of an organized BioBlitz

SPECIES

Dates

Table 3: The range of date when a species in bloom, beginning with the first bud and ending with the last trailing bloom. The peak bloom range is included between the extreme bloom categories.

	First Bud Julian Date	First Peak Bloom Julian Date	Last Peak Bloom Julian Date	Last Tailing Bloom

				Julian Date
Pride of Madeira	Jan 11	Jan 31	May 4	Dec 17
California Brittlebush	Jan 8	Jan 17	Dec 5	Nov 23
Trailing African Daisy	Jan 7	Feb 5	Nov 15	Nov 23
Indian Hawthorn	Feb 5	Feb 5	Apr 8	Oct 18
CA Poppy	Feb 7	Jan 21	Nov 23	Nov 23
Lemonade Berry	Jan 11	Feb 9	Apr 5	May 15

(* All of the following figures are graphed by the "Day of the Year" (DOY) with Jan 1, 2020 being Day 1 and Dec 31, 2019 being day 365. This was done for better visualization of the data so the Spring dates where flowering peaks are not split on opposite sides of the graph. While an individual can only be assigned integer phenostage the points have been shifted slightly off the lines to show differences in abundance. A smoothing line has been added to figures to show the phenostage across the species at a date *)

Non-Native vs Natives

The non-native species all follow a similar pattern of when in bloom and not in bloom. The non-native species do not differ in the time of peak bloom between them (ANOVA $F(2,101)=0.912$, $p=0.405$). The change from peak bloom to not in bloom for non-native species happens rather quickly both ascending to peak bloom and descending post-peak (figure 4). The native species do not differ when in peak bloom (ANOVA $F(2,84)=1.514$, $p=0.226$). The native species share a similar pattern of when in bloom and not in bloom except for the California poppy (figure 5). The ascent and decent from peak bloom are gradual and there is a wide range of phenostages at each time for all the species.

In both native and non-native species at DOY 1 are ascending into peak bloom and reach peak bloom before DOY 100. The non-native species appear to have less variation in phenostages at any given date. The slope between of the non-native species phenological pattern on average is much steeper than the native species in the accent to and decent from peak bloom.

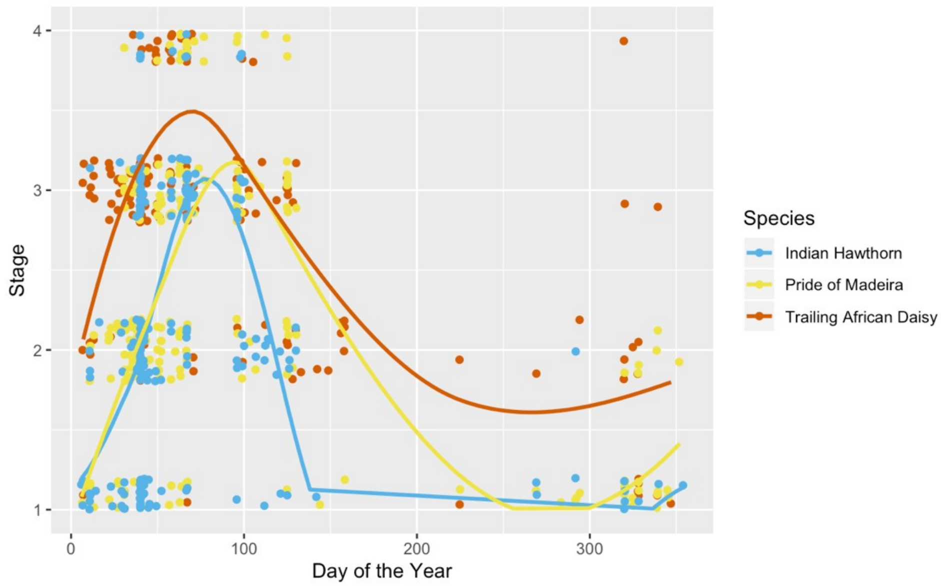


Figure 6: The non-native to California species' phenostages through time. Phenostage ranges from 1-4 where 1 represents no blooms and 4 represents peak bloom. Indian hawthorn n=270, Pride of Madeira n= 287, Trailing African Daisy n =195.

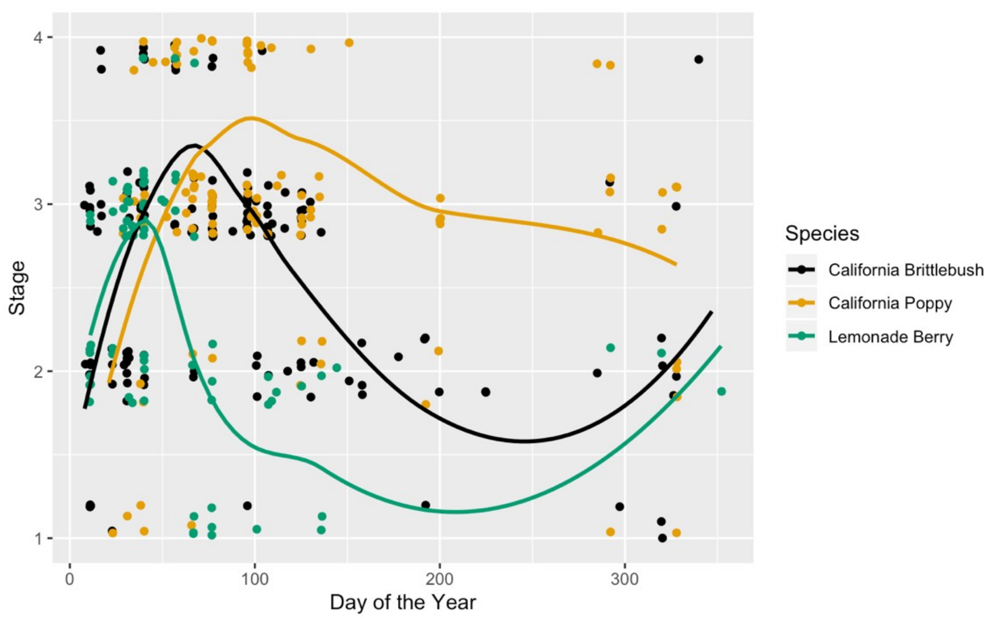


Figure 7: The California native species' phenostages through time. Phenostage ranges from 1-4 where 1 represents no blooms and 4 represents peak bloom. California Brittlebush n= 175, California Poppy n= 147, Lemonade berry n = 84.

Family Comparisons

The California Brittlebush and Trailing African Daisy are both part of the Asteraceae family (figure 6). There is no statistical difference in the peak blooms between the species (ANOVA $F(1,65)=0.146$, $p= 0.704$). The patterns are very similar at all dates. Additionally, both have a wide range of phenostages at any date while in bloom. The slope of the Trailing African Daisy is slightly steeper than the California brittlebush.

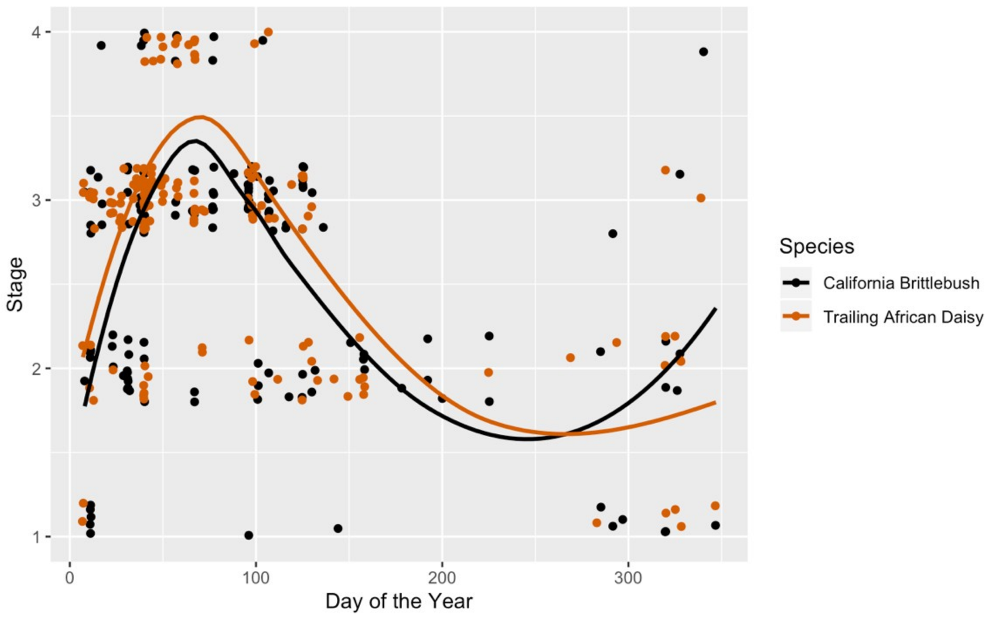


Figure 8: Comparison of the Trailing African Daisy (non-native) and California Brittlebush(native). Phenostage ranges from 1-4 where 1 represents no blooms and 4 represents peak bloom. California Brittlebush n= 175, Trailing African Daisy n =195.

Lemonade berry and Indian hawthorn are both in the Anacardiaceae family. There is no statistical difference between the peak bloom times of these two species (ANOVA F(1,28)=0.641, p=0.43). However, the overall phenological pattern between the two species are different (figure 7). Indian hawthorn and the lemonade berry both had individuals reach peak bloom between DOY 36 and 99. From DOY 1 to approximately DOY 50 the lemonade berry was in higher phenostages while the Indian hawthorn had less blooms. Past DOY 50 the Indian hawthorn has more flowers through the rest of the bloom period. After summer (DOY 244) the lemonade berry is starting to produce buds where Indian hawthorn is still not in bloom.

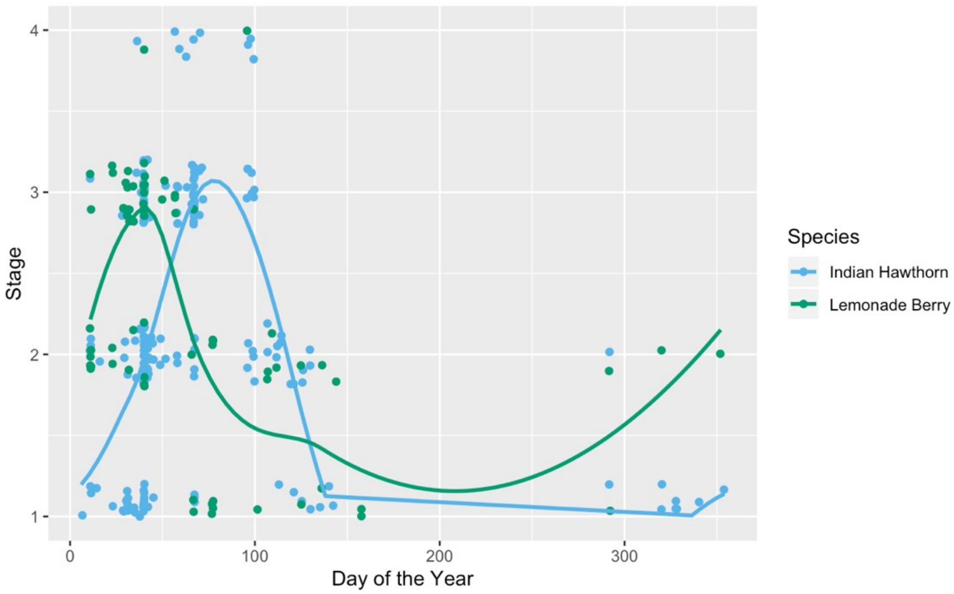


Figure 9: Comparison of Indian hawthorn (non-native) and lemonade berry (native) phenostages through time. Phenostage ranges from 1-4 where 1 represents no blooms and 4 represents peak bloom. Lemonade berry n = 84, Indian hawthorn n=270.

Peak Bloom Variance

There is differences in the day of the year individuals are in peak bloom between the different species (ANOVA $F(5,185) = 2.423$, $p=0.0372$). When grouped by native and non-native there is a difference between the day of the year of peak bloom (ANOVA $F(1,189)=6.236$, $p=0.0134$).

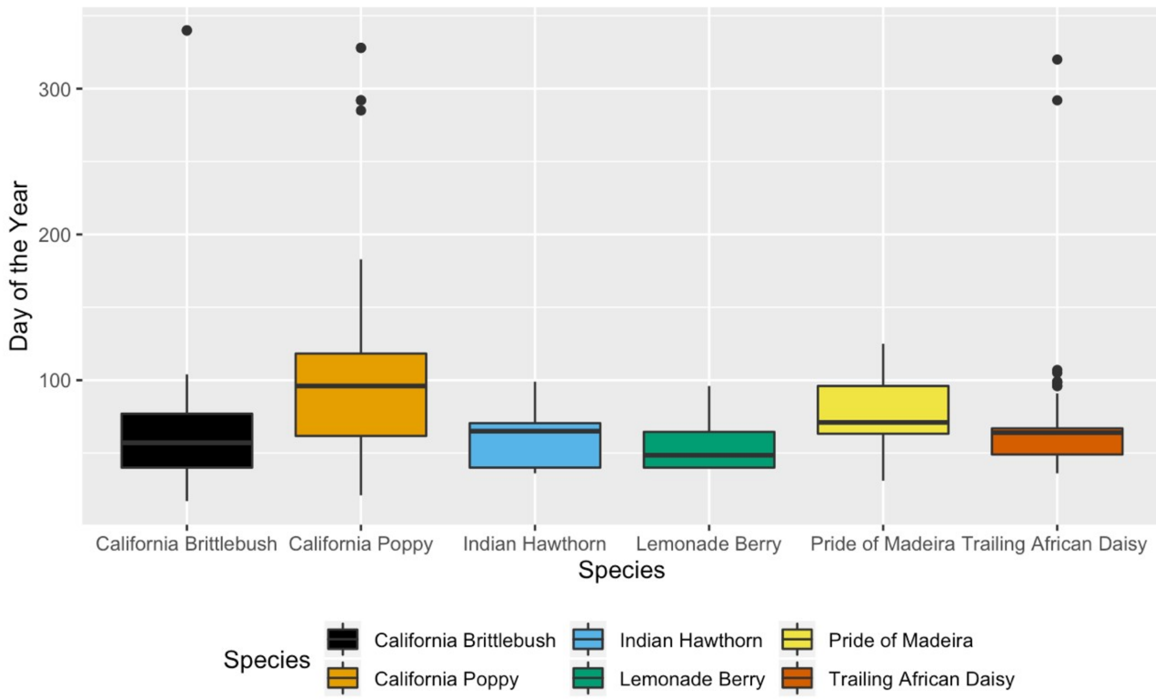


Figure 10: Boxplot of variance of peak bloom between all six species.

Growth Form

For the species that produce a secondary wood there is no peak that aligns for all species and the spread of bloom time is fairly disparate across all three species. Herbaceous species have a similar peak and spread, except for the poppy. The herbaceous species have more variation in phenostages than the woody species after DOY 250. One woody species, Lemonade berry, reached peak bloom before any of the herbaceous species. From DOY 150-250, the woody species have no flowers or buds while the herbaceous species have at least some reproductive structures throughout this time period.

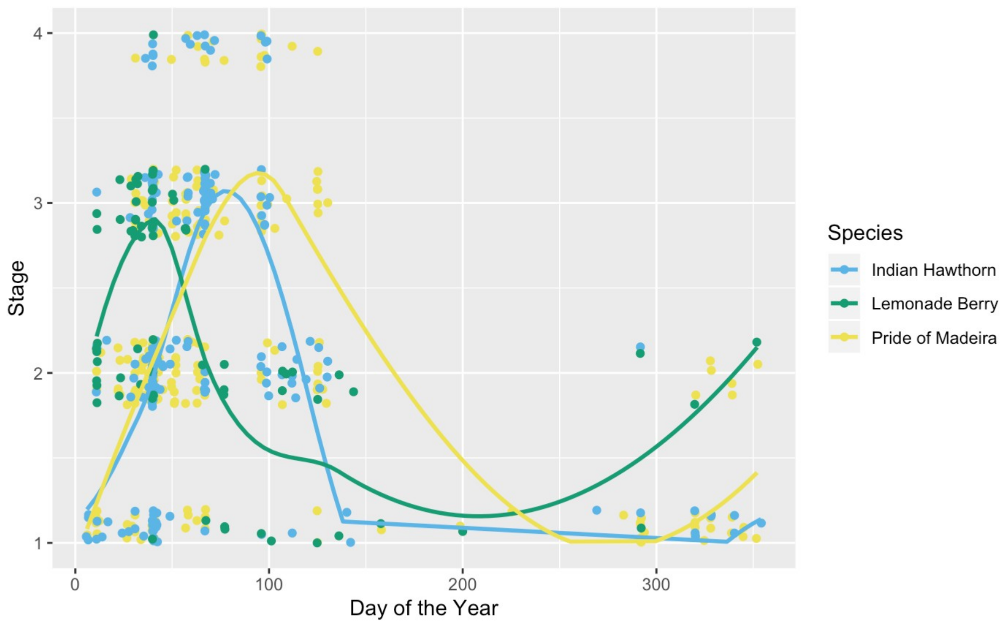


Figure 11: The woody species' phenostages through time. Phenostage ranges from 1-4 where 1 represents no blooms and 4 represents peak bloom. Indian hawthorn n=270, Lemonade berry n = 84, Pride of Madeira n= 287

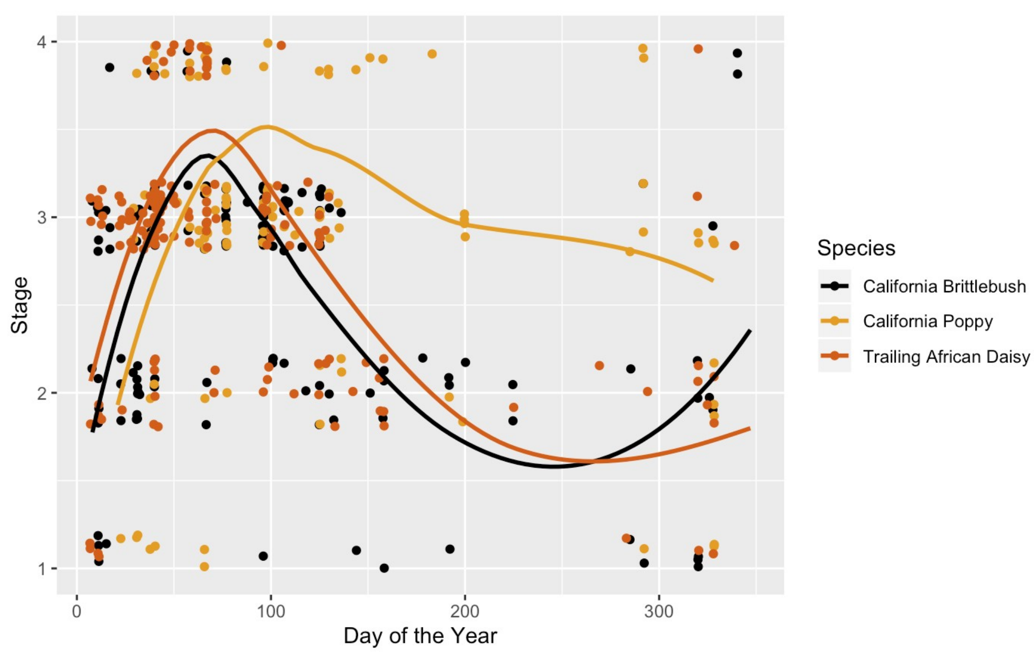


Figure 12: The herbaceous species phenostages. Phenostage ranges from 1-4 where 1 represents no blooms and 4 represents peak bloom. California Brittlebush n= 175, Trailing African Daisy n =195, California Poppy n= 147.

DISCUSSION

The study was able to highlight some key aspects of citizen science and phenology tracking. Citizen science on a university campus has many irregularities. Variation in the quantity and quality of data becomes an issue throughout the year with the number of students on campus and the types of flowering plant species that attract observers. However, with these data we were able to broadly analyze trends in phenology for our campus plants. Effects of urbanization like the urban heat island and irrigation are likely to have an effect on the phenology of species. An urban environment with native and non-native species planted for ornamental value will have many different factors affecting the phenological patterns.

CITIZEN SCIENCE

The viability of citizen science in research has had some study recently. These projects generally have a large number of participants and cover a wide range of habitat (Dickinson et al., 2010).By tracking participation of citizen scientists we found the beginning of the project had the most participants and the most observations submitted. This is likely due to the increase in enthusiasm for a project at the beginning. The summer months had a decrease in the project but not as much as the fall months. The summer months had the least amount of observations submitted to the project. This is due to the nature of university study-body. There are fewer students around during the summer to take observations and during summer students are less likely to spend time volunteering outside of requirements. There were also no BioBlitzes hosted during the summer months which contributes to the low number of observations taken during the summer verses the fall where non-BioBlitz observations were low but BioBlitz observations still contributed to a month’s data. January and February saw a rise in observations submitted to the project. This increase is likely due to flowers increasing on campus during this time. While citizen scientists were asked to take observations of plants at all reproductive stages, flowers likely increased the visibility of plants to an observer and were more motivating to take the time to observe.

The project was advertised through word of mouth and Facebook. The BioBlitzes were advertised on the Cheadle Center for Biological and Ecological Restoration’s Facebook page, and a UCSB grad student group Facebook page. After BioBlitzes announcements were made asking participants to continue taking photos outside of BioBlitz events. T-shirt prizes advertised to be given to the observer with the most observations during a BioBlitz. The advertising mostly reached UCSB students and staff. Participation in the project might have been improved with more advertising in different ways, like announcements before classes on campus and flyers around campus and the surrounding community.

BioBlitz days generated 1908 observations for the project while non-BioBlitz days generated 1680 observations. The effort was very different to get these observations. There were 8 BioBlitzes hosted for one hour each, the non-BioBlitz observations could be taken any day besides a BioBlitz day. In 8 hours, 1908 observations were observed when collecting data through an organized effort. When volunteers were left alone to take observations whenever they wanted to over 364 days only 1680 observations were taken. Additionally, the majority of non-BioBlitz observations were made by me with close friends making up almost all of the rest, people who have a greater interest in making observations than an average citizen scientist. Excluding observations made by people with interest in taking observations, would lower the number of non-BioBlitz observations considerably.

The pattern of the California poppy is the most different from the other species looked at in this study. This pattern is not because this species has a completely different phenology but because of citizen science and the life history and growth form of this species. Without the use of formal transects for volunteers to monitor it was up to the observer when and what they took an observation of. When not in bloom, the poppy is fairly inconspicuous and very difficult to identify. In the summer months when the species is not in bloom it is much more likely to get overlooked by the casual citizen scientist. With no observations of the species without reproductive structures and few observations with only a few reproductive structures the majority of observed phenostages are trailing bloom and leading bloom. This leads to the model fitting the summer months of the California poppy to a phenostage that is in at least partial bloom all year. This is not the true phenology of the California poppy but what collecting data from citizen scientists has not worked.

Citizen science can be used to collect data on a university landscape. However, citizen science will not be the best method of collecting data for all species equally. Future studies that utilize amateur scientists might consider training volunteers in species identification at all phenostages to improve equal coverage of species of interest The participation in citizen science projects will vary throughout the year and organizing a BioBlitz where the observation effort is organized will result in more observations for less days spent observing.

PHENOLOGY OF CAMPUS PLANTS

All 6 of the species in this study reach the highest phenology, when the average phenology stage of all the individuals within a species at a single date is closest to peak bloom in February and March which is expected. February might be considered a little early for flowers. However, early flowering is expected in urban plants due to the Urban Heat Island effect (Neil and Wu, 2006). All 6 species are at the lowest phenostage, when the least number of flowers are on the individuals, during the summer months which is expected in temperate regions so plants can conserve water during the dry months.

Native and Non-native

There is a difference between when native and non-native species are in peak bloom. Additionally, the non-native species have shown to move from one phenostage to the next more as a group than the native species which have much more variation in phenostages at any one date. It is unclear why this pattern between natives and non-natives is occurring as the species are adapted to similar climates. More research needs to be done to answer this question.

Family

Phenology is largely tied to environmental cues when abiotic conditions will be favorable to flowering. In general, abiotic cues are most important to flowering time regardless of relatedness (Staggemeier et al., 2010; Davies et al., 2013; Cortés-Flores et al., 2017). When the environment is less harsh, then a wider range of flowering times would be expected. This wider range of flowering times it is more likely that phenology patterns have a phylogenic tie (Lessard-Therrien et al., 2014). This pattern is reflected in the UCSBlooms data. In general, UCSB has a shared climate across campus and the two Asteraceae species has almost identical phenological patterns that we different than the patterns of the two Anacardiaceae species.

Closely related species might then share similar phenologies simply because they are adapted similar environments (Davies et al., 2013). We see this is true with the Asteraceae family. The California brittlebush and the trailing African daisy had almost identical phenological patterns. While one is native and the other is not, both are native to temperate zones so the response to abiotic factors might be playing a larger role in the phenological patterns of these two species. The two Anacardiaceae species are also adapted to temperate zones but the difference between native and non-native is pronounced. It could be that in these two species the difference between native and non-native is playing more of role in phenology than the relatedness of the species. The role phylogeny plays could be affected by microclimates.

The majority of lemonade berry individuals are in locations on campus that receive no irrigation while the Indian hawthorn individuals all receive irrigation. The lemonade berry most likely lost its flowers earlier as the temperatures warmed to reduce water loss while the Indian hawthorn was receiving additional water. The California brittlebush individuals also had the majority observed along the lagoon were no additional irrigation would be received while the trailing African daisy was observed only in irrigated areas and the two patterns were nearly identical. The two different families might be using different environmental cues to move through its phenology. The Anacardiaceae using water availability while the Asteraceae using another such as day length or temperature. This needs to be researched in depth with climate data to accurately conclude how phylogeny, environmental cues, and phenology interact.

Growth Form

Plant growth form can also influence the phenology of species as well. Mean flowering date differed significantly for different growth forms, with trees flowering earliest, followed by woody vines, shrubs and perennial herbs, and then annual herbs in China (Du et al., 2015). Moreover, perennial herbs flowered earlier than annual herbs (Du et al., 2015). Woody stems have morphology that allows them to hold water (Cortés-Flores et al., 2017). So woody stems would have more water resources than an herbaceous species earlier in the flowering season.

We do not see a definitive pattern that woody species flower before herbaceous species as only Lemonade berry flower before the herbaceous species. This could be because the irrigation species received would negate any resource advantage in early flowering that the water storing capabilities of woody vegetation would result in without irrigation.

We do see that the woody species have a definitive time period when not in bloom while the herbaceous species have some reproductive structure throughout the year. A previous study have shown no difference in the flowering time between growth form (Bolmgren and D. Cowan, 2008). It is not possible to say that this study contradicts these finding as, once California poppy is excluded, the two herbaceous species are from the same family which could be driving the close phenological ties, it is possible that with a larger sample size of herbaceous species that included non-Asteraceae species, we would find no difference between the phenology of the different growth forms.

Another study found that perennial herbs and woody species would flower before annual herbs (Du et al., 2015). The UCSBlooms data would agree with this conclusion. The herbaceous species included are perennials and all of our species reached their highest phenology stage around the same time period.

CONCLUSION

The UCSBlooms project used citizen science to track the phenology of six species on the UCSB campus. Citizen scientists are much less likely to participate in an open-ended project. The phenostage that an individual is in will influence if a citizen scientist sees it. Non-native species have less variation in phenostages at a single date than native species and families respond to different environmental cues.

Using data from a citizen science platform had some challenges. There was not an equal number of observations of all of the species which makes the conclusions less robust. Another challenge with citizen science is untrained participants carry the same weight as trained ones, so there is a possibility of misidentification of observations due to disagreement. Consistent coverage of species would require a more regimented monitoring system than allowing citizen scientists to make the monitoring decisions, such as establishing formal transects and marking plants for monitoring.

Future directions for this project are to continue collecting observations through multiple years to collect a true phenological pattern throughout the years. Also, multiple years of data would allow for researching how climate change is affecting the phenology of urban plant communities. Because the majority of species at UCSB receive irrigation and other management this data could be used in understanding how management affects multiple species phenological patterns in one community which is lacking in the literature.

This study needs more data for the current 6 species and needs to include more species to provide clear data on fine scale phenological patterns however the current data shows that an urban environment have many factors like native status, urban heat islands, and phylogeny affecting the phenological patterns. This study provides insight on how university students participate in citizen science projects and factors influencing the phenology of species within an extremely confined geographical area.

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